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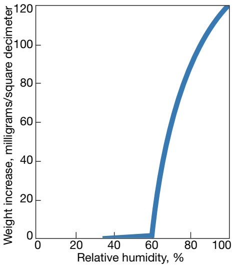

O&M Business, Araucaria


Design, Covert


O&M Major Equipment, Desert Basin


Environmental Stewardship, Holtsville

2010 Best Practices Awards


O&M Balance of Plant, Jack County


Safety, MEAG Wansley Unit 9


Management, PSEG Fossil

User Group Events

Robust technical programs define two of the world's largest user-group meetings serving the gas-turbine-based powerplant sector—the annual conferences and exhibitions of the Western Turbine Users Inc and the HRSG User's Group.

The 20th Anniversary meeting of the Western Turbine Users (March 14-17, San Diego) allowed participants to reflect on two decades of service to owners and operators of GE aeroderivative engines—specifically, the organization's many accomplishments and the valuable contributions made by its members in solving problems affecting the greater community of aero users.

The HRSG User's Group met in Jacksonville, April 12-14, the week after this issue came off the press. Pre-conference coverage offers insights into the meeting's content and the products and services offered by participants in the vendor fair.

In-depth technical reports on both conferences are scheduled for the 3Q/2010 issue.

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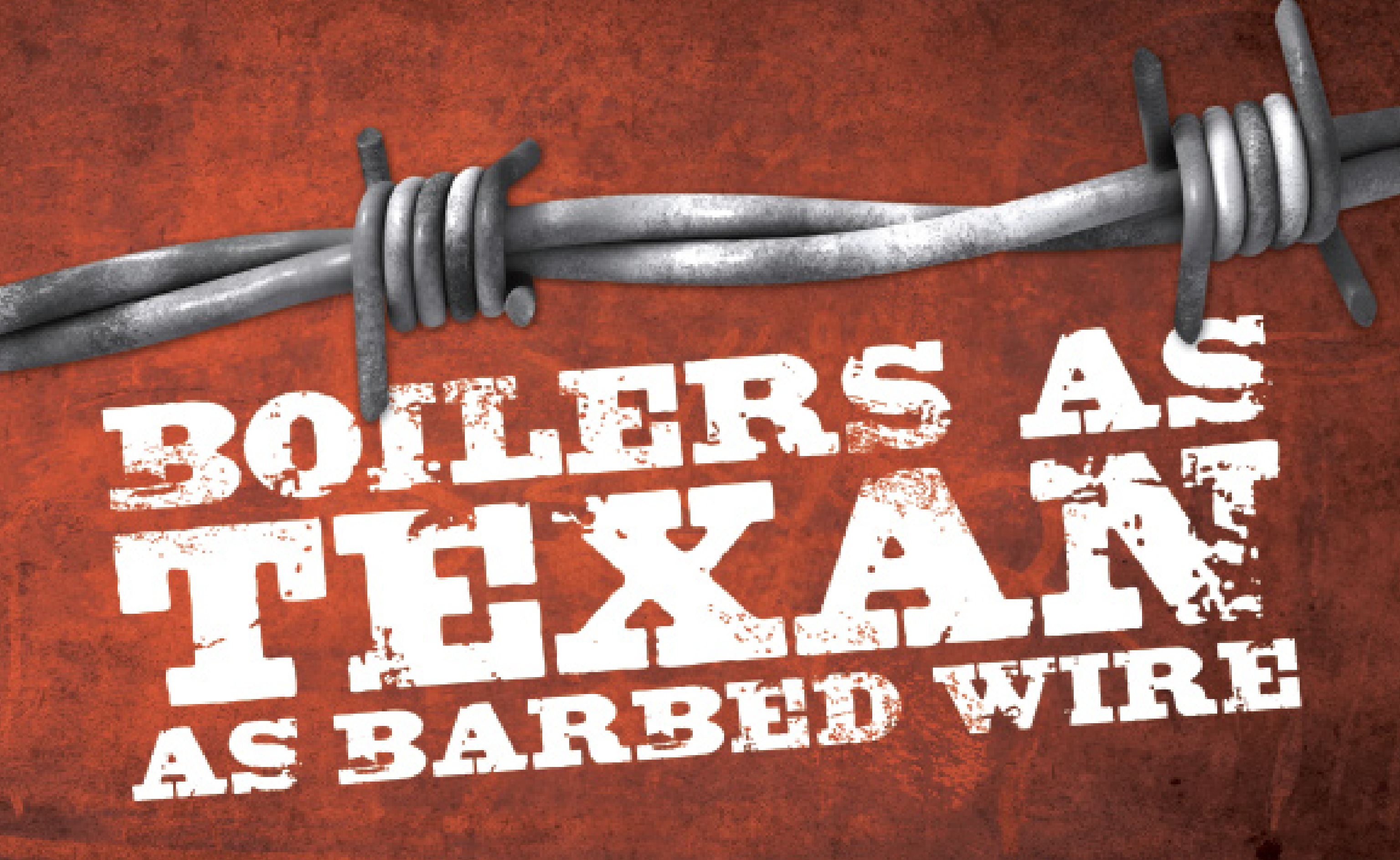
Feature Articles



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COMBINED CYCLE Journal

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Spring 2010 user-group season in full swing

Most user-group meetings in the gas-turbine-based generation sector of the electric power industry are held in the spring and in warm locations. The W501F and G groups, which have shared a common venue for the last several years, traditionally christen the new year. Their 2010 conferences and joint vendor fair hosted more than 160 users and 70 companies in Orlando, February 21-25, proof positive that the economy is on the rebound and gas turbines are running at higher capacity factors.

The Western Turbine annual conference and exhibition, which focuses on GE Energy aero engines (LM2500, LM5000, LM6000, and LMS100), is probably the largest gas-turbine (GT) user meeting in the world. It concluded March 17, attracting perhaps more than 900 participants for the first time. The exhibition featured products and services from more than 150 companies.

This was the 20th annual meeting of the Western Turbine Users Inc, a group that has never wavered from the goals established by the founding members to help owners operate and maintain their engines for maximum reliability, availability, and efficiency—and with the lowest emissions possible.

The WTUI section in this issue illustrates well the value proposition offered by user-group membership and attendance. If you are having difficulty getting approval to attend the user-group conference supporting your GT model, consider sending a copy of the Western Turbine report to the executive who is skeptical about the meeting's ROI.

HRSG User's Group. Only a week after this issue was dropped in the mail, the HRSG User's Group meeting was held in Jacksonville to help O&M personnel at combined-cycle and cogeneration plants solve steam-cycle problems. About 350 attendees were expected from among the engineering organization's 1500-plus members in more than 50 countries.

Remaining spring meetings. Don't pass up an opportunity to attend one or more of the following meetings remaining on the spring agenda. It's a sure bet you'll bring back to your plant ideas that when implemented will pay at least a 10-fold return on travel expenses.

- April 25-29, CTOTF—Combustion Turbine Operations Task Force, Spring Turbine Forum and Trade Show celebrating 35 years of service to the gas-turbine user community, Amelia Island, Fla, Amelia Island Plantation. Contact: Wickey Elmo, group and conference coordinator, info@ctotf.com.
- May 10-14, 7F Users Group, 2010 Conference and Vendor Fair, Renaissance Waverly Atlanta. Visit http://ge7fa.users-groups.com for details on registration.
- June 8-10, 501D5/D5A Users, Annual Conference and Expo, Dana Point, Calif, Laguna Cliffs Marriott Resort & Spa. Details at www.501D5-D5Ausers.org. Contact: Gabe Fleck, chairman, gfleck@aeci.org.
- June 14-17, Frame 6 Users Group, 2010 Conference & Vendor Fair, San Antonio, The Westin Riverwalk. Details at www.Frame6UsersGroup.org. Contact: Wickey Elmo, conference coordinator, wickelmo@carolina.rr.com.

BY THE NUMBERS

The mini boom in gas-turbine-based project development remains strong. However, wind projects dominate planned new capacity, driven by federal financing and regulations mandating the use of renewable energy resources

By Rita Beale, Energy Ventures Analysis Inc

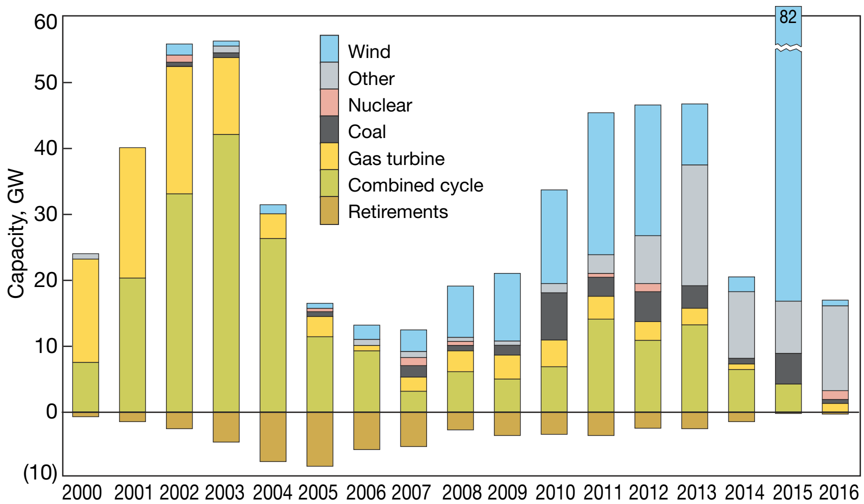
US plans for new generation capacity are now heavily weighted toward wind, gas, and non-wind renewable resources through the summer of 2016 (Fig 1). The renewable "revolution" is being facilitated by state Renewable Energy Standards and financed partially by the House American Clean Energy and Security Act of February 2009.

Last year the federal government committed billions of dollars to renewable development in the form of tax incentives (production tax credits, investment tax credits, and grants). EVA estimates that approximately 8% to 13% of retail electric sales will come from renewable energy sources by 2020 (see small sidebar).

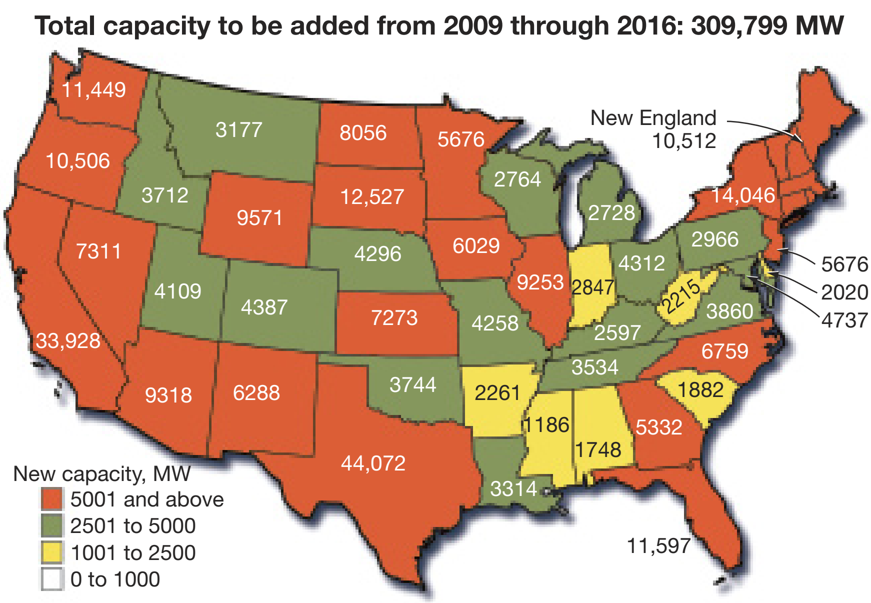
There was 309 GW of new capacity under development as of autumn 2009. Wind accounted for about half that total (Figs 2, 3), although many of these projects are in the very early development stage. Next comes gas-fired capacity with 26%, followed by "other" capacity—mostly non-wind renewable resources—with 20%. The latter group includes hydro, solar, biomass, and geothermal projects.

Who is EVA?

Energy Ventures Analysis Inc (EVA), Arlington, Va, specializes in energy and environmental market analysis and forecasting associated with the power, natural gas, coal, oil, and emissions markets. It also assists clients in the formation, execution, negotiation, and litigation of major fuel and transportation contracts, as well as in the purchase and sale of electric power assets. Rita Beale can be reached at beale@evainc.com, or at 703-276-8900.

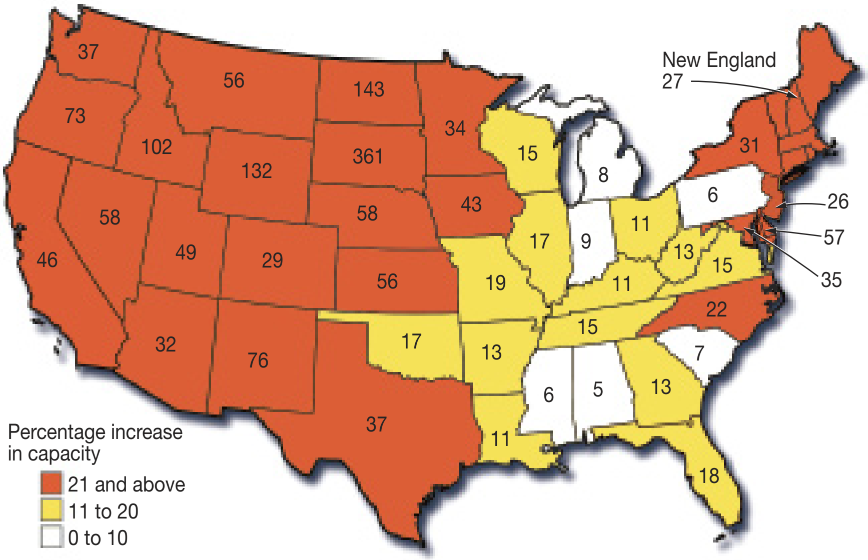


1. Capacity additions announced for the 2009-2016 period total 309 GW, based on information available at the end of last November. Wind is expected to account for 50% of the new generation. Note that data are based on nameplate capacities

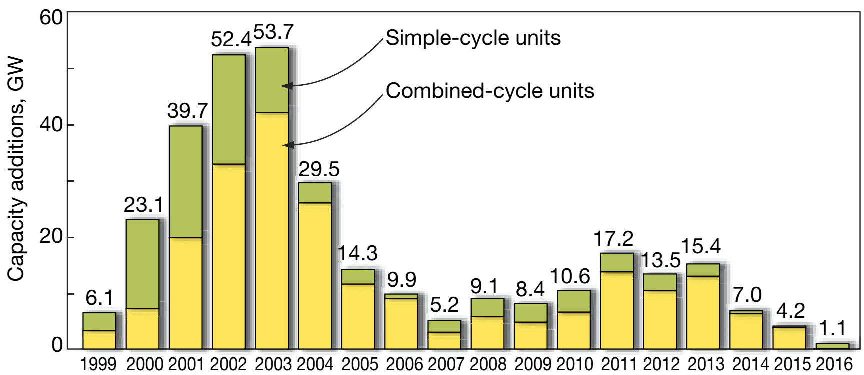


2. Absolute capacity additions by state, from Jan 1, 2009 to Dec 31, 2016, show Texas and California continue to lead, with South Dakota, Florida, Washington, and Oregon in the second tier

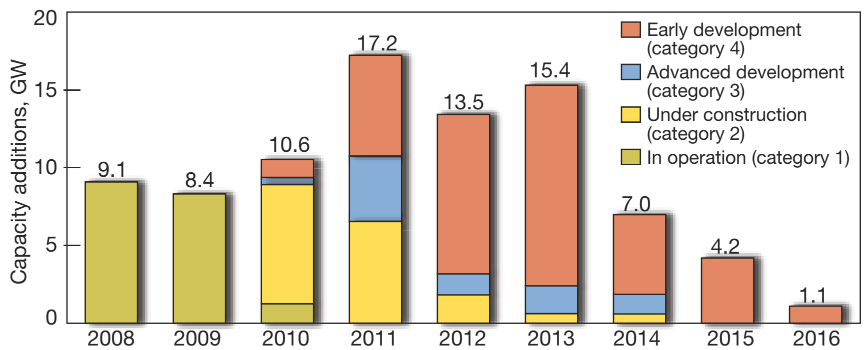
Cumulative US percentage increase in capacity from 2009 through 2016: 27



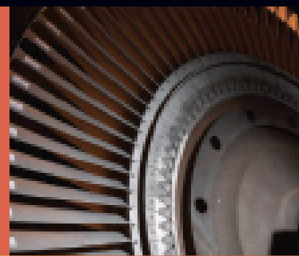
3. Relative capacity additions for 2008 to 2016, as a percentage of installed capacity, reveal that states with small current capacities have the largest increases: South Dakota (361%), Wyoming (132%), Idaho (102%), Oregon (73%), and Oklahoma (56%)



4. Profile of GT-based additions suggests that the mini-boom remains intact—one expected to last at least through 2013. Some new units are required to replace coal-fired plants announced and subsequently canceled because of environmental and cost pressures, and other are a response to new intermittent resources such as wind that require back-up fast-start generation. For the period evaluated, data suggest that 77% of the new capacity is combined-cycle facilities, remainder simple-cycle. But because peaking units are ordered much closer to their commercialization dates than combined cycles, expect the ratio between the two to decrease somewhat



5. Gas-turbine capacity by stage of development profiles 77 GW of announced generation for the 2009 to 2016 period. The recession will delay and stretch-out some projects—and possibly force the cancellation of a few. Keep in mind that gas turbines are installed quickly, so more than half of the new generation profiled (53%) is in the early development stage, making it relatively easy to tweak startup dates. About 12% of the capacity is in an advanced stage of development, another 22% is under construction; remainder already is in service



Texas and California continue to lead the states in new capacity additions, with New York a distant third.

The leaders in relative capacity additions through 2016, as a percentage of installed capacity, are South Dakota, Wyoming, Idaho, Oregon, and Oklahoma.

Coal has dropped out of the "top tier," with only about 16 GW of new capacity under construction and expected to come online by the end of 2012. There is great uncertainty about the licensing of additional new coal-fired plants once this build-out is complete.

Gas-fired technologies continue to benefit from cancellations of high-profile coal projects. The sector's mini boom continues, with 77 GW under development—about 10% more capacity than was under development a year ago.

In 2009, almost 9 GW of new gas-fired plants began commercial operation. However, the recession and resultant lower electric sales will likely delay the completion of some projects in the queue by as much as several years. The total capacity of simple-cycle projects under development increased by about 18% in the last year, while that for combined cycle projects dropped by about 1%.

US electric consumption fell by about 3.7% in 2009 compared to 2008. EVA expects an increase of about 2.6% in 2010, with additional growth of 1.7% in 2011.

A return to moderate natural-gas prices attributed, in part, to a revival of domestic production, allowed combined-cycle plants to operate at higher capacity factors despite the recessionary environment—these units being dispatched ahead of the least efficient coal plants. In some regions—the South Atlantic, East South Central, and Middle Atlantic, in particular—the capacity factors of combined cycles increased by about 10%.

Fuel switching was dormant during the winter of 2009/2010 because of the seasonal run-up in gas prices. But EVA expects that gas will again displace some coal as ambient temperatures moderate—although perhaps not to the degree it did last year.

In other regions—the West North Central and Texas, for example—new wind capacity appears to have displaced some gas-fired generation in 2009.

As part of its tracking program, EVA monitors each phase of every project as it winds through the development process. Each project is assigned a development category number that corresponds to its level of progress (see large sidebar). CCJ

EVA's project tracking methodology

Today's mixed bag of regulation and deregulation make it far more difficult to access information on power-project development than in the regulated era. EVA has continually tracked announcements of changes to powerplant capacity since 1998. This includes new plants, retirements, uprates, and derates by fuel type in six distinct stages of development.

To track project development in a consistent and orderly fashion, EVA designates each project into one of the following six categories that rank progress towards completion: In operation (Category 1); under construction (2); advanced development stage (3); early development stage (4); unlikely (5); and withdrawn (6). EVA's seasonal methodology counts capacity in service by June 1 only; units added thereafter are attributed to the following year.

Categories 1, 2, and 6 are straightforward and easily observable. New projects often, but not always, start with public introductions by the developers themselves. When first announced, natural-gas-fired and renewable-energy projects are assigned to Category 4. New coal and nuclear projects initially are assigned to Category 5 because of the difficulties associated with building these two types of plants.

During the early-development phase, project information often is difficult to access. However, EVA retains its initial ranking for at least as long as the developer continues to pursue the project actively. Distinctive qualitative attributes relate to a particular project's progress through the development phase.

A project advances to Category 3 when it has fulfilled most, if not all, of the basic elements necessary for construction—for example, permitting, financing, and orders for major equipment. A project may be moved back a category, if it misses targeted milestones or other indicators that point to a lapse in development activity—such as no site identified. Category 6 is assigned when the developer formally withdraws the project.

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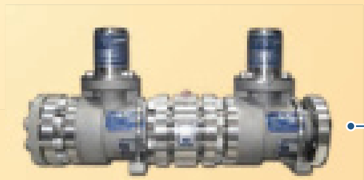
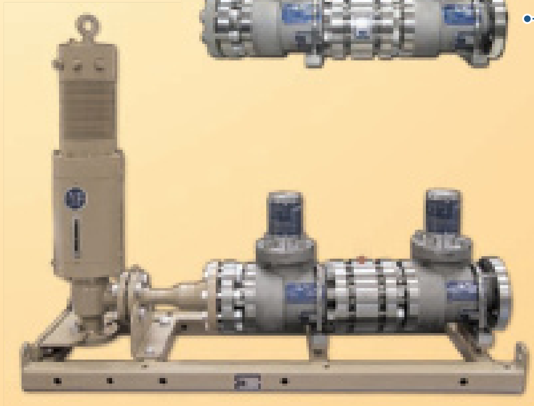


REDUNDANT SHUTOFF

The 9200D490-G001 Series Isolation Valve in Double Block & Bleed Format

Comprised of two 9200's, this valve is used to rapidly shut off gas fuel flow upstream of the primary gas control valve(s) in the event of a turbine trip condition. The valve then isolates the fuel source from the turbine engine.



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Best Practices Awards


Araucaria


CCC Saltillo


Columbia Energy Center


Blackhawk


Mustang Station

One of the biggest challenges facing owners and operators of gas-turbine-based powerplants in deregulated markets is the need to continually improve the performance of their facilities—to increase revenues and decrease expenses. One component of this goal of "continual improvement" is Best Practices. These are the methods and procedures plants rely on to assure top performance on a predictable and repeatable basis.

The Best Practices Awards program launched in late 2004 by the COMBINED CYCLE Journal has as its primary objective the recognition of the valuable contributions made by plant staffs—and headquarters engineering and asset-management personnel as well—to improve the performance of GT-based generating facilities. Entries for the 2010 awards in Operation and Maintenance (three categories this year: Balance of Plant, Major Equipment, Business), Design, Environmental Stewardship, Management, and Safety are presented in the more than three-dozen pages that comprise this report—all edited for style, some for length. A quick read is sure to uncover an idea or two that can be repurposed at your plant to increase reliability/availability, boost efficiency, reduce air and water emissions, and/or improve safety.

The entries were judged by seven members of the CTOTF Leadership Committee, chaired by Bob Kirn of the Tennessee Valley Authority. The Combustion Turbine Operations Task Force, the nation's oldest GT user group, and the one with the broadest coverage in terms of manufacturers and models served, will host the presentation of awards during the organization's Spring Turbine Forum in Jacksonville (Amelia Island), April 26.

There are two levels of awards to recognize the achievements at individual plants: Best Practices and The Best of the Best, as determined by the judges. Award recipients will be announced in the next issue.

Please judge the entries on your own, using the guidelines and scorecard presented on the last page of this report. E-mail Senior Editor Scott Schwieger (scott@psimedia.info) with your choices in each category and tell him why you selected the plants you did. We welcome your input and will include it in the next issue along with the judges' results.

Announcement of the 2011 awards program is made elsewhere in this issue. Alternatively, you can get details at www.combinedcyclejournal.com/bestpractices.html. Entries should not take more than a couple of hours to prepare and can be submitted to Schwieger at any time on or before Dec 31, 2010. This is one way to get the recognition your plant, your staff, and you have earned by your collective resourcefulness. Please plan to participate.


Covert


Jasper Generating


Desert Basin


Effingham


Granite Ridge

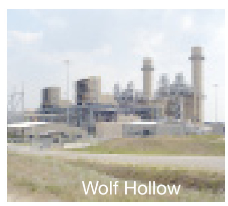

New Harquahala


Hopewell Cogen


ManChief


Pinelawn


State Line


Wolf Hollow

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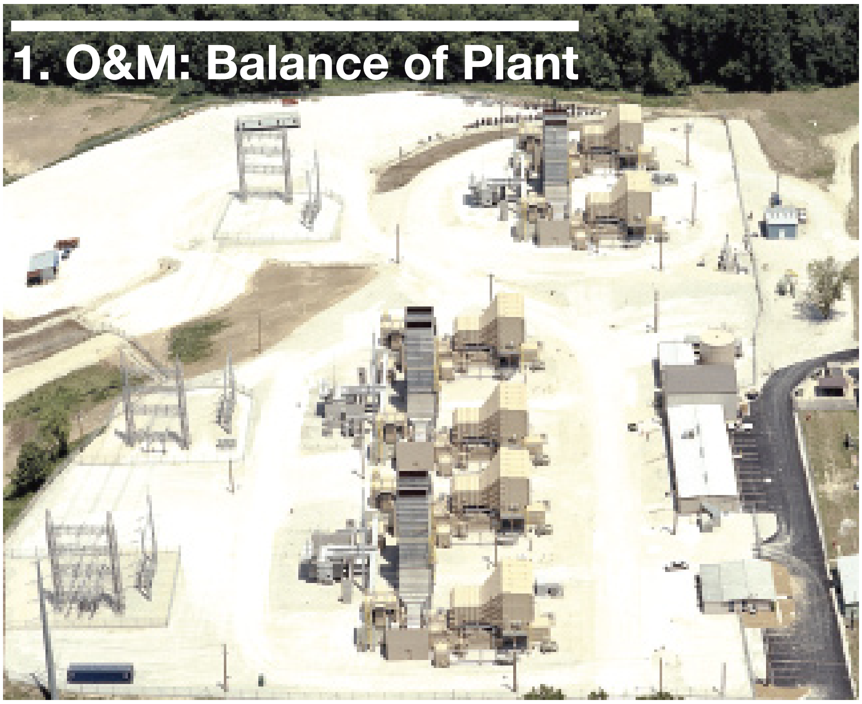
1. O&M: Balance of Plant



Spreadsheet guides safe, efficient response to protective relay operation

Ceredo Generating Station

American Electric Power Co

Challenge. Proper response to electrical power system protective relay operation is critical to employee safety, plant availability, and in some cases NERC compliance.

Solution. Plant employees assisted by a contractor have developed an Excel-based program that guides safe and efficient response and recovery from protective relay operation and "black" plant conditions. The program provides detailed response-plan flow charts and step-by-step procedures with job hazard analysis of each step to safely, promptly, and logically respond to a protective relay operation.

Ceredo Generating Station

505-MW, gas-fired, peaking facility located in Huntington, WVa

Plant manager: Pat Myers

Key project participants:

Les Adkins, Supervisor

Rich Tolley, O&M technician

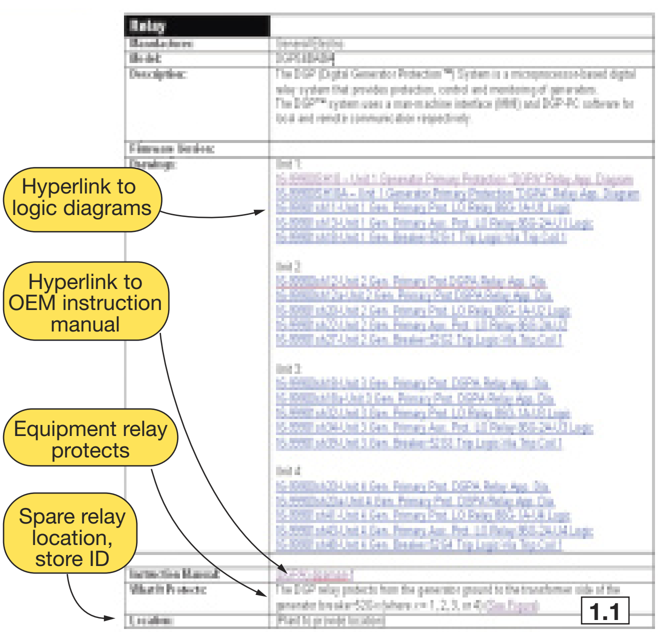
Pat Flower, O&M technician

Pat Hurst, O&M technician

All backup documentation (manuals and drawings), relay programming software, critical spare part identification/sourcing, and outside support group identification are included and are hyperlinked for immediate access via mouse clicks (Fig 1.1).

The response flow charts are arranged to respond to single and multiple relay operations. The flow chart steps hyperlink to detailed step-by-step procedures with detailed job hazard analysis for troubleshooting and response (Fig 1.2). The flow charts guide the plant employees through their level of in-plant capability to appropriate actions and decision making, and if beyond "in-plant" capabilities clearly identifies "outside" support resources.

Results. The Excel program is assembled to have all protective relay information in one place and be quickly accessed when needed (Fig 1.3). The program has evolved into a superior training tool for employees because it provides clear information complete with photos (Fig 1.4), how the relays function, zones of protection (Fig 1.5), and what and how the information from the relays is used to make criti-



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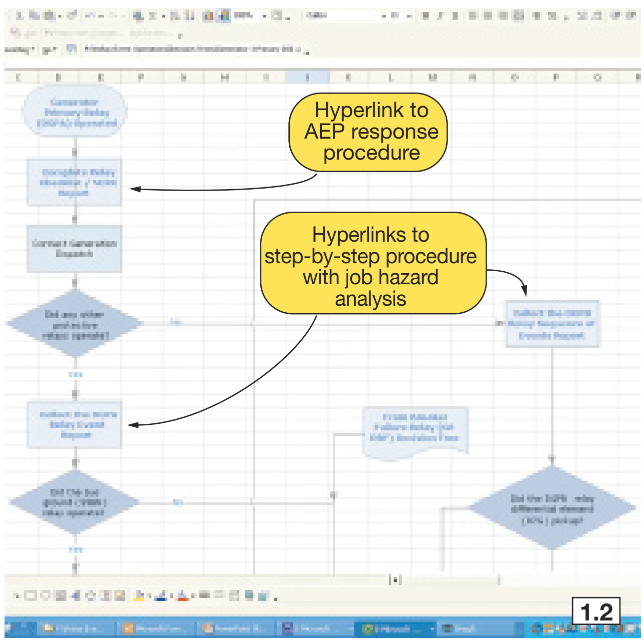

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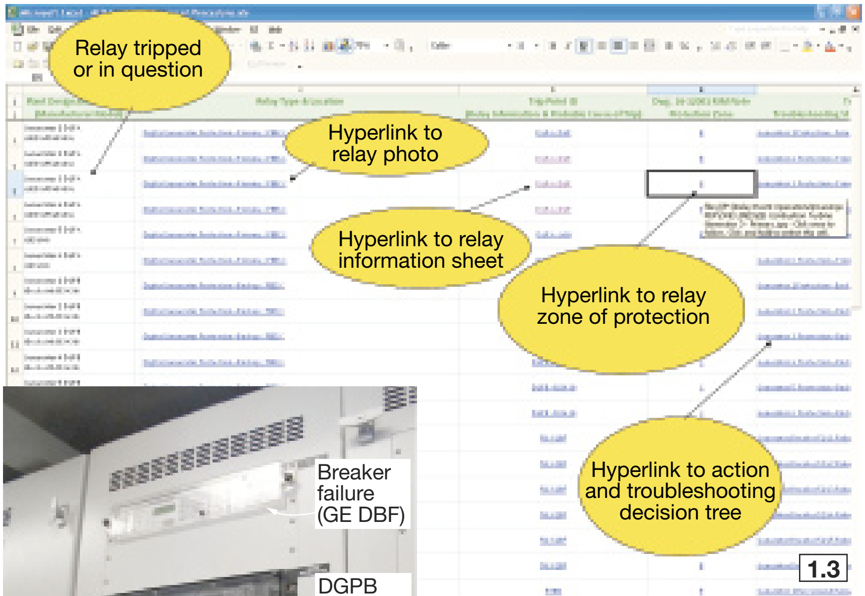

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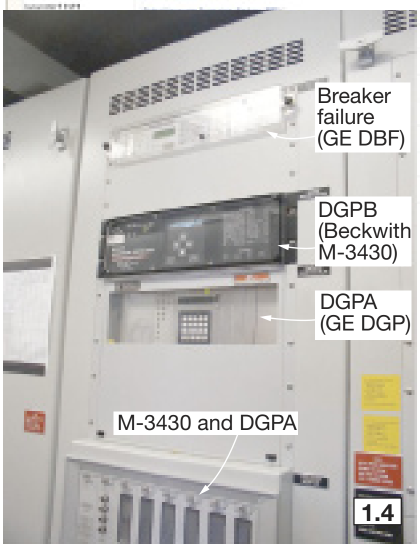

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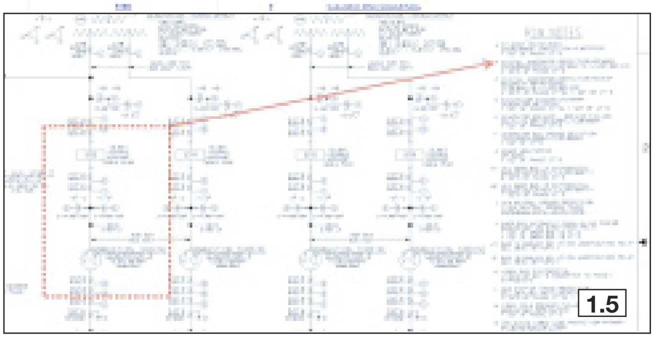


1.5

cal operating decisions in the form of equipment resetting and reclosure maneuvers.

In peaking plants and low-run-time cycling units, reducing forced outage time has significant economic impact in the calculation of plant capacity payments. Industry fines from NERC for improper reaction/operation of protective relays have been staggering.

This program should reduce protective relay operation outage time and will assist in NERC compliance.

Crystallizer on-line boil-out procedure increases reliability

Jack County Generating Facility

Brazos Electric Power Cooperative Inc

Challenge. Construction permits require zero-liquid discharge systems (ZLD) at many new combined cycles to maximize water reuse and minimize the consumption of indigenous resources (Fig 1.6). The Jack County ZLD facility uses a crystallizer (Fig 1.7) to process wastewater from cooling-tower blowdown and other waste streams through the process of evaporation. During evaporation and filtration, the filtrate has the solids removed but the soluble components still remain.

The soluble components consist of nitrates, calcium, and magnesium chloride. These components have

high solubility limits that can cause the boiling point elevation (BPE) to increase dramatically. This results in a concentration of solids in the crystallizer, known as "rock up," which adheres to walls and components and consumes the entire area of the vessel (Fig 1.8). The concentration of these components in a ZLD system can only be controlled based on the amount of brine that exists with the filter cake as moisture.

A steady concentration will eventually be established where the soluble components coming into the system will equal those soluble components that exit the system. At this point, a "boil out" becomes necessary.

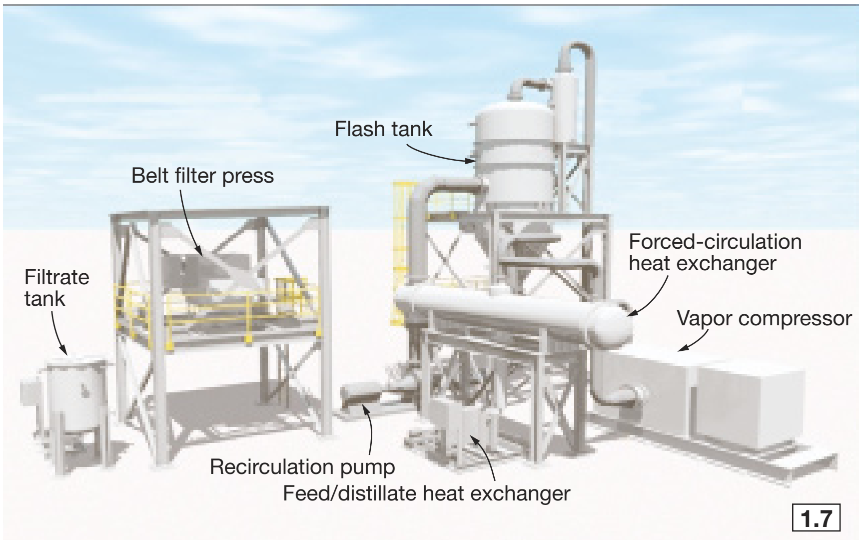
Initially, a boil out was accomplished by adjusting the drying times of the belt filter press which proved unsuccessful. Next, the unit was removed from service to perform multiple flushes and manual pressure washing of crystallizer internals. This method proved unsafe, costly, and inefficient. Another plan involved shutting down the vapor compressor and performing a boil out which also proved inefficient. The final procedure involved boiling out the crystallizer while it was in operation.

Solution. A procedure was developed to perform on-line boil outs. The facility established critical points to determine when the boil was necessary. These points included BPE, vapor compressor motor current, flash tank density, and belt-filter-press cake consistency and quantity.

The process includes the stoppage of incoming feeds, followed by the introduction of a weak brine solution (service water) while the flash tank level is decreased. When the solids in the belt filter press become a thin layer, the flash tank level is raised and brine is circulated for 1 to 2 hours. The bleed-and-feed process is repeated until the cake from the belt filter press is consistently thin. When this occurs, the boil out process is complete.

During the boil out process, two things are accomplished: (1) the brine feed is weakened below saturation levels to dissolve solids that have deposited in the system, either on the heat transfer surface or the flash tank, thereby cleaning the heat transfer surface, and (2) the concentration of the boiling soluble compounds is reduced by increasing the liquid blowdown in the cake relative to the incoming soluble compounds.

1.6



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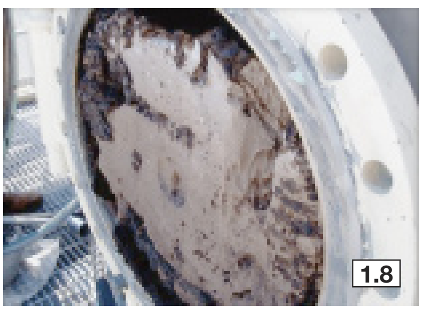
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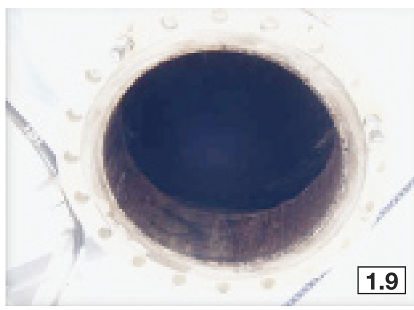
1.9

Results. This "boil out" procedure streamlined the operation of the ZLD plant and increased its reliability by reducing unnecessary shutdowns, thermal cyclic stresses, and starts on the vapor compressor. Furthermore, it reduced liquid waste disposal and eliminated forced outages by preventing "rock up" conditions. The latter benefited personnel safety by eliminating the need to enter the vessel to mechanically clean the crystallizer internals.

This operational enhancement saved the company $228,000 annually and increased availability by 32%. Subsequent internal inspections on the crystallizer revealed clean, "like new" conditions with no evidence of solids accumulation (Fig 1.9).

Design mods increase lifespan of RO membranes in ZLD system

Jack County Generating Facility

Brazos Electric Power Cooperative Inc

Challenge. The ZLD facility uses a high-efficiency reverse osmosis (HERO) system both to produce a rejects stream with a high concentration of dissolved solids for the crystallizer and to recover water for recycle. HERO is designed to operate at a high pH and is efficient in removing silica while being less susceptible to organic contamination than some other membrane processes (Fig 1.10).

Over a 30-week period, the RO units experienced a 60% loss in normalized permeate flow (NPF), significantly higher than the 15% anticipated. Further evaluation revealed a low NTU (less than 0.2) and a high SDI 15 (more than 5). NTU values alone are not enough to predict fouling in RO systems.

To further complicate issues, the design of the RO system consisted of four vessels in the first array that feed into one vessel in the second array, with each vessel having seven membranes. There is no booster pump between the arrays. There is low flow through the last array because of the high osmotic pressure of the feedwater, resulting in very low permeate production from the second array.

Additionally, the units observed a flux rate of 24 gal/ft^3 per day; 18 is the recommended maximum. These data supported the claim that the first array was generating most of the production. An autopsy revealed most of the foulant was organic or microbiological in nature.

Solution. The system was redesigned to introduce 5 ppm of hypochlorite (bleach) into the gravity filters upstream of the RO system, to maintain 0.10 ppm free chlorine residual. In addition, 1.5 ppm of DADMAC (diallyl di-methyl ammonium chloride) was added to the gravity filter to aid in the suspended solids precipitation process. Provisions also were made for a 75 ppm non-oxidizing biocide to be injected into each RO going out of service for lay-up.

Results. The design modifications listed above significantly reduced SDI 15 from 5.5 to 2.2 and the flux rate was reduced to the recommended 18 gal/ft^3 per day. The RO membranes were replaced and over a subsequent 30-week operating period the NPF reduced from 100% (new) to a consistent 82%.

As a result, the RO membranes have lasted twice as long. The plant has experienced significantly reduced RO wastewater volume (20% less), crystallizer operation, and discharge of water to an on-site process water pond.

Jack County Generating Facility

620-MW, gas-fired, 2 × 1 combined cycle located in Bridgeport, Tex

Plant manager: Jeff Nottingham

Key project participants:

Troy Cannon, Operations supervisor

Ronnie Johnson, Lead water plant technician

Tony Blair, Operations technician V

Mark Donahew, Water plant technician III

Julie Dickey, Water plant technician

Mike Vera, Chemistry specialist

Kyle Pfeiffer, Chemtreat Inc

1.10

1.11

1.12

Design mods streamline operation of the belt filter press for ZLD system

Jack County Generating Facility

Brazos Electric Power Cooperative Inc

Challenge. The ZLD facility uses a belt filter press to convert highly concentrated liquid slurry into a solid for off-site disposal. Because of a very corrosive environment, strict disposal requirements, and operational need, the belt filter press and supporting equipment required design upgrades to improve their reliability.

Solution.

- The salt cake must contain no free moisture before transporting to the local landfill. During wet weather conditions, rain water would puddle in the salt cake dumpster, requiring a "drying out" period and delaying transport. A roof structure was built over the dumpster (Fig 1.11).
- As dumpsters were moved in and out from below the belt filter press, the concrete was heavily damaged. Steel plate tracks were installed to allow the dumpster rollers to ride on the plates, thereby preventing surface damage to the concrete (Fig 1.12).
- During operation of the belt filter press, the OEM-provided four-belt configuration was very susceptible to tearing. This design was

1.13

1.14

replaced by a three-belt configuration which significantly minimized belt damage (Fig 1.13).

- During operation of the press, heavy deposits would accumulate inside the lower chamber causing the filtrate drain to plug with crystallized solids and the chamber area to fill with solids, preventing proper filtration. This required the unit to be removed from service for high pressure washing. A flush header using distillate water was installed in the lower chamber to spray during the cake discharge step to remove accumulated solids (Fig 1.14).
- The OEM only provided one proximity probe on the belt which caused belt misalignment when the opposite side became uneven. A second proximity probe was installed to detect belt misalignment, significantly minimizing belt tears.
- The OEM provided a splice bar made of flat material which often broke under stress. A new round stock bar made of stainless steel was installed which provided additional strength and reliability.
- The OEM designed the lower platen chamber pan with stainless-steel-clad carbon steel. The pan was replaced with 100% alloy AL6XN because of the very aggressive environment.

Results. The design modifications listed above increased operational availability by 36%, significantly reduced additional manpower requirements, and significantly streamlined the operational process. During a recent on-site audit by the OEM, the service technician stated that this unit was in "like-new condition" and was very well maintained.

Combating increased thermal load on cooling systems

Central de Ciclo Combinado Saltillo

Mitsui & Co Ltd and Tokyo Gas Co Ltd

CCC Saltillo

250-MW, gas-fired, 1 × 1 combined cycle located in Saltillo, Coahuila, México
Plant manager: René Villafuerte
Key project participants:
Lamberto Ortega, Mechanical coordinator
Roberto Hernández, Maintenance manager

Challenge. The facility experienced reduced power output and decreased revenue because of an increase of thermal load on cooling systems. The plant started to suffer sustained higher-than-original design temperatures and increased solar radiation with low relative humidity. These local climate changes are consistent with the perceived desertification of the area and expansion of the Sonoran desert.

The original plant design called for a maximum summer air temperature of 84F and a relative humidity of 65%. In summer 2008, we reached sustained temperatures of 95F with a relative humidity of 10%. Under these extreme circumstances, the lack of cooling capacity reduced plant output.

Solution. The plant proceeded in spring 2009 with preventive measures focusing primarily on reducing thermal load attributed to direct sunlight on radiators, finned tubes, and piping:

- Light metallic roofing was installed over the cooling-system radiators at a height such that air flow would not be impeded and oriented so that summer shade would be maximized throughout the day.
- Large garden shade tarps over the cooling system reservoir and expansion tanks, supported by light metallic structural arches, provide sufficient space between the tanks and the shade and create a draft of ambient air for further cooling.
- Metallic covers on the piping from radiators to pumps to heat exchangers allow a space between covers and pipe to induce some air flow.
- Additional high-flow axial fans compensate for the reduced relative humidity by increasing the amount of air flow through the radiators.
- Evaporative coolers were installed below the radiator fans to increase the local relative humidity and cooling capacity.

Results. During summer 2009, even when temperatures reached 99F, the plant was able to sustain maximum load. The preventive measures taken during spring 2009 will be tested again in 2010, hopefully without a further increase in ambient temperature.

Polisher upgrade reduces costs for off-site waste hauling

Pinelawn Power LLC

Owned by J-Power USA Development Company Ltd

Operated by Wood Group Power Operations Inc

Challenge. The polisher cleans up the water between the condenser and once-through steam generator. After a few days of operation, the resin in the polisher is "exhausted" and has to be backwashed off the polisher tubes. The wastewater is then sent to a holding tank. Ultimately, the exhausted mix of resin and water was hauled off-site for disposal.

Solution. A polisher upgrade was implemented to allow the plant to reclaim usable water from the polisher backwash. The design and installation of the system was completed by plant staff. The tank now settles for a few days and then the water is sent through a filter and into the cooling tower as makeup. This significantly reduces the wastewater removed from the site.

The pump and motor assembly used to transfer the water was a "leftover" assembly from previous, unrelated site work. The 100-micron

strainer used in the system was also taken from surplus site equipment. All other equipment, including motor starter and PVC piping, was purchased from local vendors.

Results. Maintenance on the system is minimal and includes inspection and cleaning of the system strainer. Eliminating the excessive costs associated with hauling the wastewater results in an annual savings of $124,000 to the operating budget.

Nitrogen generators for HRSG layup

Tenaska Lindsay Hill Generating Station

Tenaska Alabama Partners LP

Challenge. Six liquid-nitrogen cylinders are purchased per week for HRSG layup during the off-peak season. A blanket of nitrogen is required to prevent oxidation of the HRSG metal surfaces during extended downtime.

Tenaska Lindsay Hill Generating Station

845-MW, gas-fired, 3 × 1 combined cycle located in Billingsley, Ala
Plant manager: Robert Threlkeld
Key project participants:
Mark McKenzie, Operations manager
Vince Crabtree, Maintenance manager

Pinelawn Power LLC

80-MW, gas-fired, 1 × 1 combined cycle located in West Babylon, NY
Plant manager: Ken Ford
Key project participants:
Thomas Whitton, O&M technician
Daniel Frederick, O&M technician

Solution. Parker membrane-type nitrogen generators were purchased and connected to the steam drums in the HRSG penthouses to eliminate the need to purchase cylinders of nitrogen from a gas supplier. The nitrogen generators use compressed air to produce nitrogen more than 95% pure.

Results. The purchase and installation of the nitrogen generators will result in a significant cost savings and are on pace to pay for themselves in less than two years.

Compressed-air system improvements prevent desiccant fouling, alerts staff

Jasper Generating Station

South Carolina Electric & Gas Co

Challenge. During new construction, many compressed-air systems are installed with the discharge of the air compressors connected directly to the air dryers and with the dryer discharge connected to the receiver tank, as was the case at our facility.

A problem that arises is that oil can carry over into the dryers and cause the desiccant to foul prematurely when there is an upset in the compressor. Many OEM compressor skids do not have a detailed alarm, so a "system trouble" alarm is the only means of alerting staff to an upset.

Solution. Reconfiguration of the air-compressor piping was accomplished to connect the compressor discharge directly to the lower side of the air-receiver tank. This assures that any oil carryover can be collected, drained, and blown down from the air-receiver tank. Tank discharge is piped from the top side of the tank and run to the inlet of the compressed-air dryers.

A new pressure transmitter was also installed at the dryer outlet so

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Water Cooled Three-Way Purge Valve

Water cooled version of the standard JASC three-way purge valve was specifically designed to provide gas turbine owners currently utilizing three-way purge valves a means of eliminating coke formation while gaining turbine reliability and availability. Water cooling capability is added during refurbishment with bolt-on hardware. Existing turbine purge air, liquid fuel, instrument air piping and valve flange connections remain the same, making conversion much more cost effective than other upgrade options.

Smart Flow

The JASC Smart Flow monitors cooling water flow, temperature and leakage. It prevents coking and waxing of water-cooled fuel components, eliminates condensation on flame detectors and prevents damage to industrial gas turbine engines from cooling system water leaks. The Smart Flow is capable of operating several remote units on a turbine engine simultaneously. The multifunctional controller monitors water flow within user-adjustable limits and provides water system shut off with an audible alarm should a flow discrepancy of 0.1 gpm or higher occur in cooling water circuits.
JASC is presently engaged in engineering evaluation of using this device to detect leaks in liquid fuel and chemical systems.

Water Cooled Liquid Fuel Check Valve

This valve features all the benefits of the standard JASC liquid fuel check valve plus the added benefits of water cooling to effectively eliminate internal coking. A drop-in replacement for liquid fuel check valves, it uses water from the existing water system.

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Jasper Generating Station

910-MW, gas-fired, 3 × 1 combined cycle located in Hardeeville, SC
Plant manager: Steve Palmer
Key project participants:
Rusty Mezel, Maintenance superintendent
Noah Littleton, Operations engineer
Don Belle, Maintenance engineer
Kevin Croft, E&I supervisor
James Cowart, Mechanical supervisor

that the differential pressure across the dryer could be monitored with an alarm function to alert operators of dryer problems. A system trouble alarm for "A" or "B" compressor was added to help identify the unit which is experiencing problems.

Results. Compressed-air system reliability is improved by alerting the operations staff of any upsets in dryer differential pressure. The upgrade has provided positive payback by reducing E&I technician troubleshooting call-outs.

Plant staff can react more effectively to air-compressor alarms and can identify the root causes of compressed-air system problems more effectively with these upgrades. Desiccant life is extended because there is no oil fouling.

Hands-on vibration monitoring program safeguards critical rotating equipment

New Harquahala Generating Co LLC

Owned by MachGen Holdings LLC

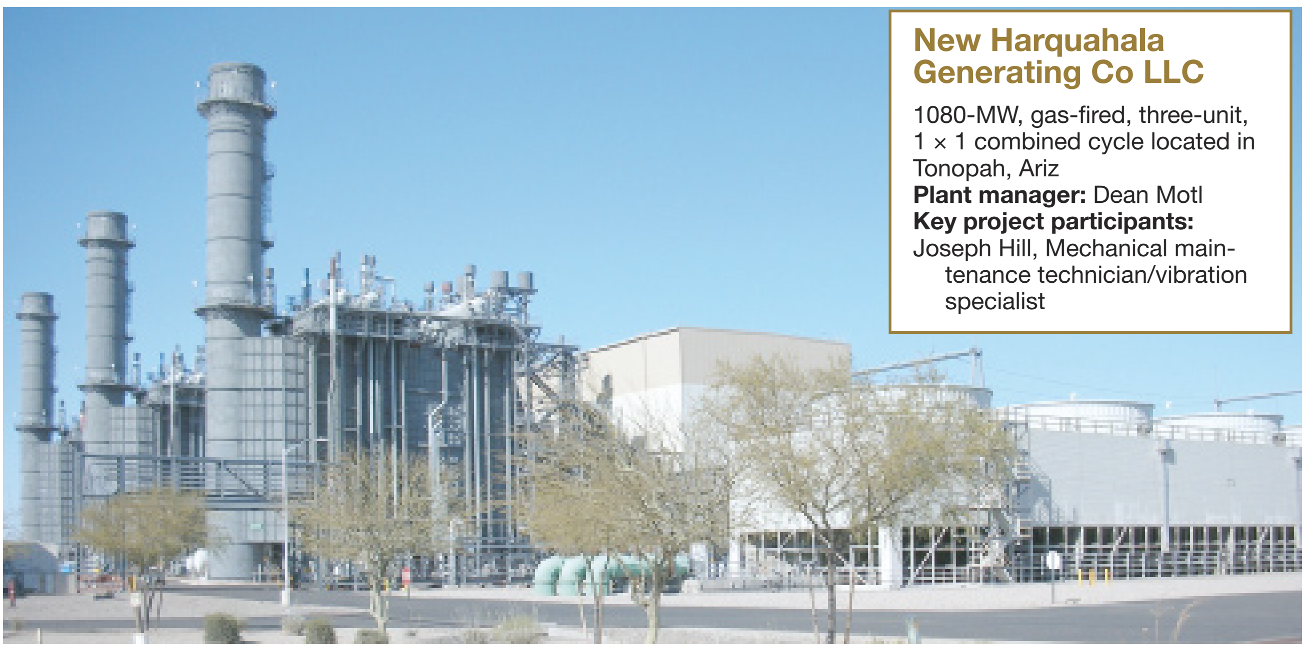
Managed by Competitive Power Ventures

Operated by NAES Corp

Challenge. Plant personnel continually strive to improve Harquahala's predictive and preventive maintenance practices. One specific area that has proven to be a valuable effort was improving upon the vibration monitoring program for rotating equipment.

Initially, the facility had incorporated a "passive" methodology for vibration sampling of rotating equipment. The facility contracted an independent, predictive maintenance company, which supplied a hand-held vibration monitor. The information collected from the hand-held device was e-mailed to the maintenance contractor, who interpreted the results and provided direction to plant personnel based upon the hand-held readings.

The analysis performed by the contractor and subsequent response could, at times, take several weeks, thereby delaying identifying potential equipment issues. Additionally, routes were established and taken based on the periodicity established in the plant's computerized maintenance management system. Although this methodology presented an adequate means of recording major equipment vibration and created a vibration history, the process did not allow for the ability to interpret and analyze the data on a real-time basis.



New Harquahala Generating Co LLC

1080-MW, gas-fired, three-unit, 1 × 1 combined cycle located in Tonopah, Ariz
Plant manager: Dean Motl
Key project participants:
Joseph Hill, Mechanical maintenance technician/vibration specialist

O&M personnel could not directly identify or address emerging issues with plant rotating equipment and detect potential failures. In 2007, the facility decided to explore other options related to vibration monitoring. After a detailed review of "best available technology," the facility purchased a portable vibration analysis unit (Fig 1.15).

In addition to purchasing the equipment, the facility arranged for monthly visits by the supplier's engineer for formal training to establish a proficiency level that would allow the plant to perform analyses in-house. Ultimately, the goal is to have two technicians on staff qualified as Level 1 (or higher) ISO-certified vibration analysts.

Solution. The following timeline illustrates the plant's experience with an unspared boiler-feed pump (BFP) that had vibration issues over a prolonged period and how the root causes ultimately were identified and corrected.

- December 2006. Operators observed that the outboard bearing on the Unit-2 BFP motor was emitting a loud clicking noise. The facility hired an outside vendor to check vibrations on the BFP motors serving the plant's three combined cycles; vibrations were within tolerances on all three units. The facility scheduled additional readings to be taken on a weekly basis when Unit-2 pump was in operation, an effort to closely monitor the rate of change in vibration level. In parallel, the plant sent its spare BFP motor for refurbishment in preparation of changing out the Unit-2 BFP motor when market conditions allowed this activity.
- January 2007. After the Unit-2 BFP motor was removed and replaced with the refurbished spare, it was sent to the shop for testing, inspection, and repair.
- October 2007. The vendor monitoring vibration returned to the site to assist in the development of a database for plant equipment, this to facilitate vibration analysis and data collection schedules and intervals. The vendor also assisted the plant technicians in the gathering of baseline vibration data on all critical equipment.
- May 2008. After analyzing the shortcomings of using a remotely interpreted, passive monitoring program and the cost of additional local vibration monitoring support, it was deemed appropriate to bring the program in-house.


1.15

The plant decided to purchase a two-channel CSI 2130 Machinery Health Analyzer from Emerson Process Management along with the supplier's hands-on training services.

- July 2008. The Unit-2 BFP motor outboard bearing was making a noise similar to that heard the previous year. Because the plant's vibration program was still in development, the facility decided to hire an outside source to monitor vibrations weekly on all feed-pump motors.

  All vibrations were well within tolerances, as they were the year before, but data signatures on Unit-2 BFP motor showed signs of clearance problems with the outboard bearing. The contractor continued to monitor weekly. The facility had Emerson field engineers train the designated vibration technician in database management and to provide instruction on the principles of data collection and interpretation.
- July 2008. Initial baseline vibration data collected on all critical equipment found Unit-3 BFP exhibited looseness on that pump's outboard bearing. Plant technicians checked foundation bolts and all were within tolerance. Based on these findings, the decision was made to continue with weekly monitoring. Unit-2 BFP still was monitored weekly, with no changes in vibration severity.
- October 2008. The decision was made to change out Unit-3 BFP and motor with the inventory spare during the fall outage. Inspection revealed that the pump had several seal issues along with the outboard bearing looseness in the housing. With the motor was due for a five-year inspection, both the pump and motor were sent out for overhaul.
- November 2008. The decision was made to pull the Unit-2 BFP motor and replace it with a spare; the motor was shipped off site for shop inspection.
- August 2009. A plant vibration technician and contract field engineer from Emerson identified a vibration signature consistent with signs of a broken or cracked rotor bar(s). The high-resolution sample that was taken revealed a pole-pass sideband around turning-speed harmonics, which is an indication of a broken or cracked rotor bar or end ring.

  The plant put the equipment on the watch list and continued to monitor weekly for changes in the pole-pass frequency amplitude and turning-speed amplitude. An increase in rotating-speed amplitude can mean a hotspot on the rotor and a resultant bow. The rotor was scheduled for removal and testing at the first available opportunity.
- September 2009. Market conditions supported the removal and replacement of Unit-3 BFP motor. This time a full array of tests was performed in an attempt to determine the resolution for the ongoing issues.

  Initial testing showed hot spots on the rotor consistent with a loose rotor bar. The motor was shipped to a qualified contractor for refurbishment and further diagnosis. Shop tests at the rotor repair shop concluded that the rotor displayed excess clearance in the rotor bar slot allowing for excess movement and subsequent insulation degradation.
- October 2009. The vibration data signature for the spare motor recently installed on Unit-3 BFP indicated the possibility of rotor-bar damage in addition to high vibration on the outboard bearing. The Emerson field engineer and plant vibration specialist determined three areas of concern with this motor:

1. The spectrum revealed the harmonics of turning speed with pole-pass frequency sidebands. This usually indicates a rotor problem—such as broken or cracked rotor bars or end rings, delamination, high-resistance joints, and possibly eccentricity.
2. The waveform showed once-per-revolution impacting of the sleeve bearings. Under normal circumstances there should not be any impacting with this type of bearing.
3. The third spectrum revealed many harmonics of turning speed, a dominant third harmonic, and a high-frequency mound of energy. The multiple harmonics and the third harmonic are indications of excessive bearing clearance; the

mound sometimes is found when there is a rub.

It was suspected that there were issues with this motor involving the rotor and outboard bearing. Some electrical tests confirmed the rotor problem, but more conclusive testing required rotor removal. Daily monitoring was conducted until the spare rotor was rebuilt and returned to the plant and market conditions allowed removal of the motor in service for detailed inspection and repairs.

- December 2009. The facility changed out Unit-3 BFP motor with the rebuilt spare. The pole-pass frequencies were eliminated there still was excessive impacting of the outboard bearing. The vibration signature indicated possible misalignment. Later in the month, the Unit-3 BFP motor was realigned to the manufacturer's specifications and ran smoothly.

Results. By creating a program with the capability to readily collect and analyze data directly at the site, any issues with rotating equipment could easily be identified and immediately addressed, thereby preventing potential equipment failure and forced outages.

The major benefit of the revised program is mitigation of the risk of unexpected downtime. While being an extremely effective safeguard against total loss, it also allows timely ordering of replacement parts to reduce expediting fees and allows advance planning to shorten repair and inspection times.

The program clearly delineates the definitions and principles behind vibration monitoring as well as establishing the plant's philosophy and action plan related to vibration monitoring. The result of the new vibration monitoring program began to pay dividends immediately.

The plant has determined that having an internally managed, comprehensive vibration analysis program prevented potentially catastrophic failure of an unspared BFP. By managing the maintenance and repair intervals around market opportunities, the BFP motors were repaired and were not allowed to impact availability; plus financial and reliability impacts were minimized. Had the BFP failed, the economic result would have been significant.

Establishing a sound understanding of the methodology behind vibration analysis will support further evolution of the technology to improve plant operating reliability. Although the facility has not achieved its final goal of having two fully qualified vibration professionals on staff, it has moved rapidly in the direction of a fully interactive predictive vibration monitoring program.

This is one of several formalized predictive maintenance programs that the plant has engaged in. But the information is clear that a properly managed, integral predictive maintenance program will play a significant role in the future success of the facility.

2. O&M: Major equipment

Generator rotor removal platform increases safety, reduces cost of rewinds

Desert Basin Generating Station

Salt River Project

Challenge. Stator insulation deterioration was found on two eight-year-old generators requiring total stator rewinds within one year. The generators are located in a fully enclosed generation building.

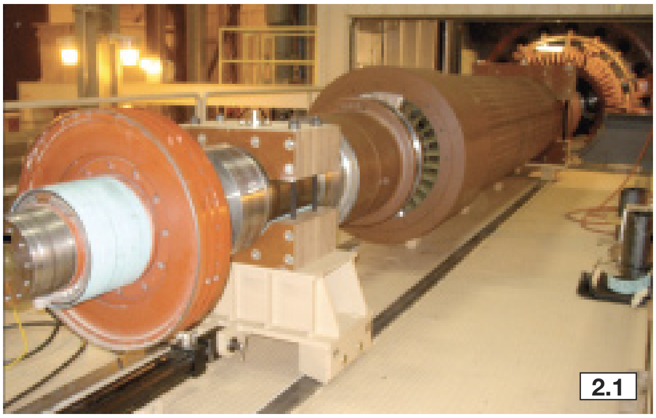
The plant personnel were faced with limited access and numerous obstacles for disassembly and removal of the generator field. These included redirecting (1) major fire system piping and (2) numerous system piping and electrical cable trays that were in the way, and (3) installing a 30 × 30 ft roll-up door to transfer the rotor out of the building. The generators had no support structure or overhead crane system to assist with the unit overhaul.

Plant personnel researched several disassembly processes and rotor removal options, including the use of a mobile gantry crane and the installation of a complete overhead bridge crane system. Neither option was cost-effective, and because of the limited time available, installation of a crane would not meet the unit overhaul schedule.

Solution. Plant personnel came up

Desert Basin Generating Station

577-MW, gas-fired, 2 × 1 combined cycle located in Casa Grande, Ariz
Plant manager: Bill Alkema
Key project participants:
Jess Bills, O&M supervisor
Moh Saleh, O&M engineering manager



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2.2

with the concept using past experience to design a working platform that could be utilized for personnel to perform disassembly of the unit safely. This platform also provided the required structure to support the 102,000-lb rotor once removed and was used as the stator rewind workspace.

The system was constructed to support the rotor removal at several critical transfer points in the process. Specially designed guided rolling skates were manufactured to support the rotor at the collector-end bearing journal and rotor core iron, with special load softening blocks to protect machined surfaces (Fig 2.1).

The working platform, designed to allow walking room and access for personnel to safely work around the rotor, was equipped with removable safety hand rails (Fig 2.2). Other attributes of the platform was the simplicity of assembly and alignment to the generator. The two-piece table has a two-bolt connection and is supported under each support leg with mechanical-screw leveling pads.

The rotor was removed and reinstalled using a double-action hydraulic cylinder that was easily positioned and moved by plant personnel. The third section of the platform was manufactured to be mounted on a heavy-haul trailer which was connected to the platform. The rotor was moved by means of a 12,000-lb dc electric winch to the transfer skid. The project from conception, design, engineering, management approval, and fabrication took 11 months.

Results. The rotor removal system provided personnel the ability to set up the table one time from removal to reinstallation. Its primary function was to allow for all the work to be done safely. It was imperative that the risk to personnel be minimized, and that the rotor shaft centerline elevation was maintained to eliminate the potential of contact and causing damage to the rotor and stator core iron and possibly impacting the outage scope and schedule.

Two identical generators were rewound at the plant with zero accidents or negative incidents. The complete set up time to install the table and have the rotor out of the stator was one and a half shifts. The cost savings, primarily in reduced man-hours by not using conventional mobile equipment was estimated in the tens of thousands of dollars.

The cost saving of this rotor removal system in comparison to the installation of an overhead crane system was close to $1 million. Since both successful generator outages, the rotor removal system has been rented to another utility with similar generators. Preliminary research shows that this equipment can also be used on the owner's other plant locations where there are different generator models.

Chiller system with eight modes of operation increases output on hot days

Palomar Energy Center

San Diego Gas & Electric, a Sempra Energy utility

Challenge. The case at our plant was straightforward: Combined-cycle gas-turbine performance degrades with increased ambient temperatures. The original evaporative-cooling system was only moderately effective. Our inability to accurately forecast plant capability, not only from day-to-day, but from hour-to hour, could adversely impact the bottom line.

Solution. The plant drew on

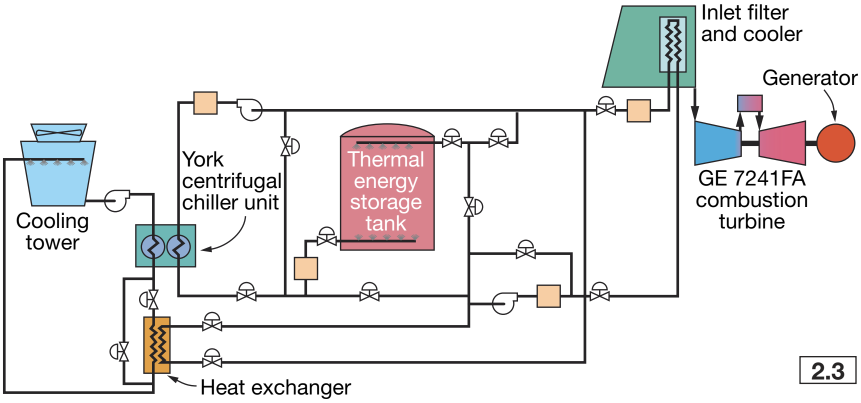
Palomar Energy Center

565-MW, gas-fired, 2 × 1 combined cycle located in Escondido, Calif
Plant manager: Dan Baerman
Key project participants:
Pete Smithson, Operations manager
Carl LaPeter, Maintenance manager
Brian Martin, Plant engineer
Travis Atherton, I&C technician
Kevin Counts, Lead operator

past experience from personnel and conducted an economic analysis with all viable options. The decision was to install a chiller system with eight modes of operation for increased operating flexibility (Fig 2.3):

1. Turbine inlet cooling (TIC) using chiller only. The centrifugal chillers cool the chilled water loop which flows directly to the gas turbines for inlet cooling (Fig 2.4).

2. TIC using discharge from thermal energy storage (TES) tank only. The centrifugal chillers are not operated to conserve parasitic load.



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Chilled water stored in the TES tank (Fig 2.5) is pumped directly to the GTs for inlet cooling.

3. TIC with simultaneous chiller and TES tank discharge. Achieves maximum turbine inlet cooling capability and meets the cooling needs of an extremely hot and humid day.

4. TES tank charging. Use of the centrifugal chillers to charge (chill) the TES tank; the gas-turbine inlets are neither cooled nor heated in this mode. The GTs do not need to be running for this mode.

5. Inlet heating/freeze protection. A heat exchanger is used to transfer heat from the cooling tower to the chilled-water loop, which flows to the GT for inlet heating. This mode is used when (1) ambient temperatures approach freezing regardless of GT operating status or load, or (2) GTs are operating at part load with ambient temperature less than the circ water/cooling tower temperature. Inlet heating at part load (with IGVs at less than fully open) increases GT efficiency.

6. Inlet heating while TES charging. While charging the TES tank with the centrifugal chillers, the chiller waste heat is transferred to the chilled water loop via a heat exchanger. This takes the chiller load off the cooling tower (conserving water and fan power) while simultaneously providing extra warm inlet heating to the part-loaded GTs to improve turbine efficiency.

7. Free heating and free TES charging. This mode takes advantage of warm days and cool nights. At night, warm TES tank water is circulated through the gas turbine to provide inlet heating while cooling the TES water. During the day, the cooled water is circulated to the gas turbine for inlet cooling, which heats the TES water.

8. Efficient TES charging. This mode is used when the ambient temperature is lower than the TES water but not cool enough for free TES charging. The warm water from the top of the TES tank is pumped through the turbine inlet coils for initial cooling. It is then pumped through the centrifugal chillers for final cooling before being pumped back to the bottom of the TES tank. The chillers can be run at greatly reduced capacity for this mode.

Results. The chiller system greatly increases plant output on hot summer days when demand is high. Prior to installation, plant output maxed out at 500 MW on the hottest days. The plant now achieves a predictable output of 565 MW regardless of season or weather.

The chillers can reach maximum capacity in around 10 minutes. The system's automated operation, combined with highly flexible design, results in most efficient operating mode without excessive operator intervention. From an environmental standpoint, the plant's overall emissions did not increase.

Tenaska Virginia Generating Station

885-MW, gas-fired, 3 × 1 combined cycle located in Scottsville, Va
Plant manager: Robert Mayfield
Key project participants:
Sam Graham, Maintenance manager
Ed Puskaric, I&E technician

Process improvement program virtually eliminates HMI failures

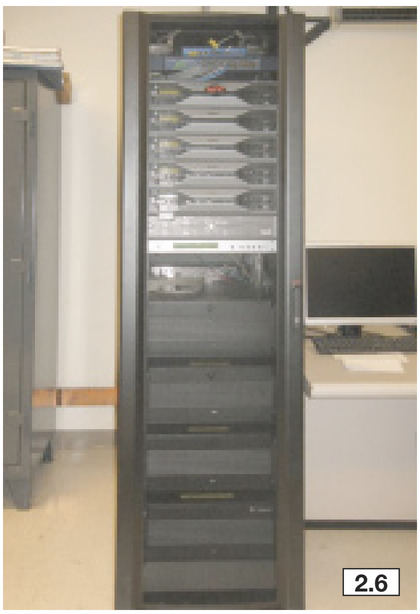
Tenaska Virginia Generating Station

Tenaska Virginia Partners LP

Challenge. The plant experienced repeated digital control system (DCS) failures which were attributed to its human machine interfaces (HMI). The facility needed to eliminate HMI failures and provide for greater reliability, efficiency, and flexibility. The HMI machines were primarily desktop personal computers. Analyzing the failure records showed the two main causes for the failures were hard drives and power supplies.

Solution. The plant optimization team, consisting of operators and maintenance personnel, worked to identify the cause of HMI machine failures. The team implemented the *Six Steps for Continuous Process Improvement* approach to correct the problem.

This process encourages employee involvement in the development of



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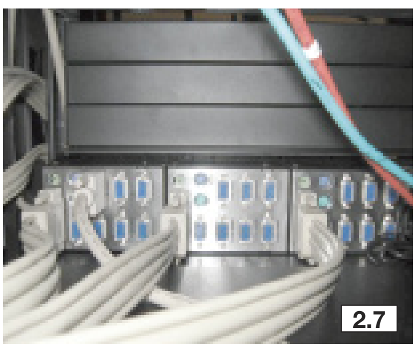

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recommendations for management. The six steps include: (1) defining and mapping a process, (2) defining process measures, (3) setting process targets, (4) analyzing the process, (5) improving the process, and (6) feedback on the process.

The *Six Steps* process improvement system was successful because the approach engenders a "team" atmosphere and encourages both managers and hourly employees to share their system knowledge. Actions taken included:

- Move the machines from the control room operator desk to the DCS room next to the control room.
- Use "server" class machines with more robust or redundant power supplies (Fig 2.6).
- Some machines required "RAID hard-drives" for added reliability.
- Use keyboard/video/mouse (KVM) switches to provide the input devices in the control room (Fig 2.7).
- Install quad-monitor video cards in the machines.
- A contractor provided training and guidance to I&C technicians during the installation process.
- Purchase an external USB hard drive of sufficient size to back up all machines and be stored in a fireproof safe away from the server rack.
- Two separate UPS power sources were pulled to the server rack and the servers were split to eliminate single-source failure points.
- Numerous ethernet cables had to be pulled from the control room to the server rack.

Results:

- The HMI rack is in a clean air con-

ditioned space.

- The servers are neatly organized and labeled.
- All machines have KVM switches that are installed in a way to enable easy replacement, if required.
- Initial planning of cable pulls allowed color coding to segregate the DCS KVM cables, Mark VI KVM cables, PLC KVM cables, and ethernet cables.
- Easier HMI troubleshooting and maintenance.
- Increased reliability and efficiency.

Duct balloons sustain proper temperature for turbine disks in cold weather

ManChief Generating Station

Owned by ManChief Power Company LLC and Capital Power Corp

Operated by Colorado Energy Management LLC

Challenge. The gas-turbine OEM at our plant recently issued a technical advisory (TA) to alert plant owners and operators of a potential issue with GT disk embrittlement. To reduce the risk of disk embrittlement, turbine starts in cold weather are now temperature-limited.

In accordance with the advisory, the turbine disks must be above the specific temperature listed before a start can be initiated. Because of the geographical location and peaking application of these simple-cycle units, the heating options to maintain the turbine disks above the minimum temperature were very costly if not impractical.

Solution. The plant O&M team researched available options and to find a solution to keep the turbine disks warm and the units ready to start without spending an exorbitant amount of money.

One option available to us was to disassemble the GTs, inspect the

ManChief Generating Station

300-MW, gas-fired, two-unit peaking facility located in Brush, Colo

Plant manager: Joe Keefe

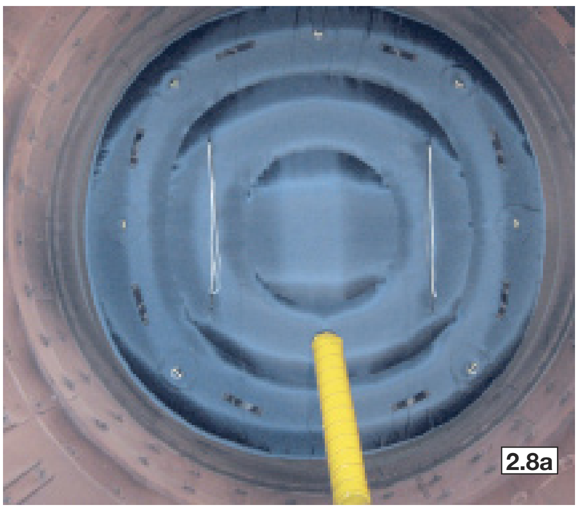
Key project participants:

Gene Jinkens, Assistant plant manager

Sam Moots, Production manager

Kyle Frick, Electrical maintenance manager

Jon Kaper, Material control administrator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2.8b

turbine disks, and either replace or requalify the disks. This option, however, was not feasible because of the length of the outage required, the availability of replacement turbine disks, and scheduling downtime with our energy customer. Another, more feasible, option was to install 450-kW heaters to bring the turbine disks to the proper temperature, but operating costs were prohibitive.

Plant management decided to purchase and install exhaust duct balloons (Fig 2.8a) in the turbine exhaust plenum to prevent cold ambient air from entering the turbine case through the exhaust stack (Fig 2.8b). The balloons were supplied by G R Werth & Associates Inc and manufactured by Scherba Industries Inc.

The duct balloons are installed by plant personnel after the required turbine cool-down period. This allows us to use the residual heat in the unit as well as the existing enclosure heating to keep the disk temperature above the minimum temperature listed in the TA.

Results. The balloons have proven to be a great success at a fraction of the cost to disassemble the units and requalify the disks, and approximately 20% less than installing 450-kW electric heaters (parts and installation only).

In addition to the capital savings, the electrical cost savings by not installing electric heaters is estimated at $30,000 per year, based on operating the heaters 33% of the time throughout the shoulder and winter months. We plan to continue using the duct balloons until the next scheduled major inspection where the turbine disks will be inspected and either requalified or replaced.

Operator adjustment of steam-seal pressure reduces turbine backpressure

Tenaska Central Alabama Generating Station

Tenaska Alabama II Partners LP

Challenge. During turbine operation, the plant engineer and LCRO noticed that small fluctuations in the steam-turbine steam-seal pressure also caused fluctuations in the condenser vacuum and increased turbine backpressure.

Solution. The default steam-turbine steam-seal pressure set by the turbine OEM is 3.5 psig. The operator slowly raised the steam seal pressure to 5.5 psig until the condenser vacuum was maximized. It was observed that setting the steam-seal pressure higher than 5.5 psig did not result in increased condenser vacuum.

The steam turbine startup procedure was changed to require the operator to change the steam seal pressure setpoint from 3.5 to 5.5 psig when the steam turbine starts rolling to full speed.

Results. The optimized steam-seal pressure and condenser vacuum has reduced the plant's overall heat rate by over 1%. We recommend that combined-cycle plant operators experiment with their steam-seal pressure setpoint to see if they can also improve the condenser vacuum and minimize backpressure on the steam turbine.

Tenaska Central Alabama Generating Station

885-MW, gas-fired, 3 × 1 combined cycle located in Billingsley, Ala
Plant manager: Robert Threlkeld
Key project participants:
Brian Pillittere, Plant engineer
Alan Foether, LCRO
Cecil Boatwright, Operations manager

Condition-based maintenance program critical to availability, reliability

Walter M Higgins Generating Station

NV Energy

Walter M Higgins Generating Station

530-MW, gas-fired, 2 × 1 combined cycle located in Primm, Nev
Plant regional director: Steve Page
Key project participants:
Felix Fuentes, Operations manager
The entire Higgins staff

Challenge. Across the country, plant staffs are facing challenges to their maintenance programs ranging from underfunding to understaffing to conflicting management priorities.

Over the past five years, our maintenance approach has been greatly enhanced because we have embraced our version of what works best at our plant. Our plant took a novel approach to launch a grassroots effort that fosters accountability and ownership.

Solution. The condition-based maintenance (CBM) program we have in place has been massaged and chiseled into what it is mainly because of the staffing changes and our evolving operational strategy.

The success and longevity of the program is attributed to the fact that it has been very helpful in keeping us regularly focused on the critical systems that do need periodic evaluations in order to maintain reliability and ensure that we are not over-maintaining equipment which can tend to take away from other critical needs.

The program's foundation lies in accurately identifying the equipment that falls into the "critical equipment" category using a line-by-line evaluation of the plant P&ID drawings with the appropriate experts in the room working through the assessment.

The entire list of critical equipment was then categorized and divided into 12 sections. Each section was entered into the work management system in a manner that assured we evaluate each section annually, revisiting and refocusing on the equipment with another year's worth of equipment history and predictive-maintenance findings.

After identifying the critical equipment, the next task was finding and researching all available technical manuals, performance data, and OEM-recommended maintenance procedures available to properly evaluate the equipment and ensure that the information was easily accessible to all O&M personnel.

Identifying all recommended critical spare parts, pricing, and availability was next. All manufacturer recommended preventive maintenance tasks were then researched and used to create PM tasks that would generate at the right frequencies in our work management system. Regular scrubbing of these PMs is and has been necessary over the years as part of the regular CBM assessment determinations.

Results. This ownership style has proven to be effective, as evidenced by our outstanding production record. It is undeniable that delegating and holding people accountable for systems increases the availability of the machinery.

Our plant staff is small but we have, through training and experience, established predictive maintenance "champions" in the areas of oil analysis, vibration monitoring, thermal imaging, passive acoustics, partial discharge monitoring, PI system, and SmartSignal.

These champions all contribute to the ongoing equipment evaluations that are brought to the table once a month. Occasionally, we don't have the time to bring data to the table, but we always bring the focus and discussion to the table at the monthly CBM meetings.

All action items captured at the monthly meetings are immediately entered into the work management system in the form of a work order, prioritized, planned, and scheduled. We have the right mix of skill and professionalism combined with a pretty laid-back approach which helps keep this program going strong.

Retraining and modified operating procedures greatly reduce tolling penalties

Effingham County Power

Owned by ArcLight Capital

Operated by Consolidated Asset Management Services

Challenge. Since entering into a new tolling agreement in 2005, the plant had been plagued by excessive monthly imbalance/variance charges associated with the generator-balancing service agreements for the plant. These charges were costing the plant tens of thousands of dollars per month with end-of-year charges reaching the hundreds of thousands of dollars.

The plant incurs charges based on variance or imbalance. A variance charge occurs when the plant net output differs from the transmission tag by greater than 1.5% of the tag value at any point during the hour, including during ramping periods. An imbalance charge occurs if the total integrated plant net output for the hour differs from the transmission tag for that hour by greater than 1.5% of the tag value.

Solution. At the end of 2007, plant

Effingham County Power

525-MW, gas-fired, 2 × 1 combined cycle located in Rincon, Ga

Plant manager: Eric Garrett

Key project participants:

James Goins, Production manager

Production team leaders: Nick Bohl, Don Johnson, and Robert Kulbacki

CT technicians: Don Fludd, Robert Scogins, Howard Beebe, Mark Gunter, Richard Blankenship, Byron Sewell, Bill Beahm, and Larry Shearouse

personnel were tasked with trying to find a way to reduce these imbalance/variance charges, while still complying with the requirements of the tolling agreement. The difficult part of the task was pinpointing exactly where to start.

Since the plant has consistently maintained a reliability factor of delivering greater than 99.5% of every scheduled MWhr, making the scheduled tag was not the problem. The operators found the true problem was in the method used to ramp the plant up and down during startups, shutdowns, and normal hourly tag changes.

Since all existing procedures within the plant were created a couple of years before the tolling agreement was in place, these procedures were designed to enable the operator to bring the plant to base load as quickly as possible while still complying with equipment manufacturers' guidelines. The same policy applied to load changes; get the plant to the scheduled tag as quickly as the equipment allows.

We determined that the plant was incurring most of its variance charges because of this operating mindset. The plant was unloading/loading faster than the actual schedule allowed, resulting in significant variance charges.

Plant operators began modifying existing procedures and startup/shutdown checklists. One of the first changes made was to delay the start time of the second GT by 10 minutes. Delaying the start of the second GT helped to keep down the hourly load. This not only reduced the variance charge, but also saved 10 minutes of fuel usage for every startup.

Operations also began to use a rate-limiting function which gave them precise control of how fast the plant will load during all load changes, startups, and shutdowns. Nothing was physically altered in the plant nor were any logic changes made to alter how the plant was operated. Only changes to existing procedures and operator mentality were made.

Results. The results of these changes were seen almost instantly beginning in 2008. While the plant operated in 2008 at a nearly identical capacity factor as in 2007, the annual imbalance/variance charges were reduced by over $340,000. The imbalance costs were reduced from $0.35/MWhr to approximately $0.06/MWhr. These results carried into 2009 and are still being seen today.

Numerous benefits from best-in-class diagnostic and analytic tools

Desert Basin Generating Station

Salt River Project

Challenge. This plant has the multi-faceted goal of continually improving performance by maximizing availability and startup reliability—along with reducing costs. With 250-300 starts per unit per year, personnel are increasingly challenged with making sure the plant is available when needed and when it can best capture opportunities to serve load and take advantage of wholesale power markets. Its biggest costs are fuel and maintenance. How does one both reduce these costs and optimize reliability and availability?

Solution. Plant personnel realized that, in order to address this goal, they needed to invest in software to help detect and diagnose emerging equipment and process problems early. This would reduce the high costs of derates and unplanned outages. In addition, if they could improve efficiency, they could attack their biggest cost: fuel.

The plant found that no one solution does it all and integrated into a powerful package several analytic

Desert Basin Generating Station

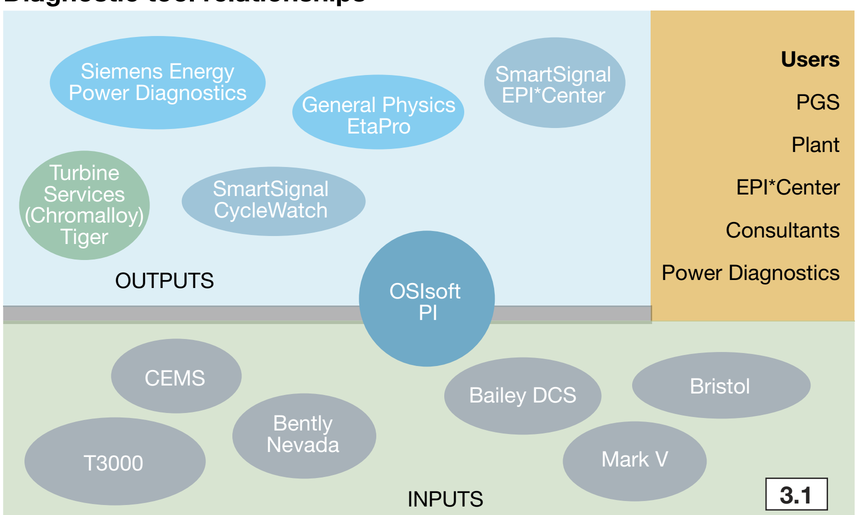
577-MW, gas-fired, 2 × 1 combined cycle located in Casa Grande, Ariz
Plant manager: Bill Alkema
Key project participants:
Jess Bills, O&M supervisor
Moh Saleh, O&M engineering manager

and diagnostic tools (Fig 3.1). The plant used a stepwise approach as opportunities arose and found that these systems, working together, provide strong value relative to their costs. Benefits include:

- Expanded troubleshooting capabilities. Both in-house and external experts can easily log on to monitoring systems.
- Optimized planning. The sooner they know that something is not normal, the sooner they can deal with it and, hopefully, do so before there is additional damage or a costly trip.
- Improved outage planning and reduced forced-outage rates. The benefits of this are huge, particularly in the summer season.
- Maximized resources. The software solutions make it easier for maintenance staff to maximize their efforts. Basically, the software points the staff in the right direction, so they readily determine what to fix and why. This allows them the luxury to decide when.

As the diagram shows, OSIsoft's PI system receives data from the turbine controls (T3000 and Mark V), the combustion dynamics monitoring systems (Alta Systems), CEMS, the vibration sensing systems (Bently Nevada), the DCS system (Bailey),

Diagnostic tool relationships



and the gas measurement systems (Bristol and ABB).

The data then are analyzed by a group of applications that reinforce each other as analytical tools. They are used as diagnostic tools and troubleshooting aids for quick evaluation of problems. With this package of tools, the plant has been able to decrease unplanned outages and reduce maintenance costs. The plant now is extending its success to include a solution that will help improve fuel efficiency.

Each tool has its function. They are presented here, in the order in which they were deployed at the facility:

1. PI (OSIsoft LLC): A data collection and historian system, PI is essentially the enabler of all the other systems below it in Fig 3.1. By installing PI early on in the life of the plant, the plant has archived an immense amount of data that can be trended and analyzed in many different ways. It also allows data to be easily sent off to other users of the information and outside consultants. PI also has very usable search and

trending abilities just on its own.

2. Tiger (Turbine Services Ltd): This program is a knowledge-based turbine condition monitoring system. Its strengths lie in having operator-type screens for the gas and steam turbines with learned parameters to highlight unusual points of operation of thousands of analog and digital signals from the turbine controls.

It also has synchronized playback capabilities that allow fast or slow motion playback of all parameters and thus the ability to view unusual events almost as in "real time." Multi time plots showing overlay of key parameters for the last five startups and shutdowns give a quick view of potential problems. Quick graphs of all analog points and performance reports also help identify issues.

3. Power Diagnostics (Siemens Energy): The gas turbine OEM monitors the GTs via a high-speed data connection and reviews the results daily at the Power Diagnostic Center (PDC). Using its fleet experience and unique expertise, the OEM is able to detect unusual issues early in the cycle. Siemens' engineers are available around the clock for emergency support and on-line diagnosis.

4. Alarm management system (Matrikon Inc). Alarms were initially printed on a line printer, boxed, and then found to be too daunting a task to search through. All major control system printers were replaced with an interface to the alarm management system. This allows synchronized review of all alarms and events from one interface that can be accessed locally or remotely. The database is archived so alarms and events can be electronically searched and filtered.

5. EPI*Center (SmartSignal Corp) is a predictive diagnostic tool that helps eliminate equipment failure and avoid surprises. It develops the unique operating profiles of all critical rotating and non-rotating equipment across all known loads, ambient conditions, and operating contexts. Every 10 minutes, it captures a snapshot of the plant assets. It compares actual to expected behavior and delivers exception-based intelligence of impending problems.

By looking for changes in learned behavior, EPI*Center is able to detect deviations that are well below control system alarm levels. The plant uses SmartSignal's Availability and Performance Center (APC) to deploy and maintain EPI*Center and monitor its assets. The SmartSignal engineers in the APC communicate with the plant via phone, email, and weekly calls, jointly reviewing immediate through less critical problems.

6. CycleWatch (SmartSignal Corp): The plant is one of the earliest adopters of this new technology. CycleWatch allows the plant to investigate deviations encountered during startups and thereby increase reliable starts in the GTs. CycleWatch can identify certain indicators that are starting to deviate from normal. It processes more data at a higher frequency than EPI*Center, allowing the plant to detect even the slightest deviations from a normal start.

7. EtaPRO (General Physics Corp) is a performance monitoring system with emphasis on heat rate. It looks for system losses and quantifies the impact of failures on capacity and heat rate. EtaPRO is in the process of being implemented at the plant. It will be visible to the operators and have models to optimize cooling tower, condenser, and individual assets. EtaPRO data will feed into SmartSignal, making its models even more robust.

Results. The plant believes that the biggest benefit of these tools is that they provide a strong level of control over the facility. Plant personnel are assured that they are receiving the earliest possible notifications of impending problems. The tools are always there—24/7—watching over the systems and equipment. If there is an impending problem, the plant knows. If it knows, it can fix it—thus meeting its reliability, availability, and cost goals.

The tools provide strong financial value. Personnel say they frequently identify issues, and that the cost of these tools has been saved many times over. Some examples:

- While operating normally, an elevated blade-path temperature was noticed on one of the GTs. The initial detection was made by the PDC. The plant engineers were able to quickly confirm the anomaly with Tiger.

  Even though it was the height of the summer and system conditions were such that units were on "critical" status, these two tools and the OEM's recommendation convinced management that the unit had to be taken offline. A transition piece was found to have a major crack and a certain catastrophic failure of the unit was averted. The plant had avoided a wreck that would have taken many more weeks to recover from, and it avoided major financial cost for repairs.
- A GT tripped at full load on high exhaust pressure in the middle of the night. By plotting exhaust pressure for a year period, a pattern of high pressure in winter time was observed. Higher humidity had also increased the exhaust pressure. Trends that night showed an extra cold and humid night with exhaust pressure just reaching trip level.

  This was the first time the plant had experienced these conditions, but it was seen how close a similar condition and subsequent trip had been many times in the past. With PDC and Tiger diagnostics, the decision was made to simply adjust the pressure switch and restart the unit, thus avoiding a three-day investigatory outage. All of this was done from an engineer's home.
- A boiler-feed pump failure was averted this past year when EPI*Center identified a rising bearing temperature long before it reached alarm levels. The ability to trend this bearing temperature historically confirmed that the mechanical seal at that end of the pump was starting to fail. The plant was able to strategically schedule a unit outage to replace the mechanical seal and avoid a complete unit outage.
- SmartSignal EPI*Center alerted the plant to a decrease in RO system reject flow. Investigation into this led to identifying a scaling issue of the membranes. The early detection resulted in the replacement of eight membranes versus 40 had the problem not been detected, resulting in considerable cost avoidance.
- Several days after startup from an HGP inspection, low-frequency dynamics were being observed in a few of the combustion baskets. While the plant was attempting to

diagnose the problem, EPI*Center observed other, almost imperceptible deviations in temperature in other baskets that seemed to be unaffected initially.

While observing closely, the operators noticed that the conditions were changing and that the symptoms were getting worse. Fuel piping was inspected. The mechanics found the flange gaskets were excessively tightened and that the spiral wound gaskets were migrating into the fuel gas flow stream. Again, a more serious outage was averted.

More generally, failed sensors and/or drifts in controls or chemistry are identified on a weekly basis. The weekly calls between plant operators and the SmartSignal APC and the frequent emails from the PDC help highlight these potential problems. These issues are resolved prior to them causing forced outages or equipment degradation. Every tool has its purpose.

Infrequent Operating Procedure dramatically increases steam supply reliability

Blackhawk Station

Owned by Borger Energy Associates LP

Operated by NAES Corp

Challenge. In January 2007, NAES Corp took over operations of Blackhawk Station, a gas-fired cogeneration reliability center, the effective forced-outage rate (EFOR) was very high and station reliability was approximately 92%. Consequently, the thermal host suffered from regular interruptions to the steam supply.

In March 2008, NAES assigned Ron Eldred, plant manager of another NAES-operated facility, to act as interim plant manager for Blackhawk Station and to address the reliability issue. The station, which achieved commercial operations in June 1999, has two W501D5A gas turbines and is intended for base-load operation.

Solution. Eldred instituted a program designed to reduce interruptions, thereby reducing the EFOR and improving station reliability.

Blackhawk Station

230-MW, gas-fired, 2 × 1 combined-cycle cogeneration facility located in Borger, Tex

Plant manager: Craig Courter

Key project participants:

Steve Nelson, Operations supervisor

Robert O'Bannion, Maintenance manager

The program consists of a single operating procedure, the Infrequent Operating Procedure (IOP), which requires senior-level approval prior to implementing any new work permit that "involves unusual or unfamiliar actions that could potentially affect personnel or plant safety, environmental protection, or power or steam generating capacity."

Anyone on the O&M staff can submit the IOP, which includes space for describing the following:

- Task or problem, including identifying all affected or potentially affected equipment.
- Purpose for conducting the work.
- Risk analysis and assessment.
- Required preparations.
- Plan details, including procedural steps and documents to be used, date of activity, contingency or recovery plans, and any special training that might be required.

Once the IOP has been filled out, it is reviewed by staff in successively higher levels of responsibility to ensure that the work order receives adequate attention and approvals. The IOP is routed through a series of signatures as follows:

- Supervisor other than that of the requestor.
- CRO.
- Plant manager, if the "reliability" box is checked on the IOP.
- NAES project manager or division director
- General manager
- Customer notified if general manager and plant manager decide it is necessary.

If the IOP is approved, and after the work is conducted, the IOP also includes space to describe the results of the project, including any issues, concerns, or recommendations. IOP data also are entered into a "lessons learned" database for future reference by the station and the NAES fleet of plants.

Results. During the first three months of the implementation of the IOP program, the EFOR dropped to zero incidents and the station reliability rate increased to nearly 100%. This is a direct result of work process management as well as improved maintenance management practice.

Results continue to be strong, as the reliability of the plant remains greater than 99%. The customer has been so happy with these results, that now they maintain an ongoing dialogue with plant staff to discuss potential outage events and work as a team to aid each other in future planning. Blackhawk recently celebrated a one-year anniversary since a trip from full steam load occurred. This is a great achievement for the site.

Plant personnel received the IOP program enthusiastically. The IOP program not only supports appropriate outage decision making, it enables the plant staff to be proactive regarding potential outage events. Plant personnel are now more likely to submit the IOP with the understanding that they will be supported in making observations regarding potential outage events.

Not only does the IOP program promote safe and efficient routine operations, it enables staff to respond more effectively during emergency or abnormal operations. It fosters a positive and cooperative work environment where everybody has the opportunity to discuss and determine potential outage events without affecting daily operations.

Preservation program for combined cycle minimizes degradation during layup

Araucaria Power Station

Owned by UEG Araucaria Ltda

Operated by Copel SA

Challenge. Located in Southern Brazil, near Curitiba, Araucaria Power Station was commissioned in September 2002. Because of commercial issues, the plant remained in layup until 2006. During these four years, the O&M team developed and implemented a comprehensive plant preservation program aiming to keep the equipment safe from degradation.

All OEM recommendations were strictly followed. Operations, tests and inspections were performed according to the Long-Term Standby Procedure. Preventive, predictive, and corrective maintenance were performed in conformity with the Plant Maintenance Manual. Such activities, always in compliance of the ES&H regulations, were controlled by means of a corporate computer-based O&M management system.

The wood cooling tower was maintained wet, the circulating water system was kept in operation, the demineralized water-treatment system was run monthly, and water

microbiology/chemistry control (including chemicals dosing and weekly water analysis schedule) was ongoing.

In a totally outdoor plant, corrosion prevention is fundamental. For this reason, a surface protection program was implemented. The Plant Valves Lubrication and Test Schedules provided guidelines for each manual and automatic valve serviced.

The two Aalborg HRSGs (including condensate and steam piping) were laid up dry, backfilled with nitrogen, and the nitrogen maintained at 7 psig (minimum). Dehumidifiers and heaters were installed on the gas side of each HRSG to maintain the environment between the gas-turbine (GT) air inlet and the HRSG stack at a relative humidity of less than 40%. A similar system was installed for the steam turbine (ST). Both systems were automatically controlled and supervised from the control room.

Araucaria Power Station

484-MW, gas-fired, 2 × 1 combined cycle located in Araucaria, Parana, Brazil

Plant manager: Amilton Bizi Jr

Key project participants:
Fernando Albuquerque, Operations manager
Marcos Freitas, Operations supervisor
Jean Ferreira, Operations shift leader
Pedro Vieira, Maintenance manager
Edson Goncalves, I&C engineer
Carlos Vieira, I&C technician
Cleber Dantas, Mechanical technician
Angelo Kanning, Electrical technician
Flavio Chiesa, Owner's technical director

Operations team:
Adalberto Hiareck, Adriano Carlos, Carlos Souza, Edson Zorzi, Emerson Silva, Eurides Barbosa, Gelson Rocha, Heverson Goncalves, Ivan Gaio, Joao Moraes, Josoe Lima, Luciane Faustino, Luiz Cortez, Luiz Padilha, Mauro Cavichioni, Milton Silva, Neuri Weber, Red Cachoba, Reginaldo Barreto, Sergio Santos

Maintenance team:
Ademir Leite, Auro Pedroso, Claudia Coelho, Dante Freitas, Gerson Waltrick, Joao Henrique, Joao Santos, Jorge Reinhardt, Ranier Moraes, Lauremir Dudek, Petter Gonzales, Rogerio Cantarelli, Ronaldo Lesky, Willen Silva

When the facility was recommissioned in mid 2006, that strict program proved its effectiveness once no major problems were found and the plant startup succeeded in a very short time. The plant has been commercially operated since June 2007 with an average availability in excess of 98%.

In our current operating profile, the plant typically remains shut down in the rainy season (September through March) and in some other shorter periods when not dispatched. In order to be applied to mid-term shutdown periods, the original preservation program had to be improved. With shorter installation/removal time, the present program provides as well higher performance preservation schemes.

For more detail on Araucaria's preservation program, please see the feature article on this facility elsewhere in the issue.

Solution. Based on the original preservation program, the current program key points can be summarized as follows:

1. After shutdown and if a restart is not planned for the next 30 days, each HRSG's water side (together with kettle boiler, boiler-feed pumps (BFPs), condensate system, and associated piping) is drained while still hot (after pressure decays to about 4 psig), filled with nitrogen, and maintained at 7 psig throughout the layup period.

2. In dry layup, boilers are drained of condensate every other day during the first week of the outage, then weekly for the next three weeks, and quarterly after that. Periodic checking for residual oxygen by bleeding off a sample of gas has proved unnecessary.

3. If the unit is scheduled for restart within 30 days, a nitrogen blanket is applied when boiler internal pressure is about 4 psig and maintained at 7 psig throughout the outage.

4. In case a short-term layup (30 days or less) is extended, the wet layup is maintained; boilers are not drained when cold.

5. After 30 days in wet or dry layup, the GT inlet is sealed off with a plastic curtain and a stack balloon is installed. The dehumidifier for the GT/HRSG circuit also is placed in operation to maintain the gas-side environment at less than 40% relative humidity—this to protect against corrosion. Temperature and relative-humidity probes (Fig 3.2) and corrosion test coupons also are put in place at this time.

5. Thirty days after shutdown, the condenser hot well is drained and another dehumidifier is placed in service to protect ST internals and the condenser.

6. BFP lube-oil systems are tested twice a month; BFPs and condensate pumps are disconnected from motors and manually rotated twice a month when in long-term layup (more than three months).

7. Generator air inlet filters are removed and replaced by plastic curtains in long-term layup; heating systems are always turned on.

8. Turbine/generators are placed on turning gear weekly for two hours.

9. The circulating-water system operates continuously at 50% nominal flow; water chemistry and microbiological control are maintained; corrosion test coupons are used to assess condenser tubing and tubesheet condition; cooling-tower fans run monthly for one hour.

10. Demineralized water is produced weekly for one hour; backwash, regeneration, and rinsing are run monthly.

11. Motor-operated and pneumatic valves are tested monthly; rotating equipment and electric motors are lubricated quarterly; manual valves are lubricated and tested twice a year; corrosion preventive compound applied on exposed surfaces of shafts and couplings; heating systems for all oil tanks and electric motors are kept on.

12. Systems in normal service: Plant instrument air and service air, closed-cooling water, circulating water, miscellaneous chemical feed system, potable water, raw water, wastewater, fire protection, DCS and unit control systems, electrical auxiliary system.

13. Preventive maintenance: rotating equipment vibration test, electric-motor ground-insulation test, lubricant and transformer oil analysis, instrumentation calibration, thermographic inspection of electric panel, turbine borescope inspection.

Results. Manpower requirements for the implementation of the preserva-

3.2

tion program are minimal. Specifically, it takes three people four hours to install the plastic curtain in each GT inlet, two people two hours to install a stack balloon, and two people four hours to line up the GT/HRSG dehumidifier. Curtain removal is done by three people in four hours, two people remove the stack balloon in two hours, and two people take two hours to secure the dehumidifier.

For the ST/condenser, it takes three people four hours to line up the dehumidifier and three people three hours to remove it from service. Inspections, tests, lubrication, etc, are routine and do not take any extra time to be performed.

The first opportunity we had to assess our preservation program was when the plant was recommissioned in 2006 after a four-year shutdown. Only minor problems were found and recommissioning was completed in seven weeks.

Since the plant has been in commercial operation, the average availability is in excess of 98% and no major problem so far that could be related to degradation. That accomplishment certainly can be credited to the preservation techniques applied.

Another positive signal is the short time necessary to produce steam in accordance with the Alstom specification for rolling the ST (degassed cationic conductivity less than 1 µS/cm and less than 50 ppb of iron). It normally takes four hours or less for cold starts, particularly because of the very low iron residual. Fundamental to reliable cold starts is frequent inspection and testing of the equipment to be sure it is in ready-to-start condition.

The most important result: For default purposes, a 3% average output degradation factor and a 1.5% heat-rate degradation factor normally is acceptable for a combined-cycle plant. We expect to achieve at least a one-third reduction in those numbers. That definitely would prove worthwhile the expenditure in dehumidifiers, stack balloons, stacks access doors, liquid nitrogen monthly cost, etc.

In the current dispatching scenario in Brazil, the plant can remain offline as long as five or six months. Preservation is as important as the operational procedures or the maintenance policy. The preservation techniques and procedures presently available make it easier for implementation, so that the program is applied to even shorter layup periods. We believe that the equipment would deteriorate quickly if a proper preservation program were not conducted.

Effective procedures for seasonal operating occurrences

Mustang Station

Owned by Denver City Associates LP, GS Electric Generating Cooperative Inc, and Yoakum Electric Generating Cooperative Inc

Operated by NAES Corp

Challenge. Many plant evolutions, such as steam power augmentation, occur only during a certain time of

Mustang Station

486-MW gas-fired, 2 × 1 combined cycle located in Denver City, Tex
Unit 4: 145-MW gas-fired, simple-cycle facility
Unit 5: 145-MW gas-fired, simple-cycle facility
Plant manager: Bob VanDenburgh
Key project participants:
Joe Broadwater, O&M manager
The entire Mustang Station staff

the year. Many months can pass between these seasonal evolutions. Additionally, some events are casualty type events and only occur during casualties.

O&M staff may be required to safely complete an evolution that they have not serviced in several months. Errors occur at greater frequency during unfamiliar operations. Unfortunately, these situations arise during a critical demand or casualty evolution when the risk is highest and the need greatest. Our goal was to implement a training program to minimize the potential occurrence of operations errors during both rare and unforeseen events.

Solution. O&M manager Joe Broadwater, recalling his experience in the US Navy, instituted a program designed to review operations procedures only seasonally utilized. In December 2008, the Shift Training Evolutions program was developed, implemented, and continues to be monitored by Earl Shoemaker, operations supervisor for Mustang's 2 × 1 F-class combined cycle and two F-class peakers.

The Shift Training Evolutions program consists of a set of monthly evolutions conducted by each operating shift. The shift lead operator is responsible for conducting the evolutions with his/her shift. In 2009, two evolutions per month were completed by each of the four operating shifts.

The lead operators provide a written critique to the operations supervisor to input results into a lessons-learned database that is shared among the shifts and used to make operating-procedure improvements. The Shift Training Evolutions schedule is written and maintained by the operations supervisor and is seasonally relevant.

For example, steam-power augmentation only occurs in the summer months. An evolution that highlights the risk of not accomplishing lean blowout on the gas turbine correctly is performed in the May-June timeframe. Each shift performs steam-power augmentation evolution walk-through training to ensure a high level of operational proficiency.

Results. Shift personnel received the Shift Training Evolutions program enthusiastically. Operators feel that the shift evolutions provided a relatively stress-free training evolution to refresh their operating skills on evolutions they may not have completed in several months. This allowed them to build confidence such that when the real evolution was needed, they could do the tasks safely and efficiently.

The program also provided the secondary benefit of professional leadership development for the lead operators. This has improved their ability to effectively provide leadership and oversight to their respective operating shifts.

Modifications allow for efficient fuel-oil operation

TermoEmcali

Owned by Empresas Municipales de Cali

Operated by NAES Corp

Challenge. The dual-fuel, combined-cycle peaking facility was required to achieve regulatory compliance for operating solely on its secondary fuel—fuel oil. The Colombian governmental mandate was ordered to maintain a stable power supply in the event of supply shortages of natural gas, which is the primary fuel.

Running the plant effectively on its secondary fuel is not only a regulatory requirement, it is necessary from an operations perspective. To achieve regulatory compliance and operations performance goals, plant staff recognized that several issues would need to be resolved in order to operate the plant on fuel oil.

The plant, which achieved COD on July 15, 1999, operates a W501FC high-efficiency combustion turbine (CT), one 85-MW Mitsubishi steam turbine, and one multi-pressure HRSG.

Solution. The O&M staff, led by O&M supervisor Adier Marin, aggressively met the challenge of operating solely on fuel oil. First, they began to identify issues throughout the system, starting with leaks within

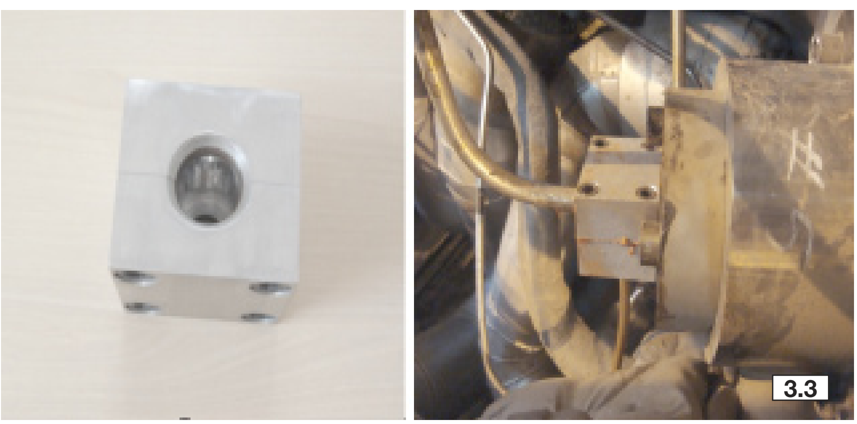
TermoEmcali

233-MW, dual fuel, combined-cycle peaking plant located in Cali, Valle, Colombia
Plant manager: Fabio Ruiz
Key project participants:
Adier Marin, O&M supervisor
The entire TermoEmcali staff

the CT and ending with the fuel-oil delivery trucks. This team identified several areas requiring improvement and then took innovative and proactive steps to alleviate all possible issues. The team methodically implemented their plans to resolve each issue as it was discovered:

- Innovative design prevents plant outages caused by fuel oil leaks. One of the biggest problems when operating with fuel oil is leaks inside the CT, a common and frequent occurrence. When a fuel oil leak is detected, the CT needs to be shut down immediately to repair the leak and to prevent a potential fire. Shutting down the CT effectively causes an outage, interrupting the power supply.

  To prevent such outages, plant staff designed a piece of equipment that can be used to repair leaks while the system is on-line. The on-line leak repair kit allows the maintenance team to address any fuel oil leak that is detected as soon as the machine is started. The kit is essentially a "tube inside of a tube" and can be installed within minutes, depending on the location of the leak (Fig 3.3). This way, plant personnel can respond to the leak without experiencing a shutdown.
- Starting valve locked in place to provide correct amount of fuel oil at each start. During plant starts, staff noticed that the starting valve on the CT needed to be in a certain position in order to provide sufficient fuel oil. They conducted several tests to determine the ideal position for the starting valve, including ensuring that the quality of the fuel oil delivered to the CT was not compromised, and then literally padlocked the starting valve in that position to prevent inadvertent changes to its position.
- Air valve DCS logic design enhances water injection. When operating a CT with fuel oil, it is desirable to inject water to reduce NO_x and provide cooling. Plant staff noticed a considerable performance variance when they injected water, and decided to disassemble the candlesticks on the fuel-oil nozzles to investigate. They discovered that the injection water circuit had fuel oil inside. On further investigation, they found that the air valve was not opening because of a problem with the DCS (Distributed Control System) logic. The DCS logic for the air valve had not been implemented, so the plant staff changed the DCS logic and alerted the OEM to the problem.
- Replaced igniters, shoes, and valve gaskets to improve performance. Plant staff proactively researched several issues that pertained to successfully operating the plant with fuel oil. First, they recognized that the CT igniters had to be in excellent condition before beginning a long running


3.3

operation based on fuel oil, so they replaced the igniters.

Second, when they were making an inline change, they noticed that the shoe assembly of the three-way valve in the suction portion of the main pump was damaged thus permitting fuel oil to pass through both filters. They discovered that the shoes were not made of fuel-oil resistant material, so they installed new fuel-oil resistant shoes.

Third, they discovered that a blade-path spread temperature problem was caused by an obstruction in the strainer funnels located after the flow divider. On further investigation, they learned that the valves in the balance of the plant also contained gaskets that were not fuel-oil resistant, so they replaced all the valve gaskets.

- New fuel-oil truck unloading station ensures smooth delivery. In order to operate the plant in base load mode on fuel oil, the facility needed to receive 27 fuel-oil truck loads per day. Because the plant had only one unloading station, this would require that the 27 truckloads arrive around the clock in 50 minute intervals to prevent delivery disruptions and to keep the trucks moving in and out of the facility in an orderly fashion. Plant staff recognized that this would be nearly impossible to orchestrate, so they built a second unloading station.
- Storage tank maintenance required upgrading. Fuel oil is fed from the storage tank to the CT via a floating suction system, so that fuel oil is removed from the top of the reservoir at all times. Plant staff recognized that having the storage tank full of fuel oil for long periods of time posed a problem with maintaining high quality fuel oil. They installed particle filters and coalescent filters, with suction provided at the bottom of the tank, so they could maintain the quality of the fuel oil in the tank without disrupting the floating suction at the top of the tank.

As if all these measures were not enough, plant personnel have also planned future actions to improve plant reliability while operating on fuel oil, including:

1. Install two forwarding pumps, two main fuel-oil pumps, and a backup flow divider.
2. Consider installing centrifugal pumps, and perhaps a second storage tank.
3. Re-evaluate the quality of parts to accommodate the use of fuel oil as the primary fuel.
4. Shorten the CT maintenance cycles, based on the OEM Service Bulletins.
5. Adjust outage planning, since the Single Point of Failure List has been amended.

Results. TermoEmcali was the first gas-turbine-based powerplant in Colombia to achieve regulatory compliance for operating solely on its secondary fuel—fuel oil. Not only has the plant achieved regulatory compliance, it has exceeded its performance goals while operating on fuel oil and has set the standard for other facilities within Colombia, as well as creating a model to be implemented by powerplants outside of the country.

Not only did plant staff identify and resolve every possible performance issue at their facility, they passed on their lessons learned to the CT manufacturer, creating an opportunity for plants with similar equipment to achieve outstanding performance results.

Plant personnel have been recognized for their outstanding efforts in meeting and exceeding performance goals and regulatory compliance in a timely and efficient manner. It was their dedication, persistence, and innovative solutions that brought the plant to such a high level of performance.

Tracking startup duration and costs for benchmarking purposes

Emery Generating Station

Interstate Power and Light Co, an Alliant Energy company

Challenge. Plant staff was uncertain if the dispatcher had accurate startup cost for its units. They sought a means to measure the cost for each startup by tracking a function of fuel-gas usage, electric generation, and duration.

Solution. An evaluation was conducted to determine a start time and end time for startup. It was determined that start time was when start was initiated on the Mark V, and an end time was when the unit was turned over for external load to the dispatcher.

A member of the operations staff selected points to be monitored on a spreadsheet that includes fuel-gas flow, a megawatt-hour meter, total megawatts generated, and fuel flow to the auxiliary boiler. The operator wrote a script in Microsoft Visual Basic to input the dates and times and capture the necessary data.

The operator used EtaPro and Excel to gather and format data to proper units. The startup date and time are input along with the end date and time. The operator is queried as whether the auxiliary boiler was used for the startup and its start and stop date.

Emery Generating Station

565-MW, gas-fired, 2 × 1 combined cycle located near Mason City, Iowa
Plant manager: John Boston
Key project participants:
Mike Ravera, Operations manager
Chris Labby, Maintenance manager
Dennis Follis, Boiler operator/maintenance technician II

The spreadsheet tracks the fuel flow in 1000 lb/hr and megawatts produced every minute. The spreadsheet converts the 1000 lb/hr to lb/

min and cumulative fuel flow. This total fuel-gas flow is added to the fuel gas used by the auxiliary boiler.

The spreadsheet takes a snapshot of megawatt-hours at start and at end and subtracts them to determine megawatt-hours generated. Then the total fuel-gas flow in pounds is multiplied by fuel-gas higher heating value in Btu/lb to get total heat input in Btus. This is converted into total heat input in million Btu.

The spreadsheet polls EtaPro for current natural gas price in dollars per million Btu. The total heat input is multiplied by current natural gas price to determine startup cost.

The following data are tracked: date and time of startup, duration of startup, total heat input, natural gas price, startup fuel cost, and whether or not the auxiliary boiler was used. Data also are tracked for hot, warm, and cold startups of the HRSGs. Manufacturer criteria for an HRSG startup are: (1) hot, more than 700 psig in HP drum, (2) warm, 460-700 psig in HP drum, and (3) cold, less than 460 psig in HP drum.

Results. The operators now have a better idea of how their startups compare to other operators. Benefits include increased operator awareness of the average, standard deviation, maximum and minimum duration, total heat input, cost of natural gas, and cost of startup.

Daily meetings keep staff abreast of emerging trends

Central de Ciclo Combinado Saltillo

Mitsui & Co Ltd and Tokyo Gas Co Ltd

Challenge. Unforced outages lead to lost revenue, plant unavailability, and reduced useful life of plant com-

CCC Saltillo

250-MW, gas-fired, 1 × 1 combined cycle located in Saltillo, Coahuila, México
Plant manager: René Villafuerte
Key project participants:
Juan Díaz, Operations manager
Roberto Hernández, Maintenance manager

ponents. The plant's vulnerability to unexpected failure became apparent when post-failure analysis showed some trending that could have forewarned personnel.

While it seemed everyone had an opinion about the "should haves, could haves," the fact remained that a system must be implemented to avoid similar events in the future. The plant is equipped with an online monitoring system, but it was clear that a more effective and proactive approach was needed.

Solution. A new approach at daily morning meetings includes a proactive measure to evaluate data from the online monitoring system. O&M staff reviews, evaluates, and discusses the daily trends since the last outage to help mitigate the risk of a failure.

Data include gas consumption and heat rate, compressor efficiency, exhaust temperature, flashback temperatures, blade path topology, spread, vibrations, bearing temperatures, inlet pressure, filter pressure drop, cycle water consumption and quality, CEMs, and AQMSs.

Results. Reviewing the parameters and conducting an operational overview of the last 24 hours, and evaluating pending work orders, in the morning meeting takes no longer than 30 minutes. The daily review has become the focal point for everyone to be constructively involved and aware of emerging trends, with the added benefit that incipient failures can be consulted with the OEM Monitoring Service before they become a revenue loss issue.

Plant availability has benefited from the new approach to the morning meeting but safeguarding the turbines is its most important result. As an added benefit, the daily review of these trends has been shown to be quite helpful in finding optimal operational parameters for the plant to increase revenue

Increased productivity from formal operator qualification program

Walter M Higgins Generating Station

NV Energy

Challenge. Plants are always struggling with maintaining optimum training for their operators. Tighter budgets and thinner staffs make it difficult to justify offsite training courses. The need for an effective, onsite operator training and qualification program was necessary to increase productivity.

Solution. The solution was derived during construction by assigning everyone in O&M with a system. Over 50 plant systems were identified, and O&M personnel were asked to report out every week on their progress and become system experts.

As the construction closed and the startup commissioning began, all personnel were asked to start filling out a standard template for all the systems, creating the standard operating procedures (SOPs) for the facility. Although the plant staff are not technical writers, all of the SOPs are uniform and all-inclusive. At the end of the startup, all system experts were officially qualified on their respective systems and are now able to sign off others who demonstrate comparable proficiency.

The operator qualification program takes all of the information that has been acquired and it has been divided into 52 modules: 40 comprehensive modules for outside systems and 11 for CRO duties. All are working functions that must be demonstrated on each system task. Module 52 consists of a comprehensive 144 question exam of all 51 plant systems. O&M personnel who pass are officially signed off by the operations manager.

Results. The flexibility the plant has achieved with the formal operator qualification program is noteworthy. Maintenance personnel who complete the training program qualify as outside operators, familiar with all 40 outside systems. All of our plant operators are qualified for the control room which allows operators to rotate in and out of the control room daily.

Walter M Higgins Generating Station

530-MW, gas-fired, 2 × 1 combined cycle located in Primm, Nev
Plant regional director: Steve Page
Key project participants:
Felix Fuentes, Operations manager
The entire Higgins staff

4. Design

Valve replacement project improves availability, reliability

Covert Generating Facility

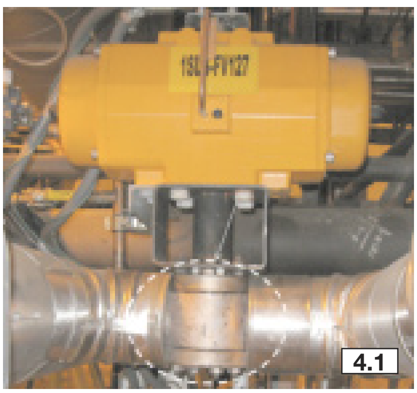
Owned by Tenaska Inc
Operated by NAES Corp

Challenge. Motor-operated valve (MOV) failures in critical system positions prompted plant personnel to take a new look at valve design. The original MOVs were screwed bonnet with a canopy weld and socket-welded ends. The original design also had an extremely high failure rate and was unreliable. Replacement cost with respect to downtime and specialized workforce mobilization was significant.

Replacement required cutting out the old valve and then welding its replacement back in-line, a very expensive process in P91 chrome piping requiring pre- and post-weld heat treating. In addition, the original design provided no options for repairing the valve in place.

It is estimated that a single average failure cost an estimated $50,000. The estimated cost does not include lost generation revenue or the added impact on the equivalent operating factor calculation.

Solution. Plant personnel researched options for a suitable replacement to meet or exceed original design specifications. A new MOV design was identified that met all specifications and has proven to be more reliable and maintenance friendly.



4.1

4.2

Covert Generating Facility

1100-MW, gas-fired, three-unit, 1 × 1 combined cycle located in Covert, Mich
Plant manager: Richard Evans
Key project participants: The entire Covert team

The new design provides access to the valve internals without the need to remove the valve body from the piping. For steam drains, the new MOVs have a horizontal flange that allows for easy disassembly and repairs (Fig 4.1). For HP drains, LP steam lines, and feedwater lines, the new MOV design allows the entire valve to be disassembled down to the valve seat in place, which can be resurfaced in place with special tooling (Fig 4.2).

Results. Approximately 45 new motor-operated valves were replaced in our three units altogether. The valves have been in operation five years with zero failures to date.

A bent stem or seat leakage can now be repaired by removing the motor actuator, packing, and stem/disc assembly. Special tools allow inline seat repairs and the valve can be reassembled using new trim and packing. Repairs can be made by in-house technicians in a matter of a couple of hours versus the several shifts, qualified welders, special heat treating equipment, and boiler repair permits that were required with the old valve designs.

The design change worked so well it use was extended to a replacement program for thirty three (11 per unit) air-operated ball valves in severe service on the HRSG using the same methodology with the same excellent results.

Incorporating lessons learned, document system increases efficiency for new construction

Harry Allen Generating Station

NV Energy

Challenge. When developing a new powerplant there are numerous benefits to be gained by effectively incorporating "lessons learned" from similar past projects.

Every stage of a project presents opportunities to improve the processes and practices followed during project execution—beginning with project development and including:

- Budget/estimating specification and contract writing;
- Major equipment specification and procurement;
- EPC contract development, proposal, bid evaluation, and final contractor selection;
- Oversight of contractor, engineering, procurement, and construction activities;
- Plant commissioning and testing;
- and project completion, plant turnover, documentation, and warranty administration.

Harry Allen Generating Station

484-MW, gas-fired, 2 × 1 combined-cycle addition located near Las Vegas, Nev

Plant regional director: Tom Price

Key project participants:

Andy McNeil, Executive, New Generation

Nitin Luhar, Manager, Project New Generation

J B McKinney, Site manager, Project New Generation

Michael Ferguson, Project manager, Project New Generation

Jack Wickersham, Project controls, Project New Generation

Duane Bledsoe, Manager, Generation

Doug Daniel, Project manager, Zachry Engineering Corp

Jim Fischer, Engineering manager, Zachry Engineering Corp

Michael Dailey, Counsel, Skadden, Arps, Slate, Meagher & Flom

The new power project often includes team members who may be unfamiliar with these past projects and who cannot draw from specific experiences with the execution of similar projects.

The challenge for project management is to develop and maintain an efficient and effective method to identify and categorize the learned lessons and then to communicate them to the new project team members in such a way that they are considered and, when appropriate, incorporated into the design and execution of the new project. Unfortunately, the project "wheel" is then invented, re-invented, tweaked, and/or discarded time and time again.

Solution. A process was put into place to identify and categorize lessons learned from past projects and then to communicate them to the team members of future projects. Unless measurable steps and related accountability is addressed, this common-sense step too often falls by the wayside. During the course of executing past projects, a "Lessons-Learned Process" has been developed and refined into as series of steps:

1. Develop record of project notes. Each team member is encouraged to take notes over the course of the project and to keep a separate notebook to capture and document his or her ideas for areas of improvement.

Later, when these ideas are discussed with other team members, these written records will facilitate effective discussions aimed at developing best practices to be passed along and incorporated into future, similar projects. At this stage of "note taking," team members are encouraged to record any and all ideas that might be expanded into useful lessons learned.

2. Assign one person to gather ideas from team members. A "Lessons-Learned Champion" is designated and assigned to follow through with gathering and recording lessons learned throughout the course of the project. The champion develops and maintains the overall record of lessons learned in addition to offering ideas of his or her own. He or she also regularly interviews team members, operations personnel, project management team and construction team members, and others who have knowledge of the project and who can offer ideas for improvement of the project and future projects.

Ideas should include any and all areas that can be improved—including major equipment specification and procurement, vendor interface, EPC contract development, project organization and procedures, design improvement, materials specification, operations processes and limitations, etc.

3. Incorporate into request for proposals (RFP) and contract. The champion develops and maintains a lessons-learned record throughout the project and ensures that the recordings become a part of the new project beginning with specifications, RFPs, and contracts.

This champion identifies and communicates ideas as the project progresses; brings them up during meetings and pertinent communication; reviews project documents to ensure they incorporate lessons learned; continually updates, adds to, and improves the lessons learned database.

4. Develop lessons learned record. The champion develops a record of lessons learned to categorize each and identify where it can be most effectively incorporated into project documentation. This record also serves as an "action item list" for assignments to project team members. The champion continues to develop, revise, and distribute the lessons learned record throughout the course of the project.

5. Organize lessons learned review meetings. The champion commu-

nicates the latest lessons learned to project team members and organizes and leads review meetings to discuss ideas for implementing lessons learned on the current project. Assignments to team members regarding incorporating and improving lessons learned are made during meetings, as the record grows and improves.

6. Evolution and improvement of lessons-learned record. The champion adds to and revises the lessons-learned database following each meeting and distributes it to team members and project management. The database is updated with results following completion of the project and becomes a permanent project record to be used for reference for future projects.

Results. There is no question that the lessons-learned documentation from the most recent major construction project is having a significant positive impact on our current major construction project. However, no spreadsheet has been developed to track time saved NOT having to reinvent the wheel . . . time and time again. That said, the past lessons-learned information was used in the planning stage, and is continually used in the current project management team efforts. And, once again a new lessons-learned database is taking shape during the current project.

This best practice also enhances a project environment where each project team member takes greater pride and ownership in doing things right the first time and checking to make sure some new challenge has not already been tackled.

Managing interdepartmental responsibilities during new construction

Harry Allen Generating Station

NV Energy

Challenge. When developing a new powerplant, the project team is always faced with challenges related to calculating and maintaining the project's scope, schedule, and cost.

These challenges are typically compounded by internal and external commitments, as well as the need to forecast various costs and schedules that can be 18 to 24 months in advance of the actual start of construction. Additional compounding factors occur when numerous internal departments and stakeholders are involved in the project, as well as when there are external costs associated with owner-furnished equipment procurement that must be aligned with the Engineering/Procurement/Construction contracts.

Work handled by other inter-company departments (permitting, managing sales taxes, legal counsel, communications infrastructure, builder's risk insurance, operations support, sale of power, procurement of fuel, etc) can equate to 20-25% of the project cost and scope.

Regardless of the good intentions of each department and the owner's engineer, the scope, cost, and schedule often are disjointed and can be extremely challenging for the group that is responsible for project management for designing, building, and commissioning the new plant.

Solution. Some of the best solutions are often simple in concept, but unfortunately rarely used. A process was put into place to have each department accurately depict its project scope needs, and then hold these separate departments accountable. During the course of executing

Harry Allen Generating Station

484-MW, gas-fired, 2 × 1 combined cycle addition located near Las Vegas, Nev

Plant regional director: Tom Price

Key project participants:

Andy McNeil, Executive, New Generation
Nitin Luhar, Manager, Project New Generation
Jack Wickersham, Project controls, Project New Generation
Duane Bledsoe, Manager, Generation
Doug Daniel, Project manager, Zachry Engineering Corp
Jim Fischer, Engineering manager, Zachry Engineering Corp
Bill Esposito, Manager, Power Systems Engineering
Kim Williams, Manager, Environmental Services

two previous major construction projects, this process was refined into a series of steps:

1. Initiate preliminary project cost, schedule, and work scope. This first round starts by forming the work scope and holding a series of reviews with individual departments or areas of responsibility. In each case, lessons learned from previous projects were surfaced and discussed in this initial round.

2. Generate a project initiation form (PIF). Each department is then required to generate a Project Initiation Form for its assumed and anticipated scope of work. This document contains information on: the work scope to be conducted; work breakdown structure (WBS) subcategories to be used; key deliverables to the project, including milestone dates; what is not included in the work scope, but related; anticipated interfaces with other departments; and that department's assessment of project risks. A detailed work schedule and cost estimate (without contingency) is included.

3. Hold a "Red Team Review" once the PIFs are completed and reviewed by the project management team. As this name connotes, this meeting is a high-attention, high-importance gathering. Each department presents its PIFs for review and discussion in the meeting. Those in attendance include the project management team, the safety department, the project owner's engineering manager, and each departmental head.

Company senior executives also are invited, which is important for project parameter understandings, continuing buy-in, and expectations management. During the review, information is respectfully challenged, questions are answered, related recommendations are made, and changes incorporated.

4. Revise and document PIFs after the Red Team Review. The PIFs are revised according to the results of the meeting. These revised PIFs then are subjected to a final revision and reviewed with each department individually. As a final verification and alignment step, each department head, the overall project manager, and the senior company executive over that particular department will sign the PIF. The PIF document will be used as the basis for the overall project information, and it serves as an extremely useful tool for the regulatory filing.

5. Resign and redistribute changes to PIFs. With the commitments made with the PIF, each department is expected to execute its part of the project as indicated on the PIF. However, if there are unforeseen changes in the cost, schedule, and work scope, an internal change order request is required. This revised PIF then requires the approval of the overall project manager and related senior executive.

Results. Although no spreadsheet is available to track project differences, the impact of this best practice was dramatic. With the Red Team Review and signed PIFs, it was nearly impossible for individual departments to casually prepare their work scope and related costs. During the most recent project that used this process from beginning to end, there were no significant project scope or cost surprises, and no significant duplications.

The initial review process identified numerous scope overlaps and "holes" between departments. These issues were resolved during this best practice, instead of later after equipment was double-ordered or certain works was not done because of inevitable assumptions. Each department took serious consideration of their work planning process, and each department's executive signed-off on the work scope and costs. Better and more accurate information was incorporated into regulatory filings that avoided amended filings.

Klamath Cogeneration

500-MW, gas-fired, 2 × 1 combined-cycle cogeneration facility located in Klamath Falls, Ore
Plant manager: Ray Martens
Key project participants:
Greg Dolezal, Maintenance manager
Bruce Willard, Operations and engineering manager

GT drain modification eliminates inlet suction during offline water washes

Klamath Cogeneration Plant
Iberdrola Renewable Energies

Challenge. The plant is configured with two Siemens 501F units. The packages were delivered and installed with a single drain line that combined the inlet scroll drain and the combustor case drain. During an offline water wash, the valves are opened, tying the two drains together.

With the inlet running at a low pressure and the combustor high, water and debris would drain from the combustor and get sucked back into the inlet. Furthermore, there was no mechanical or visual means to determine if the drains were actually flowing water. If the drains were plugged with debris or corrosion, there was no mechanism to clear the drain or verify it was functioning properly.

Solution. The solution was as simple as splitting the two drain lines and running them separately to the CT drain tank. Now it's impossible to pull dirty drain water from the combustor back to the inlet. Also, we installed an air gap from the case/scroll and a scupper to collect the


4.3

water (Fig 4.3). This allows the operator to visually determine if the drain is operating correctly. It also allows for the removal of debris or corrosion in the event the drain line becomes plugged.

Results. During periods of offline water washes, the drains can be monitored for proper operations. In addition, water draining from the combustor case is not drawn back into the inlet. The operators now have the ability to clean out the drains if they become plugged for any reason.

Modifying existing CEMS allows greater GT tuning flexibility

Jasper Generating Station

South Carolina Electric and Gas Co

Challenge. GE Contractual Services performed annual, remote combustion tuning for the three 7FA units at our plant. Tuning services requires that third-party workers be present onsite for the connection of temporary sample lines and to interpret data from rental analyzers (emissions trailer). This process became increasingly cost-prohibitive.

The original CEMS analyzers were not connected upstream of the SCR. For tuning, emissions readings must be taken upstream of the SCR or with the SCR out of service. Our regulatory agency prohibited the SCR from being taken out of service during tuning.

Solution. Sample lines (½ in. Tracepak in cable tray) were permanently installed from the SCR inlet to the CEMS redundant analyzers. This allows tuning to be conducted without incurring downtime on the primary CEMS analyzers or removing the SCR from service. The design/fabrication/install was completed entirely by our own personnel.

Results. Emissions can now be monitored by plant personnel and CEMS tuning can be conducted remotely, eliminating the need for onsite contractors and renting of an emissions trailer. Annual cost savings are $40,000 in avoided trailer rental charges alone. Labor cost to conduct temporary hookups is also eliminated. Now, remote or local tuning of GTs is easily conducted whenever required.

Jasper Generating Station

910-MW, gas-fired, 3 × 1 combined cycle located in Hardeeville, SC
Plant manager: Steve Palmer
Key project participants:
Rusty Mezel, Maintenance superintendent
Noah Littleton, Operations engineer
Don Belle, Maintenance engineer
Kevin Croft, E&I supervisor
James Cowart, Mechanical supervisor

5. Environmental Stewardship

New operating procedures reduce NO_x emissions on startup

Hopewell Cogeneration Facility

GDF Suez Energy North America

Challenge. The three Alstom GT11NM gas turbines at this combined-cycle facility require steam injection for NO_x control, which normally is supplied from an extraction point on the steam turbine. However, during startup, it is taken from the heat-recovery steam generator.

When following the OEM's startup procedure, a large amount of NO_x was produced by the first GT because no steam was available at the temperature and pressure the manufacturer specified for warm-up of its steam injection system. While steam pressure was building, the GT was being ramped up to its rated output, all the while producing a significant amount of NO_x that was offset by purchasing NO_x credits.

The bottom line: The first GT to start ran for about an hour with no emissions control, allowing the release of about 600 lb of NO_x. There had to be a better way.

Solution. Reviewing historical NO_x emissions data for the plant, personnel identified that one shift team's average emissions were consistently lower than those for all of the other teams. This team manually warmed the GT steam injection systems prior to automatic system operation, thereby reducing the time the turbines operated without emissions control.

Working from the operating blueprint of the resourceful shift team, plant personnel created a new startup procedure. The first step is to manually route steam bypassing the steam turbine during unit startup to the GT NO_x skids rather than to the condenser. The second step is to hold the GTs at low load (nominally 12% to 20% of rated output) while the NO_x skids are warming up and continue ramp-up only after automatic steam injection is initiated.

Next step is to optimize the steam injection skids for faster starts.

Results. Based on 2008-2009 data, the plant reduced its NO_x emissions by more than 40 tons during the ozone season. That translates to an annual saving of nearly $40,000 with NO_x credits trading at approximately $1000/ton.

The plant has received recognition for its leadership and innovation in pollution prevention in the form of the 2008 Virginia Governor's Environmental Excellence Award. Next target: The EPA Region 3 Environmental Excellence Award.

Hopewell Cogen

365-MW, gas-fired, 3 × 1 combined-cycle cogeneration facility located in Hopewell, Va
Plant manager: Robert L Greene
Key project participants:
Chuck Barnes, Plant engineer
Mike Wargo, I&C specialist
Christ Fegley, Operations technician
Enrique Toro, Operations technician
Ken Blalock, Operations technician
Jeff Vilines, Operations technician

Plant, local regulatory agency partner to reduce NO_x, NH_3 emissions

Mint Farm Generating Station

Puget Sound Energy

Challenge. Our combined cycle normally uses ammonia to control NO_x emissions. There can be excess ammonia emitted during the process, known as "slip." Ammonia is not considered a priority pollutant and is given less importance as compared to controlling NO_x.

The focus, however, is changing in the environmental community, and there are increasing concerns about other pollutants, including ammonia from powerplants. Most of the operating permits issued are focused on

NO_x and SO_x limits and have substantial amount of margin in ammonia-slip limits. This tends to encourage plants to control their NO_x while increasing ammonia emissions.

Solution. This potentially harmful side-effect of pollution control was identified by the local regulatory agency and the plant. The regulatory agency proposed amending an appendix in the operating permit to work toward minimizing overall plant emissions.

The plant performed various tests using its newly installed CEMS system. Tests were performed to minimize NO_x by increasing the ammonia flow up to the point where slip started to increase. Tests were conducted in various operating conditions.

Based on the test results, the plant calculated an optimum cumulative emission (OCE) for NO_x and ammonia slip. This optimum point would reduce NO_x below permit limits and also limit slip. The OCE point was proposed to the regulatory agency as an intended operating limit (IOL) for the plant during normal operations.

In partnership with the regulatory agency, an optimum emission point was decided as the IOL for the plant. The plant continues to operate at that IOL and will monitor the CEMs for changes in the emissions profile. If an erratic condition is observed by the plant, then discussions with the regulatory agency will be conducted to perform additional testing to recalculate the optimum emission point, and the IOL will be amended as needed.

Results. Based on the agreed IOL between regulatory agency and plant, the total reduction in the combined emissions are 3.5 ppmvd or 47%. This is considerably below the Best Available Control Technology level designated by the agency for the plant.

Mint Farm Generating Station

311-MW, gas-fired, 1 × 1 combined cycle located in Longview, Wash
Plant manager: Chetan Chauhan
Key project participants:
Dave Hooper, Environmental scientist
Joey Henderson, Compliance program manager
Robert Liner, Plant engineer, GE Energy
Wess Safford, Air quality engineer, South West Clean Air Agency
William Steiner, Consultant, URS

Bromine use for water treatment drastically reduces chlorine consumption

Granite Ridge Energy

Owned by Granite Ridge Energy LLC

Operated by NAES Corp

Challenge. The source of plant cooling water, local municipal wastewater effluent, contains high levels of ammonia that require large volumes of chlorine for proper treatment. The plant was using up to 5000 gal/day of chlorine to remain above its minimum permit limit.

Process conditions dictate that chlorine levels be constantly monitored and manually adjusted in order to maintain appropriate concentrations. In addition, high free-chlorine residuals contribute to cooling-tower degradation.

Solution. Working with our chemical supplier, plant personnel were able to identify an alternative chemical that would reduce the use of chlorine while still maintaining permit and process parameters. With the introduction of approximately 50 gal/day of bromine to the water treatment chemical profile, chlorine input was reduced to around 1000 gal/day. The lower levels of chlorine reduced cooling-tower degradation and subsequently reduced maintenance costs.

Results. The addition of bromine to the circulating water reduced chlorine use by approximately 80%. With the stabilized circulating-water chemistry in the system, automatic control of the disinfectant was achieved. The introduction of bromine, a

Granite Ridge Energy

730-MW, gas-fired, two-unit, 1 × 1 combined cycle located in Londonderry, NH
Plant manager: Ralph Leidy
Key project participants:
Jim Carlton, President
Jim Barrett, Operations manager
Larry Hawk, Plant engineer

natural freshwater biocide, allowed the plant to lower the permit level by approximately 60%.


5.1


5.2

System for high-pressure water injection into fuel oil cuts NO_x in half

Holtsville CT Power Station

National Grid

Challenge. Our peaking facility operates 10 P&W FT4-C1 or C1D twin-pack aircraft engine/generators with a nominal total output of 550 MW. The owner complies with Reasonably Available Control Technology (RACT) requirements for NO_x through a system-wide average from both its base-load steam units and peaking combustion turbines.

The steam units produce NO_x credits while the combustion turbines use these credits to operate within compliance of the NO_x RACT average. In recent years, more power is being imported into the area and the steam units are operating less, generating fewer credits. In addition, the NO_x regulations are expected to require lower emissions from the steam plant and possibly the combustion turbines in the near future.

During our ozone season, May 1 to September 30, compliance must be demonstrated on a 24-hr basis. The company needed to be prepared to provide peak power throughout the ozone season despite the lower output and fewer NO_x credits produced by the steam units.

Solution. Various NO_x reduction technologies were evaluated, and it was determined that high-pressure (HP) water injection and mixing with the fuel oil prior to combustion was the most cost-effective and proven technology that could be employed at this facility.


5.3

The project consisted of the design and installation of filters, HP positive-displacement pumps, strainers, fuel/water mixers, piping, valves, variable-speed drives, instrumentation, and controls to provide a complete system which would operate automatically when the combustion turbines were remotely started.

The major equipment and controls were provided by Seaworthy Systems Inc. The equipment installation required the construction of a new building with foundation and new electric power supply (Fig 5.1). The building was to be protected from freezing in winter and from overheating in summer.

Auxiliary systems installed along with the HP water injection system included a new compressed air system (Fig 5.2), building ventilation fans with automatic controls, and a silica analyzer to monitor the quality of the water being injected into the combustion turbines (Fig 5.3).

Information on the water-injection system operation is monitored and automatically sent back to our environmental engineering department to allow appropriate reports to be completed and submitted for compliance reporting. Electrical and civil work was provided by subcontractors and the mechanical work was completed by in-house forces.

Results. Environmental testing was carried out at the completion of the project by a third-party testing company, and the NO_x emissions were found to be reduced by 50-60%. These units can now operate in compliance with NO_x RACT without the need for credits. The HP water injection system proved its reliability and availability during the 2009 ozone season.

Holtsville CT Power Station

550-MW, dual-fuel, peaking facility located in Holtsville, NY

Key project participants:

Matthew Gaskin, Project engineer
Frank DeRiso, Site supervisor, East End
Peter Grzybowski, CT manager
Ronald Brodman, Senior foreman
Edward Hendrickson, Senior foreman
John Barnes, Senior electrical engineer
Richard Paccione, Engineering manager
Steven Mathieson, Design engineering manager
James C Clark, Controls engineer
Cathy Waxman, Environmental manager
George Martin, Environmental engineer
Paul Lynch, Environmental engineer
Edward Meier, Shop supervisor, MSD
Robert Guteres, A1 welder, MSD
Mario Martinez, B mechanic, MSD
John Mahlstadt, Purchasing agent

Chemical-tank alarm system reduces time for accident response, cleanup

Osprey Energy Center and Columbia Energy Center

Calpine Corp

Challenge. Reduced staff levels combined with reduced budgets left the plants vulnerable for properly monitoring chemical-tank levels and quickly reacting to leaks. Tank levels are routinely checked by outside operators, typically performed only twice per shift.

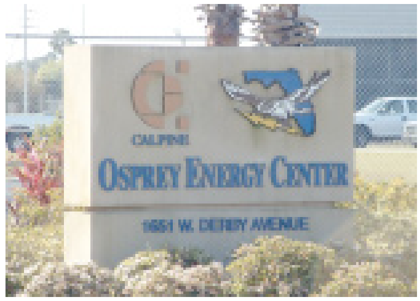
This potentially leaves from four to six hours where chemical tanks are unseen. A routine screen check of the tank levels is effective, but they can still remain unchecked for hours. It was our goal to find an efficient, cost-effective resolution to avoid a harmful and costly chemical excursion.

Solution. Plant personnel utilized the DCS's ability to continuously track and compare tank levels to design an alarm based on tank-level rate-of-change. Alarms would signal when chemical consumption is three times the normal rate for three minutes.

This significantly decreases the amount of time a suspect leak can exist and brings proper attention to a situation that requires immediate action well before operator rounds would have recognized it. The three-minute time requirement removes system instability and nuisance alarms from occurring and helps to ensure proper attention is paid to the alarm.

Results. Bleach and ammonia tanks with a normal system usage of 0.03 in./min results in a rate-of-change alarm threshold at 0.09 in./min for a sustained three-minute period. The alarm system effectively reduces response time to tank or system leakage, chemical costs, and clean-up activities and costs.

The alarm system was successfully implemented at Columbia Energy Center in early 2009 under plant manager Gil Kaelin. The procedure was replicated at Osprey Energy Center after Kaelin switched plants in late 2009.



Osprey Energy Center

600-MW, gas-fired, 2 × 1 combined cycle located in Auburndale, Fla
Plant manager: Steven Smith
Key project participants:
Gil Kaelin, Maintenance manager
Roy Price, Lead IC&E technician

Columbia Energy Center

600-MW, gas-fired, 2 × 1 combined-cycle cogeneration facility located in Gaston, SC
Key project participants:
Kevin Bolton, Lead IC&E technician

6. Management

Mobile technical training facilities increase scheduling flexibility, employee participation

Bethlehem Energy Center and Linden, Bergen, Guadalupe, and Odessa Generating Stations

PSEG Fossil LLC

Challenge. The company was implementing an aggressive program to improve operational performance across the fleet. Throughout the organization there was agreement that plant personnel needed better technical training if their level of performance was to improve significantly. Cost and logistics posed considerable challenges.

The fleet has plants in four states, three in the Northeast and one in Texas, which use a variety of technologies. Each station has unique training needs. The plants lacked the space necessary to provide classroom and practical training using the appropriate equipment. The need to keep the plants operating and travel costs involved made it impractical to have workers come to a single location for continuing training.

Solution. Deploying mobile training facilities to provide on-site welding and customized technical train-

6.1


6.2

ing. Working with Mobile Resource Associates Inc, a mobile trade show/training trailer manufacturer, we designed and developed two training trailers.

The mobile training units are 53-foot long, climate controlled, expandable trailers (Fig 6.1). Each contains classroom (Fig 6.2) and workshop/welding facilities (Fig 6.3) for six students with the air and power needed for various applications.

PSEG Fossil LLC

Key project participants:
Richard Lopriore, President
Mike Dammann, Technical training manager
Herman Joe Mosteller, Technical training instructor—controls
Ken Stockton, Technical training instructor—mechanical/welding

Bethlehem Energy Center

747-MW, gas-fired, 3 × 1 combined cycle located in Bethlehem, NY
Plant manager: Will Tingleff

Linden Generating Station

1566-MW, gas-fired, combined cycle and peaking facility
Plant manager: Phyllis Liu-Rauffer

Bergen Generating Station

1246-MW, gas-fired, combined cycle and peaking facility located in Ridgefield, NJ
Plant manager: Michael Brown

Guadalupe Generating Station

1000-MW, gas-fired, two power-block 2 × 1 combined cycle located in Marion, Tex
Plant manager: Peter Geissler

Odessa Generating Station

1000-MW, gas-fired, two power-block 2 × 1 combined cycle located in Ector County, Tex
Plant manager: Roy Sanchez

6.3

Among the trailers' features to ensure quality training are classroom space, work benches, air conditioning and heating, instructor station with multimedia equipment, and a lift gate. Recent training sessions have included air-operated valve calibrations, valve-packing, and laser alignment using our portable training mockups.

The trailers are powered by 480-volt, three-phase electricity. A power supply was installed at each station so the trailers can be driven up and plugged in. Once on site, it takes about an hour to set up the mobile training units for training. The program allows us to bring customized training to the site with our instructors and equipment.

Results. The concrete benefits that the mobile, on-site training program offers include:

- Greater scheduling flexibility which allows greater participation.
- No impact on plant operations.
- Customized training programs to meet the individual needs of a plant's workers.
- Cost effectiveness.
- Spares employees the inconvenience of traveling long distances.

Document control policy ensures P&IDs, electrical diagrams up-to-date

Klamath Cogeneration Plant

Iberdrola Renewable Energies

Klamath Cogeneration

500-MW, gas-fired, 2 × 1 combined-cycle cogeneration facility located in Klamath Falls, Ore
Plant manager: Ray Martens
Key project participants:
Greg Dolezal, Maintenance manager
Bruce Willard, Operations and engineering manager

Challenge. Throughout the plant, one can find numerous revisions of P&IDs, electrical drawings, etc, used for reference, construction, or even lockouts. The quantity and accessibility of these drawings and all other applicable drawings must be controlled so that only the most recent revisions are available for the purpose of lockout.

Periodically, drawings are updated and depict changes made throughout the facility, and that allows the possibility of unrevised drawings still circulating. Plant management decided that a policy must be designed to set a standard for labeling drawings and tracking changes.

Solution. All prints of P&IDs, electrical drawings, etc, are kept electronically in AutoCAD and updated regularly as plant modifications occur. In order to maintain accurate lockout documents, only the latest versions will be approved. The approved versions will reside in only four locations:

- Control room.
- Instrument shop.
- Maintenance office.
- Engineering manager's office.

All prints approved and placed in these books will be stamped with the following green stamp:

APPROVED COPY

All other prints or copies of prints will not be approved for the use of lockout and will be stamped with the following red stamp:

FIELD COPY
Not Approved for LOTO

All print modifications shall go through an approval process using the Management of Change (MOC) policy. Approval of all drawings will be completed solely by management, and he/she will retain possession of the "Approved Copy" stamp.

At no time shall there be any prints at the facility that do not have one of the two stamps. If a print is found without a stamp, it must be discarded immediately.

In addition to the MOC policies, all changes in prints shall be logged in our "Drawing Update Log." Revisions of all prints must be placed into each of the four approved lockout books and documented accordingly. This process is managed by the engineering manager or designee.

Results. A successful document management program is now in place. Clear identification of approved drawings has been established and numerous copies of old revisions have been removed from the plant site. Contractors have expressed approval of the system without hesitation or reservations.

Predictive model minimizes exposure to market risks

Wolf Hollow I

Owned by Stark Investments
Operated by NAES Corp

Challenge. The current economic conditions, with depressed market demand and pricing in the power generation industry, require innovative means to improve earnings. Predicting the maximum plant capacity a day ahead has limited the ability of gas-turbine-based powerplants to realize their maximum earnings potential as the output is directly impacted by ambient conditions.

The plant can be short and required to purchase real-time replacement power at costly prices or can be operating with additional available capacity during high real-time market conditions and miss the opportunity for additional revenue.

Providing real-time maximum plant capacity limits to the dispatching entity to capture maximum earning potential every hour in the market is essential. Assessing real-time (or as close to real-time as market rules allow) plant capability has become a key parameter in maximizing plant earnings.

Solution. The plant maintains and updates a weekly model of capacity and performance based on ambient temperature, relative humidity, and compressor efficiency. The model incorporates the effects of inlet air cooling and HRSG duct firing.

The plant's dispatching entity utilizes National Oceanic and Atmospheric Administration (NOAA) weather prediction data, ambient conditions, and the current plant model for day-ahead capacity submittal to the Electric Reliability Council of Texas. NOAA provides weather predictions on an hour-by-hour basis for the upcoming 48 hours, which is updated every hour.

Developing an interface and programming between NOAA and the plant model, the software provides an hourly update of the plant's maximum capacity based on the current model and NOAA data. The system has been automated to update each hour and include alarm capabilities at the plant and dispatch entity locations to notify both parties when the current submitted schedule and plant predicted capacity vary by set limits.

Wolf Hollow I

730-MW, gas-fired, two-unit, 1 × 1 combined cycle located in Granbury, Tex
Plant manager: Kelly Fleetwood
Key project participants:
Adam Jackson, Plant engineer
Alan Harding, Operations supervisor
Dimitri Anichkov, Berke Solutions

Results. This system was implemented in early 2009, and the plant has realized a reduction in exposure to market risks associated with inability to meet scheduled maximum capacity because of scheduling errors as a result of changing ambient conditions.

The ability to predict and schedule the plant's capacity on an hourly basis has minimized negative earnings. The accurate prediction and scheduling has also provided additional opportunities to increase earnings through optimizing ancillary service earnings and out-of-merit capacity dispatch.

Additionally, this system has led to the development of a system to optimize the plant's capacity and performance model on a real-time basis. This is a continuing effort to ensure the plant's earnings potential is maximized.

OSHA VPP Star facility establishes solid safety partnership with contractors

Tenaska Virginia Generating Station

Tenaska Virginia Partners LP

Challenge. Our on-going challenge is to obtain "buy-in" into our safety culture from the on-site contracted employees, and ensure contractors understand the facility's safety policies and partner in our safety culture.

Solution. We maintain and strengthen our safety culture by utilizing every employee and contractor's opinion to maintain a safe worksite. The following are some components used to develop our contractor safety relationships:

- All employees are open and eager to learn from best practices, safety experiences, and lessons learned. The staff exhibits a positive attitude, integrity, and they are always looking to identify, track, and correct safety deficiencies.
- Our annual contractor 45-minute safety brief and exam were translated into Spanish. A written exam is given at the completion of training to test retention of

6.4

6.5

presented information. A grade of 100% is required to pass the exam and work at the facility.

- Crucial to achieving contract employee "buy-in" in our safety culture is building trusting and helping relationships. Employees and contractors work together to perform detailed job hazard analysis and LOTO system walk-downs.
- We work with the contractor to determine the best method for execution of a job. We ensure that contractors know their opinion counts. Each contractor job has a facility team member assigned to be their main point of contact.
- All outage work permits, hot work, scaffolding, and confined spaces are posted in the control room so everyone knows what jobs are in progress.
- A safety toolbox meeting occurs every Wednesday morning during our maintenance outage in the control room. Safety issues identified are discussed with all plant personnel, contract supervisors, and their employees.
- An outage safety barbecue is held with all contractors and employees to express the importance of following our safety policies, sharing safety ideas, and understanding our commitment to safety and esprit de corps.
- A safety traffic stop light is mounted in the control room (Fig 6.4). A green light represents no safety near misses or missed opportunities. A yellow light indicates a near miss. A red light indicates an accident or hazardous situation.
- Contractor supervisors and all employees are required to sign our team safety charter (Fig 6.5). This ensures we are all on board in maintaining an open honest safety culture.
- Contractors are scheduled to provide employee training on complex maintenance tasks such as setting up and inspecting scaffolding and valve maintenance.
- A safety stand-down has been used in the past when an employee believed there was an unsafe maintenance practice. All facility maintenance stops and a brief is conducted with those involved.
- Every year the facility decides on "Contractor of the Year" and a special award is presented to the contractor during lunch.

Tenaska Virginia Generating Station

885-MW, gas-fired, 3 × 1 combined cycle located in Scottsville, Va
Plant manager: Robert Mayfield
Key project participants:
Sam Graham, Maintenance manager
Rich Collins, Safety committee chairman
Steve Mattson, Contractor safety trainer

Results. Contractors know they can bring up safety concerns/issues and their opinions are important to improve our safety culture. OSHA VPP benchmarked our contractor safety brief process. We know we are doing it correctly when contractors, who work with companies all over the world, take time to walk up to us before they leave facility to say "thank you," shake your hand, and tell us how much they enjoyed working with the team.

Management plans ensure effective response to critical equipment failure

Granite Ridge Energy

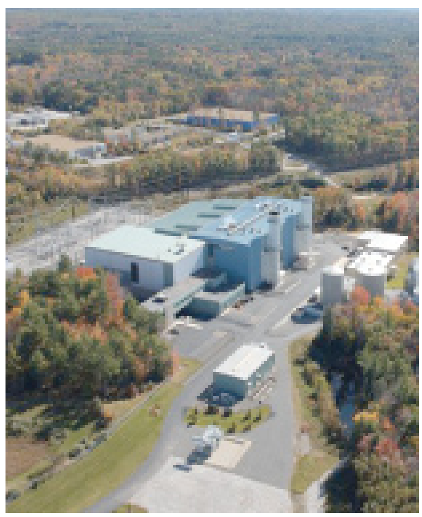
Owned by Granite Ridge Energy LLC

Operated by NAES Corp

Challenge. The challenge was to minimize plant unavailability in the event of a major component failure. The facility performed an evaluation of high risk areas that would impact plant availability in such an event. Two high-risk areas in particular

Granite Ridge Energy

730-MW, gas-fired, two-unit, 1 × 1 combined cycle located in Londonderry, NH
Plant manager: Ralph Leidy
Key project participants:
Jim Carlton, President
Dan Jorgensen, Maintenance manager
Larry Hawk, Plant engineer



were identified: (1) cooling-water pipeline and (2) generator step-up transformers.

The cooling-water pipeline was identified based on its complex configuration, impacting public roadways and local communities. The transformers were a priority based on their availability, lead times, and complicated installation.

Solution. The solution to this problem was to establish management plans that address the possibility of generator step-up transformer and/or cooling-water pipeline failure. The management plans are a compilation of information that include equipment specifications, supplier lists, contacts, schedules (including Gantt charts), and insurance information. These plans outline an efficient reaction to restore proper production in an expedient and safe manner.

Results. Following the completion and training on these management plans, the facility is confident in its ability to react appropriately and efficiently to these unscheduled events.

7. Safety

Tenaska Virginia Generating Station

885-MW, gas-fired, 3 × 1 combined cycle located in Scottsville, Va
Plant manager: Robert Mayfield
Key project participants:
Sam Graham, Maintenance manager
Rich Collins, Safety committee chairman

Comprehensive fall hazard initiative brainstorms solutions, establishes procedures

Tenaska Virginia Generating Station

Tenaska Virginia Partners LP

Challenge. A well-conceived fall protection program begins with identification of all fall hazards in the workplace.

Solution. The safety committee implemented the plant's *Continuous Improvement Process* to identify and improve safety relating to fall protection. Continuous improvement is one of Tenaska's core values and is integrated into the management and operational fabric of the company. The simple approach to continuous improvement is a three-step process that defines, measures, and improves.

Our process improvement team, applying the three-step process to improve our fall protection program, focused on measures and processes and sought out interaction and consensus among the process owners, users, suppliers, and customers:

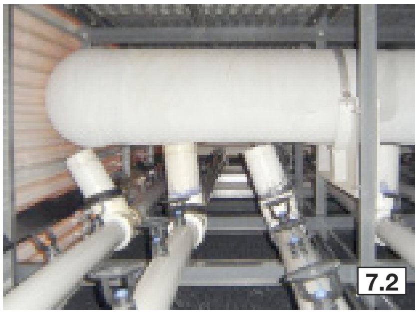
1. Identify fall hazards:

- Plant fall-hazard areas were identified where work was actually performed, the frequency, and the risk was recognized. Discussion with various disciplines helped the team to understand the work being performed using a risk matrix to determine the priorities.
- Priorities were determined to identify the areas where employees were placed at higher risk or where employees were placed at risk more often (table).

2. Solutions to the fall hazard areas:

- The facility has miles of heat tracing because it is dispatched in cold weather. Heat tracing runs along the top of the mezzanine level. Based on our priority table, the risk of possibly falling is considered "high" and the frequency of maintenance is "any." The facility installed lifelines designed to


7.1


7.2

Prioritizing fall hazards

Priority level	Risk	Maintenance frequency	Solution
1	High	Any	Significant risk that must be addressed before continuing work
1	Medium	Frequent	Significant risk that must be addressed before continuing work
2	Medium	Common	Implement precautions as soon as practical
3	Medium	Uncommon	Implement precautions as needed
4	Low	Any	Implement precautions as needed

be used for tie-off points as part of our fall protection program. A 100% tie-off policy is enforced on this area (Fig 7.1).

- The fiberglass cooling tower was another difficult area for fall protection. There is a significant amount of manpower needed to perform the required upkeep, and there was a small level of comfort when you need to tie-off while working inside (Fig 7.2). The cooling-tower manufacturer was contacted and came to the site to provide training and documentation regarding the structural design of the tower and ways to enhance our fall protection program.

3. Establish procedures and training:

- Maintaining the solutions even after the project is complete is a high priority. When the higher risk items are corrected the facility begins the next round which starts with another evaluation and priority system being developed.
- Improvement in safety or any other aspect of powerplant operation is a constant system of self evaluation and improvement. Training is incorporated for all employees and communication lines among management, safety committee, and employees are used to ensure all safety concerns are addressed.

Results. The overall safety program improved during this process. Like all systems, a successful fall protection program is only as good as the personnel who implement the program. Employees' safety concerns are valued and innovative solutions were provided by all involved to ensure a safe worksite. OSHA VPP benchmarked our fall protection program.

Staff involvement, pride keys to a thriving safety culture

Walter M Higgins Generating Station

NV Energy

Challenge. The crew knew that we had a great safety program, so we contacted the "professionals" and invited in OSHA to ensure that we were doing the very best.

Solution. Management ensures that ample opportunities exist for employee involvement in safety and health decision-making and problem-solving. These avenues include serving on committees and subcommittee problem-solving groups, participating and leading incident investigations, continuous improvement sessions, acting as safety observers, assisting in training other employees, analyzing hazards inherent in site jobs through the job-hazard-analysis process, and planning activities to heighten safety and health awareness.

Management encourages employee involvement and rewards employees for outstanding participation. Each employee is empowered (and expected) to address safety concerns at any time, and safety always comes before production (sidebar, p 74). This safety culture is continually reinforced and encouraged. All employees are involved in the completion of routine safety inspections, preventive, and predictive maintenance tasks.

Walter M Higgins Generating Station

530-MW, gas-fired, 2 × 1 combined cycle located in Primm, Nev
Plant regional director: Steve Page
Key project participants:
Felix Fuentes, Operations manager
The entire Higgins staff

Our personnel also exhibit their level of commitment to the safety program through acquiring high levels of safety and health certifications. Staff member certifications and qualifications include but are not limited to:

- Safety professional with Associate Safety Professional (ASP) certification.
- Forklift operation trainer.
- Scaffolding trainer.
- Electrical arc flash protection trainer.
- Hazwoper incident commander.
- NFPA technical advisor.
- OSHA 10- and 30-hr trainer.

Employees also actively participate in the OSHA VPP participant groups through attendance at regional and national meetings, serving as mentors and as OSHA special government employees. The team at Higgins exhibits pride in the safety culture and excellent safety record because of the commitment and support of management and the involvement from all employees.

Results. Our plant was awarded OSHA VPP Star status in May 2007. The program promotes effective worksite-based safety and health programs. VPP Star status is reserved for those worksites which demonstrate to OSHA they maintain a world-class and comprehensive safety and health management system. The key to the plant's successful safety and health program is based upon the level of employee involvement and pride taken in the plant.

Higgins has 17 full-time employees. As a plant, they have worked over 400 days without a recordable or lost time injury, equivalent to 45,000 safe work hours. The OSHA VPP program requires an annual self-evaluation. Higgins Station has (1) a three-year incident injury rate 9% lower and (2) a three-year lost time injury rate 46% lower than other power generation facilities with from 11 to 49 employees.

Clear directions to safety showers can minimize damage

Mint Farm Generating Station

Puget Sound Energy

Challenge. During a chemical spill on personnel, it is very a difficult task to look for emergency safety showers. During these types of situations, personnel keep their heads down to either get the chemical off their hard hats or look at their clothing and could enter a state of panic.

If the personnel are not familiar with the locations of the showers, it becomes more risky to get there before the chemical has done any damage to the safety suit or skin. Even though the safety showers have never been used, a preventive approach could save someone from severe injury. Plant staff identified the water treatment building as one


7.3


7.4

of the more dangerous locations to experience a chemical spill.

Solution. Plant employees came up with a solution to minimize this problem. All the emergency safety showers in the plant were clearly identified and big decal signs were posted on the main walkways of the plant to identify the locations. From those decals a white line was painted which would take the person to the safety shower (Fig 7.3). Some of the safety showers in the plant cannot be seen from all directions.

Now all the safety showers are marked on the walkways. All the safety showers in the plant are monitored visually and an alarm on those showers will indicate a use of the shower (Fig 7.4). Control room operators can dispatch help to that safety shower area, if necessary.

Results. This improvement allows easy access to the safety showers with the directions provided by decals and painted directional lines. Luckily, the plant has had zero lost-time incidents since its construction in 2006. To this day, no one has ever had to use the safety shower for any safety reason, but we are comfortable with our measure to avoid preventable injury.

Mint Farm Generating Station

311-MW, gas-fired, 1 × 1 combined-cycle located in Longview, Wash
Plant manager: Chetan Chauhan
Key project participants:
Robert Mash, O&M supervisor
George Kostin, Plant operator
Mitchell Smith, Control room operator

Indoor stairs to evap cooler allows for safe, efficient maintenance

Covert Generating Facility

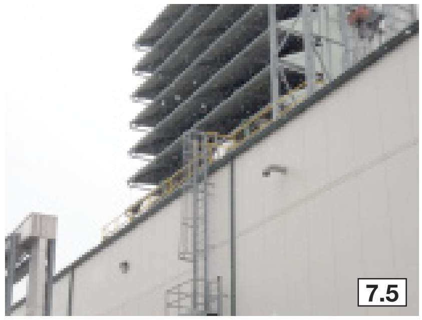
Owned by Tenaska Inc
Operated by NAES Corp

Challenge. Basket ladders were used for climbing from ground level to access the evaporative-cooler filter house (Fig 7.5). In similar applications where access is only occasionally required, a basket ladder would be considered adequate because of its infrequent use. An added problem was that this design was placed outside of the building and subjected employees to inclement Michigan weather along with the challenges of basket ladder use.

As the plant matured, it became apparent that frequent work and inspections required more access than originally thought. The safety committee assessed that the more frequent use and need for periodic maintenance equated to significant added job risk. Plant owner Tenaska agreed and subsequently funded the project.

Solution. Personnel collaborated with plant owners and mutually agreed that since more frequent access than originally expected was required, a new design was necessary to manage risk. A new stairway and landing platform were designed and installed inside of the building sheltered from the weather with stairway access (Fig 7.6). This initiative required a significant amount of partnering with the ownership team to creatively develop an appropriate engineering solution.

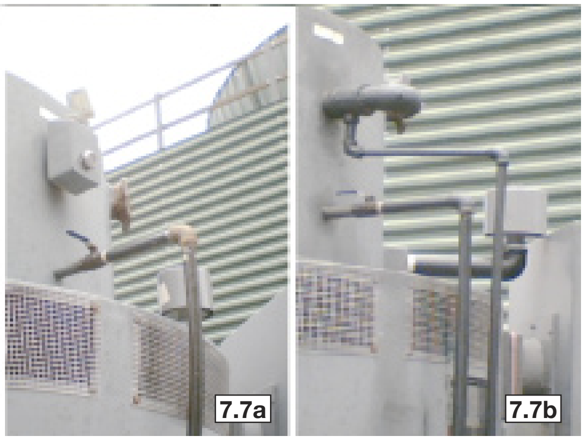
Results. The evaporative-cooler filter house is now easily accessed from within the building by way of a more suitable set of stairs and landing points. Tools, parts, and people can now be easily mobilized for repairs and routine inspections. Unlike the original design, weather no longer impacts how work is done.


7.5


7.6

Covert Generating Facility

1100-MW, gas-fired, three-unit, 1 × 1 combined cycle located in Covert, Mich
Plant manager: Richard Evans
Key project participants:
The entire Covert team



7.7a 7.7b

Modifications allow ground-level access to maintain circulating-water pumps

AE Units 3,4,5

Allegheny Energy

AE Units 3,4,5
540-MW, gas-fired, 2 × 1 combined cycle located in Springdale, Pa
Plant manager: Anthony Hallo
Key project participants:
Carl Massart, O&M technician
Ed Stewart, O&M technician

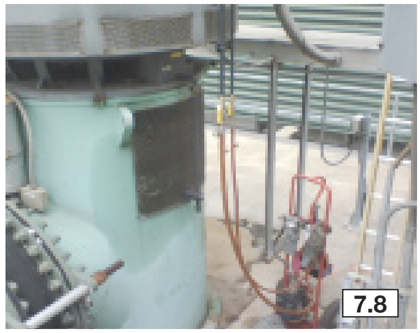
Challenge. Accessing the top motor-bearing fill cap of our circulating-water pump motors to perform lubrication activities involves using a ladder or man-lift which inhibits safe work activities and increases ergonomic hazards. Also, the 62.5 gallons of oil used in the bearing is costly to change when it may only need to be filtered to reduce particle counts.

Solution. We removed the oil fill box (Fig 7.7a) from the motor housing and installed a tee, which allowed us to place a ½-in. return pipe into the bearing oil reservoir. This pipe was run externally down the side of the motor along with a ¾-in. drain line to provide easy access (Fig 7.7b). We then installed a street elbow to the tee, added a reducer bushing, and reinstalled the sight glass at a 90-deg angle. This makes it easier to see the sight glass from the cooling-tower deck.

Ball valves and quick-connect fittings allow easy hook-up of our mobile filter cart and eliminated the need for a fill cap (Fig 7.8). Also by removing the standard bearing vent which was nothing more than a coarse screen, and replacing it with a filtered vent, airborne contamination of the oil is minimized.

Results. The need for a ladder or man-lift and the associated physical and environmental hazards has been eliminated. A dangerous job has been made safer. Oil cleanliness is improved by not exposing the reservoir to the environment when removing the fill cap to add or sample the oil.

Using a filter cart will allow us to polish the oil to maintain target cleanliness levels and extend oil change intervals. Each annual oil change we can eliminate will save us $425 per motor. Improving safety: Priceless.



7.8

Bottle racks for calibration-gas tanks mitigate risk of falling

MEAG Wansley Unit 9

Owned by Municipal Electric Authority of Georgia

Operated by GE Contractual Services

MEAG Wansley Unit 9
503-MW, gas-fired, 2 × 1 combined cycle located in Franklin, Ga
Plant manager: Keith Feemster
Key project participants:
William Wright, Maintenance technician

Challenge. NO_x emissions control is provided through the use of anhy-

drous ammonia. Because ammonia is highly toxic, remote sensors are installed at all four corners of the ammonia-tank containment area. In the event of a release, the sensors will detect the ammonia and send a signal to the control room with the airborne concentration.

As part of the plant's preventive maintenance program, an I&C technician is required to perform a monthly calibration of the four detectors which are located 8 ft above grade. This task presented both a fall hazard and ergonomic issue for the technician because it required the use of portable ladder. While standing on the ladder he would have to hold the calibration gas cylinder, any necessary equipment or tools, and make needed adjustments (Fig 7.9a).

Solution. The plant's I&C technician came up with a very simple solution using stock stainless steel pipe with a diameter slightly larger than the calibration cylinder and cut to length so that it was shorter than the cylinder. A piece of flat bar was welded across the bottom to keep the cylinder from falling through. Four racks were fabricated in-house and attached to existing steel structure beneath each of the detectors (Fig 7.9b).

Results. Although the need for climbing the ladder was not eliminated, this simple project greatly reduced the potential fall hazard by allowing a technician to maintain three-point contact on the ladder while calibrating the sensors. Empowering site personnel to identify safety hazards such as this and develop solutions to those hazards continues to reinforce a strong safety culture at the facility.


7.9a


7.9b

Permanent platforms provide safe access for HRSG, GT inspection

Granite Ridge Energy

Owned by Granite Ridge Energy LLC

Operated by NAES Corp

Challenge. In every powerplant, there can be potentially unsafe areas that require fall protection. We found ourselves spending significant time and money making routine areas of maintenance safer by utilizing temporary scaffolding. Our challenge was to increase personnel safety with a permanent solution for performing O&M tasks in high-risk areas.

Solution. A survey of the facility was completed to identify high-traffic areas in need of fall-protection improvement. Once identified, specific solutions were designed and installed to provide safe access. Design considerations included equipment access and ease of removal.

For example, all platforms are of bolted construction and the GT platforms are made of lightweight aluminum which increases ease of disassembly and removal from inside the GT enclosure.

Some of the more challenging areas to access, where permanent platforms were installed include the gas-turbine igniters, HRSG manway access doors, clarifier operation area, and the generator breaker filters (Figs 7.10a-d).

Granite Ridge Energy

730-MW, gas-fired, two-unit, 1 × 1 combined cycle located in Londonderry, NH

Plant manager: Ralph Leidy

Key project participants:

Jim Carlton, President

Larry Hawk, Plant engineer


7.10a


7.10b


7.10c


7.10d

Results. The installation of these platforms has provided a safe, efficient, and convenient access to equipment that was previously challenging. The platforms reduce preparation time during unplanned events. The permanent platforms provide additional support that was not there with small temporary scaffolding.

HRSG inspections can be conducted without having to involve scaffolding contractors. GT igniter checks are quicker, minimizing time inside the GT enclosures during startup operations. In addition, the facility has realized savings in costly repetitive temporary scaffolding rental and labor.

Safety sheds and hurricane window film protect personnel against severe weather

Jasper Generating Station

South Carolina Electric and Gas Co

Challenge. The facility is periodically subjected to storms with high wind speeds, tornadoes, and/or hurricanes. A nearby powerplant was impacted by a tornado which destroyed its cooling tower, a large metal building, and rolled large metal containers around the site.

Our facility had experienced a few "close calls" from tornadoes. There were no safe areas onsite that gave personnel sufficient shelter from these events. Underground shelters were impractical with our high groundwater levels and the amount of infrastructure underground. The main building containing the control room, craft shops, warehouse, and offices is a simple metal structure with no impact protection.

Solution. The plant purchased and installed two 8 × 10-ft safe sheds from Safe Sheds Inc. These are aboveground, steel-reinforced concrete units made in one cast piece, anchored 4 ft deep on the corners.

They meet FEMA Pub 320 specs and are designed to withstand an F5 tornado with 250 mph winds and attendant debris impact. They are fireproof, low/no maintenance, and each comfortably holds 20 standing persons.

There is one steel door in front and an escape hatch in the rear in the event the door is blocked with debris (Fig 7.11). After much research, we procured these for an extremely reasonable price and they were delivered and installed by the manufacturer.

These units were placed just outside the back door of our main building, easily accessible by everyone. Identical units are found at military bases in Guantanamo Bay and Ft Sill, Okla.

For additional protection in the main building, 3M hurricane window film was installed on all exterior glass to improve impact resistance and prevent shard formation if a window fails.

Results. Plant staff, particularly shift personnel, who were previously nervous about shelter from severe weather and had questioned the company's commitment to their protection, expressed great satisfaction with the project. Anyone onsite is now able to quickly retreat to safe shelter in the event of severe weather. Evacuation is possible in less than two minutes.

Jasper Generating Station

910-MW, gas-fired, 3 × 1 combined cycle located in Hardeeville, SC
Plant manager: Steve Palmer
Key project participants:
Don Belle, Maintenance engineer

7.11

State Line Combined Cycle

500-MW, gas-fired, two-unit, 2 × 1 combined cycle located in Joplin, Mo
Plant manager: Bill Howell
Key project participants:
Ed Eason, Operations manager
John Woods, Maintenance manager
The entire State Line Combined Cycle staff

Computerized LOTO system increases personnel, contractor safety

State Line Combined Cycle

Empire District Electric Co and Westar Generating Inc

Challenge. Equipment, including motor control centers, is spread over a significant distance. Lower staffing levels, especially the lack of 24/7 operations supervision, create challenges to properly maintain plant equipment. These items, in addition to considerable contractor presence, leads to significant LOTO tracking concerns.

Solution. A computerized LOTO system was developed that ties into our maintenance management system and master-group lockbox, which is located in the control room. A LOTO is generated by the LOTO authority based on the boundaries required to perform work order.

Equipment to be locked out is locked by the LOTO authority with locks which have unique keys. Those keys are then placed in one of the boxes in the master-group lockbox and secured by a lock which only the LOTO authority has the key.

The LOTO is then verified by another employee. Both individuals initial each boundary line on the LOTO. This copy is placed in a master LOTO notebook. Copies of the LOTO are also placed in a tube which protrudes from the front of the individual locked boxes of the master-group lockbox. This tube is not locked and LOTO documents are examined and verified by any individual needing access to the equipment within the boundary.

Individuals needing access to the equipment then place their individual LOTO lock on a multi-hasp attached to a separate hasp in the individual box door. Therefore, all individual's locks and the LOTO authority lock must be removed before equipment may be released from the LOTO.

Results. By having the master-group lockbox in the control room, it is readily apparent what LOTOs are in progress, who has access, and that no locks are inadvertently left on plant equipment. Zero lost-time accidents or reportable injuries since implementation of system have been recorded from equipment under control of LOTO system

Klamath Cogeneration

500-MW, gas-fired, 2 × 1 combined-cycle cogeneration facility located in Klamath Falls, Ore
Plant manager: Ray Martens
Key project participants:
Greg Dolezal, Maintenance manager
Bruce Willard, Operations and engineering manager

Regulated air for chemical off-loads mitigates risk of exceeding pressure limits

Klamath Cogeneration Plant

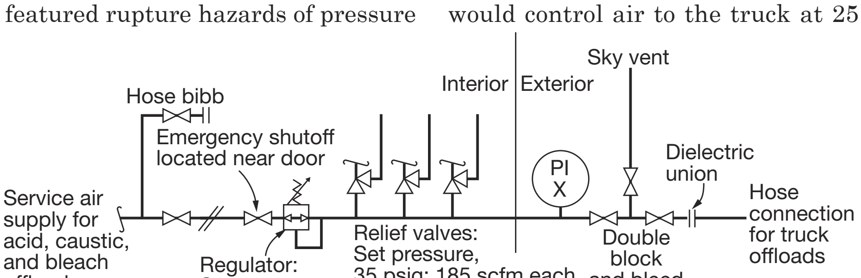
Iberdrola Renewable Energies

Challenge. The EPA sends out a periodic newsletter entitled "Chemical Emergency Prevention & Planning." The March-April 2008 issue featured rupture hazards of pressure vessels. After reading the newsletter and reviewing our processes, we discovered an area of possible exposure in chemical off-loads.

Chemical delivery trucks often use pressurized air to move product from the truck to the site storage tank and frequently utilize plant air for this evolution. Because plant air operates at approximately 120 psig, far exceeding the truck's pressure rating, relying on the truck's safety valve and maintenance procedures was not an option. We needed to develop a definite method to ensure the truck could not be over pressurized.

Solution. We contacted all vendors supplying applicable chemicals to the site and requested their trucks' normal working pressure, safety valve set point, and trailer test pressure. The most conservative number became our design goal.

We purchased a regulator that would control air to the truck at 25 psig with a flow rating of 440 scfm. We installed a set of three relief valves that will relieve 550 scfm—125% of maximum. For additional safety, a double block and bleed system was installed and a pressure gage was placed at the hose reel to enable the operator to monitor air pressure throughout the evolution. A dielectric union and a grounding strap remove the static electricity hazard of the offload (Fig 7.12).



7.12

Results. The exposure of exceeding pressure limits of chemical delivery trucks has been mitigated. The operators and drivers are more comfortable with using the plant's high-pressure air and management no longer has the fear of possible poor maintenance of the trucking company's equipment.

Safe scaffold access with "yo-yo adapter" lanyards

Whiting Clean Energy

BP

Challenge. Unprotected permanent scaffold ladders created a fall hazard for plant personnel and third-party contractors.

Solution. According to OSHA requirement 1926.451(g)(3), personal fall protection can be attached to a scaffold structural member. To eliminate the exposure and risk for falls, retractable "yo-yo adapter" lanyards were installed on all permanent scaffold access ladders. As an added safety measure, one-foot, "d-ring extenders" were used to provide easier reach when attaching to the "yo-yo adapter" lanyards.

Results. The installation of the retractable lanyards has virtually eliminated the potential for falls when accessing a scaffold. Our site scaffolds range from four-foot platforms to seventy-foot scaffolds that allow work to be performed at the tops of our HRSGs. Meeting OSHA requirement 1910.66(c)(10), each "yo-yo lanyard" has a maximum load of 5500 lb. Each retractable device is inspected as part our site's daily scaffold inspection.

Mechanical lifting device for compressor suction valves

Whiting Clean Energy

BP

Whiting Clean Energy

525-MW, gas-fired, 2 × 1 combined-cycle cogeneration facility located in Whiting, Ind
Plant manager: Richard Moroney
Key project participants:
Randy Itter, Performance supervisor
Curtis Hartsook, HSSE manager
The entire Whiting Clean Energy staff

7.13

Challenge. Installation and removal of natural-gas-compressor suction valves required manual lifting. The position of the valves would not facilitate the use of a lifting strap or other lifting device, creating an ergonomic hazard for personnel.

Solution. Plant staff designed and fabricated a new lifting device to safely and securely remove and install compressor suction valves (Fig 7.13).

Results. The new mechanical lifting device, when used in conjunction with a hoist or chain fall, easily removes and installs compressor suction valves. The device has successfully eliminated potential injuries from manually lifting suction valves.

Little things at Higgins go a long way

Emergency response

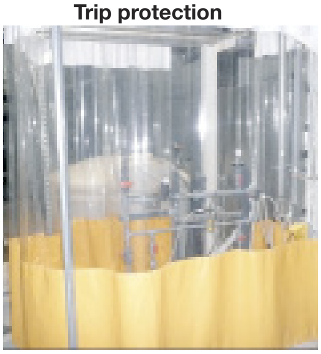
Safety bulletins

Trip protection

Tank labels

Manhole identification

Scaffold inspection

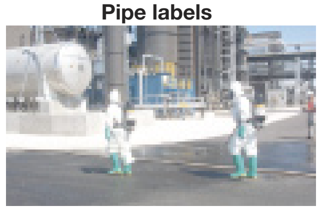


Bleach splashguard

O&M platforms

Protective gear

Pipe labels



Emergency drills

How Best Practices entries are judged

Objective judging is critical to the success of any awards program. The CTOTF Leadership Committee, chaired by Bob Kirn of Tennessee Valley Authority, Chattanooga, selected from its ranks a panel of seven judges for 2010. Note that Best Practices entries were scrubbed of company, plant, and personnel names before they were submitted for judging.

Entries were received from many gas-turbine-based combined-cycle, peaking, and cogeneration plants. The panel of judges reflected expertise in each of these sectors of the industry to ensure a level playing field for all participants. Here's a thumbnail sketch of the panel's qualifications:

- Four judges are located at their companies' headquarters sites and have engineering and/or management responsibilities for multiple generating resources; one is a plant manager; two are responsible for fleet-wide maintenance.
- All of the judges operating out of headquarters locations are former plant or O&M managers at GT-based generating facilities; several have conventional steam-plant experience as well.
- Two judges are experts in aero engine O&M, the others specialize in frames.
- Plant management/operations experience of the panel is well over 125 years.

Each judge received a notebook containing the entries arranged by category: Management, Environmental Stewardship, Safety, Design, and Operations and Maintenance (now divided into O&M Business, Major Equipment, and Balance of Plant); plus, a score sheet. The assignment: Read each entry for a given category and rate it from 1 to 10 for the five evaluation parameters listed below. The weighting factor assigned to each evaluation parameter is in parentheses.

1. Achieved business value—both real and measurable (weighting factor of 10).
2. Complexity of the issue (8).
3. O&M staff involvement (6).
4. Degree of coordination across multiple groups at both the plant and corporate levels (5).
5. Duration of the value proposition (9).

Next step is to multiply the score for each parameter by its weighting factor; then add the results. Entry with the lowest point total in a given category is awarded a "1," next highest a "2," and so on. Each judge submits his or her rankings to the editors, who then add them. Lowest point total in each of the seven categories is rated The Best of the Best.

This year the voting was extremely tight, with ties in two of the categories. A total of nine Best of the Best plaques were awarded in 2010.

You be the judge

By the time you get to this segment of the Best Practices Awards special section hopefully you've at least skimmed all of the entries and read through, and benefitted from, a couple that were of particular interest. If you have been associated with the GT-based sector of the industry for a few years, your reaction to several entries might be the following: "We did that a couple of years ago." You might also add: "And we did it better." And if that's true, you probably have continued to innovate and have ideas that your colleagues would find valuable. Please consider participating in the 2011 Best Practices Awards program (instructions at www.psimedia.info/bestpractices.htm).

To better gauge how your entries might be rated, consider evaluating the 2010 entries and see how the results compare with those of the judges. The score sheet below is helpful in this regard.

Category/ Submittal		Business value Score × Wt +	Complexity Score × Wt +	Staff involvement Score × Wt +	External coordination Score × Wt +	Duration of value Score × Wt =	Total score	Rank
Management	1	× 10 +	× 8 +	× 6 +	× 5 +	× 9 =		
Management	2	× 10 +	× 8 +	× 6 +	× 5 +	× 9 =		
Management	N	× 10 +	× 8 +	× 6 +	× 5 +	× 9 =		
Environmental	1	× 10 +	× 8 +	× 6 +	× 5 +	× 9 =		
Environmental	2	× 10 +	× 8 +	× 6 +	× 5 +	× 9 =		
Environmental	N	× 10 +	× 8 +	× 6 +	× 5 +	× 9 =		
Safety	1	× 10 +	× 8 +	× 6 +	× 5 +	× 9 =		
Safety	2	× 10 +	× 8 +	× 6 +	× 5 +	× 9 =		
Safety	N	× 10 +	× 8 +	× 6 +	× 5 +	× 9 =		
O&M	1	× 10 +	× 8 +	× 6 +	× 5 +	× 9 =		
O&M	2	× 10 +	× 8 +	× 6 +	× 5 +	× 9 =		
O&M	N	× 10 +	× 8 +	× 6 +	× 5 +	× 9 =		

CTOTF Champions Sponsor

Best Practices Awards

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SPECIAL SECTION

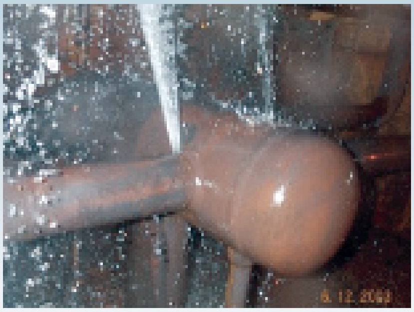
2010 Conference & Expositiom

APRIL 12-14 • Hyatt Regency Riverfront Jacksonville

Participate in these Open Discussion Sessions

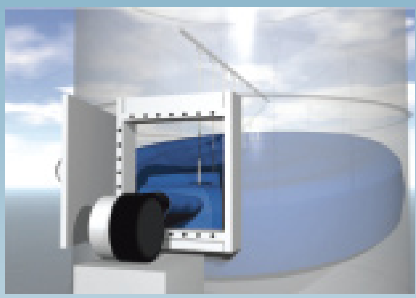
Heat Transfer Equipment
Tuesday, 8 a.m.

Water Treatment
Tuesday, 11 a.m.



Piping Systems
Tuesday, 3:30 p.m.

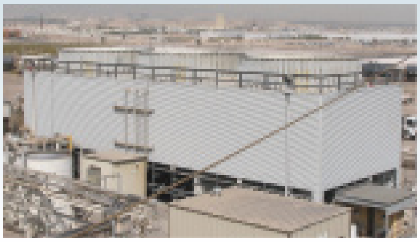
Controls
Ductwork, Dampers, Stacks
Wednesday, 8 a.m.

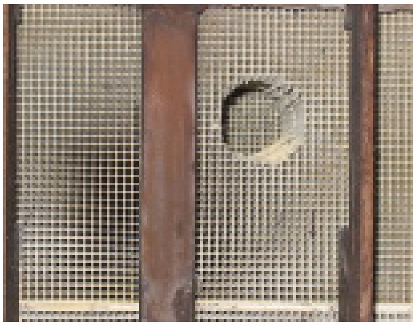


Contents

Valves
Supplementary Firing
Wednesday, 11 a.m.

Environmental Systems
Balance of Plant
Wednesday, 2:45 p.m.





Conference

All conference sessions are in Conference Center A on the third floor

All receptions, meals, and the exposition are in the Grand Ballroom on the second floor

Monday, April 12

MORNING

7:00 to 8:00	Breakfast and registration for the pre-conference seminar
8:00 to 4:00 pm	Pre-conference seminar is in River Terrace 1 on the third floor (this event requires special registration)

"The Powerplant Leadership School"

A practical blend of technical and managerial training is presented by Sterling Energy, a global leader in power-generation management. The specifics of this popular seminar include:

- Making the leap from technical supervision to asset management
- Staffing plants as competition intensifies and the workforce ages
- Accounting fundamentals for pump-kickers
- Creating a culture of commitment with bottom-line results
- Managing machinery and leading people

AFTERNOON

Noon to 9:00 pm	Registration for conference delegates
Noon to 5:00 pm	Exhibit set-up/exhibitor registration

EVENING

6:00 to 9:00 pm	Official opening of the 2010 Conference & Exposition
	Reception and dinner
	Expo open

Tuesday, April 13

7:00 am to 6:00 pm	Registration for conference delegates

MORNING

7:15 to 8:00	Breakfast
8:00 to Noon	Technical sessions
8:00 to 9:30	Open discussion: Heat transfer equipment
9:30 to 10:00	Break

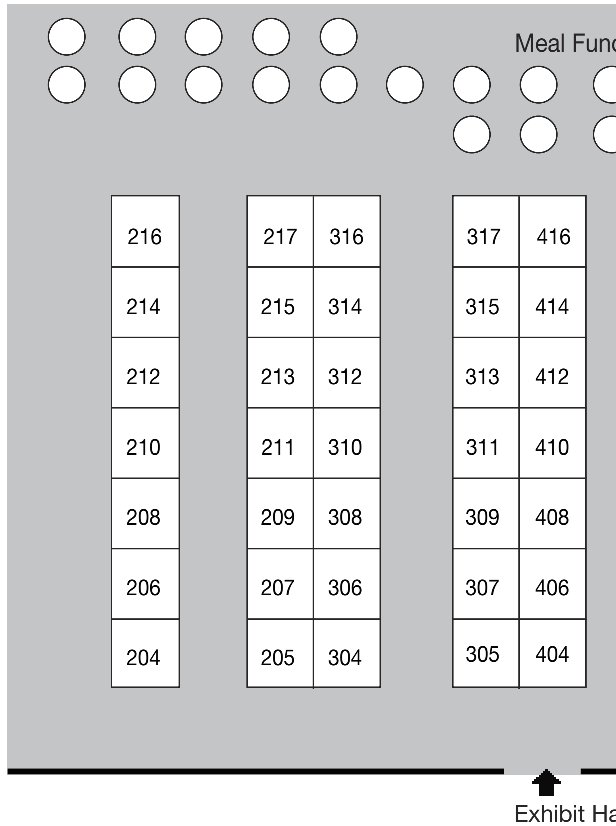
Program

10:00 to 11:00	"Chemical cleaning of HRSG tubes: Why, when, and how"
	Robert D Bartholomew, *associate, Sheppard T Powell Associates LLC*
11:00 to Noon	Open discussion: Water treatment
AFTERNOON	
Noon to 2:00	Luncheon
	Expo open
2:00 to 5:00	Technical sessions
2:00 to 3:00	"Slashing oxygen content of make up water using gas-transfer membranes"
	Don Belle, *maintenance engineer, South Carolina Electric & Gas Co's Jasper Station*
3:00 to 3:30	Break
3:30 to 5:00	Open discussion: Piping systems
5:00 to 6:30	Reception
	Expo open

Wednesday, April 14

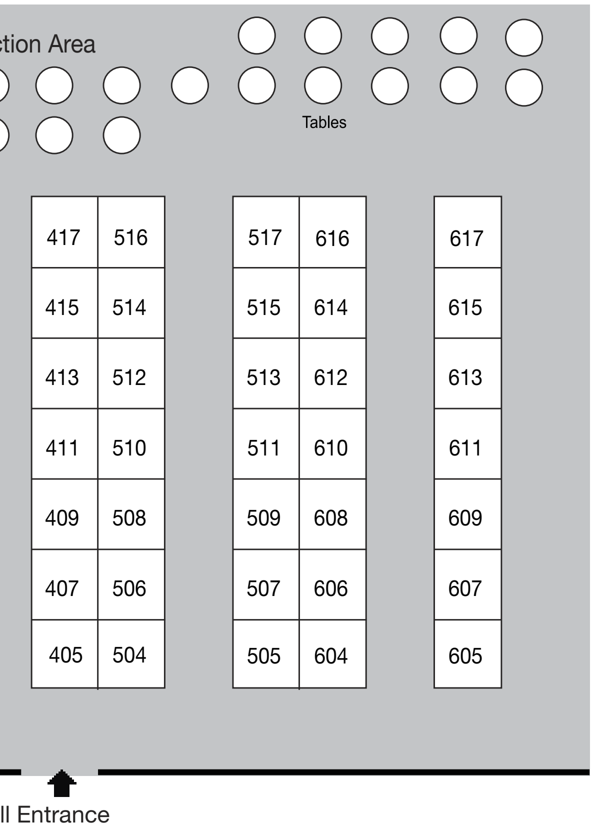
7:00 am to 1:30 pm	Registration for conference delegates
MORNING	
7:15 to 8:00	Breakfast
8:00 to Noon	Technical Sessions
8:00 to 9:30	Open discussion: Controls, duct-work, dampers, and stacks
9:30 to 10:00	Break
10:00 to 11:00	"New life-assessment software to optimize commercial startup procedures"
	Jimmy E McCallum, *manager of CCP and CT technical support, Southern Company Generation*
11:00 to Noon	Open discussion: Valves, supplementary firing
AFTERNOON	
Noon to 1:30	Luncheon
	Expo open
1:30 to 4:00	Technical sessions
1:30 to 2:30	"Typical boiler feedwater-pump problems in combined-cycle plants"
	Daus Studenberg, *Ludeca Inc*
2:30 to 2:45	Break
2:45 to 4:00	Open discussion: Environmental systems, balance of plant
4:00	**Conference adjourns**

Exposition Area



Exhibition Hall

Company	Booth
Alstom Power Inc	417
BASF Catalysts LLC	205
Bremco Inc	506
CCI-Control Components Inc	217
Central Maintenance & Welding Inc	212
Chanute Manufacturing	414
ChemTreat Inc	407
Clark-Reliance Corp	306
CMI Energy	408
Coen Company Inc	409
Conax Buffalo Technologies Inc	607
Conval Inc	216
Cormetech Inc	410
Cortec Corp	615
Dekomte de Temple	604
Donaldson Company Inc	511
EagleBurgmann Industries LP	213
EST Group	207
European Technology Development	312
Express Integrated Technologies LLC	307
Fluidic Techniques	505
Fuel Tech Inc	613
GEA Power Cooling Inc	515
General Physics Corp	513



Alphabetical Order by Company as of March 5

Company	Booth
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Hamworthy Peabody Combustion Inc	510
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HRST Inc	616
Hurst Technologies Corp	416
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ISOPur Fluid Technologies Inc	309
JASC-Jansen's Aircraft Systems Controls Inc	617
John Crane Mechanical Seals	313
Johnson Matthey	211
KE-Bergmann USA Inc	316
Ludeca Inc	406
Megawatt Machine Services LLC	509
Membrana	606
Midwest Towers Inc	311
MOGAS Industries Inc	404
NAES Corp	412
National Electric Coil	411
Nooter/Eriksen Inc	517
Parker Hannifin Corp	304
Peerless Mfg Co	508
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Piping Technology & Products Inc	206

Exhibition Hall

Alphabetical Order by Company as of March 5

Company	Booth
Precision Iceblast Corp	214
Puretec Industrial Water	310
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Revak Turbomachinery Services Inc	415
Scientech LLC	504
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Exhibition Hall

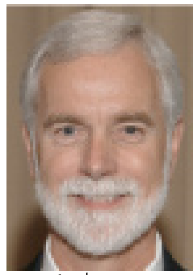
Numerical Order by Booth Number as of March 5

Booth	Company
204	Innovative Steam Technologies
205	BASF Catalysts LLC
206	Piping Technology & Products Inc
207	EST Group
208	Tyco Flow Control
209	SICK Maihak Inc
210	Zeeco Inc
211	Johnson Matthey
212	Central Maintenance & Welding Inc
213	EagleBurgmann Industries LP
214	Precision Iceblast Corp
215	Stress Engineering Services Inc
216	Conval Inc
217	CCI-Control Components Inc
304	Parker Hannifin Corp
305	Severe Service Technology Inc
306	Clark-Reliance Corp
307	Express Integrated Technologies LLC

Booth	Company
308	Voith Turbo Inc
309	ISOPur Fluid Technologies Inc
310	Puretec Industrial Water
311	Midwest Towers Inc
312	European Technology Development
313	John Crane Mechanical Seals
314	Siemens Energy
315	Haldor Topsoe Inc
316	KE-Bergmann USA Inc
317	Vogt Power International Inc
404	MOGAS Industries Inc
405	Valvtechnologies Inc
406	Ludeca Inc
407	ChemTreat Inc
408	CMI Energy
409	Coen Company Inc
410	Cormetech Inc
411	National Electric Coil
412	NAES Corp
413	Ice Solv LLC
414	Chanute Manufacturing
415	Revak Turbomachinery Services Inc
416	Hurst Technologies Corp
417	Alstom Power Inc
504	Scientech LLC

Booth	Company
505	Fluidic Techniques
506	Bremco Inc
507	Structural Integrity Associates
508	Peerless Mfg Co
509	Megawatt Machine Services LLC
510	Hamworthy Peabody Combustion Inc
511	Donaldson Company Inc
512	Titan Contracting & Leasing Inc
513	General Physics Corp
514	Southeastern Construction & Maintenance
515	GEA Power Cooling Inc
516	Quest-Tec Solutions
517	Nooter/Eriksen Inc
604	Dekomte de Temple
605	E H Wachs Co
606	Membrana
607	Conax Buffalo Technologies Inc
611	HRSG User's Group
612	Thermal Ceramics Inc
613	Fuel Tech Inc
614	Phoenix Turbine Services Inc
615	Cortec Corp
616	HRST Inc
617	JASC-Jansen's Aircraft Systems Controls Inc

HRSG XVIII


Anderson


Swanekamp

The annual conference and exposition of the HRSG User's Group is perhaps the largest gathering in the world of major owner/operators affiliated with the combined-cycle/cogeneration sector of the electric power industry. It traditionally draws about 350 participants; many are plant managers and heads of O&M departments.

The organization has matured, since its inception in 1993, from a handful of powerplant managers discussing elementary problems like "gage glass leaks" to a globally recognized professional association of more than 1500 members in more than 50 countries committed to pushing back the boundaries of HRSG technology.

Chairman Bob Anderson and Communications Director Rob Swanekamp say, "We're fortunate in that we continue to expand and increase our service offerings to a growing global community of HRSG users." Key to that success, Chairman Anderson points out, is the true collaboration the group fosters among users, manufacturers, and service providers. All conference and workshop sessions are open to all three to provide the broadest possible perspective and experience base.

Swanekamp reminds that the organization was founded with the focused goal of helping members solve problems associated with the steam-cycle portion of GT-based combined-cycle and cogeneration facilities.

It is unique in terms of "deliverables," he continues. The many GT user groups serving the industry publish no "proceedings"—written or audio—although most provide copies of PowerPoint presentations on their websites. By contrast, the in-depth content of HRSG meetings is captured in a comprehensive summary report of 30 or more pages written by Swanekamp—a registered professional engineer, veteran plant manager, and respected editor—and provided to each attendee as part of his or her registration fee.

Swanekamp is the editor of the *HRSG Users Handbook*, which contains more than 500 pages of useful ideas and best practices on the design, operation, and maintenance of these specialty boilers (details at www.hrsgusers.org).

HRSG Users Handbook a valuable resource

The knowledge base for proper design, operation, and maintenance of that special class of power boilers known as heat-recovery steam generators (HRSGs) essentially resides in the minds of a thousand or so engineers. Surprising as it may seem, relatively little generic information on the subject had been compiled in one volume until the *HRSG Users Handbook* was published four years ago this spring.

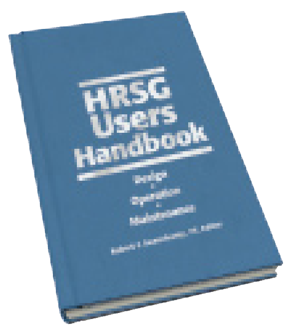
The 6 x 9 in. handbook, which contains more than 500 pages of valuable information on the design, operation, and maintenance of HRSGs, is a ready reference in hundreds of combined-cycle and cogeneration plants worldwide. Rarely a month passes that Editor Rob Swanekamp, a registered professional engineer with nearly two decades of hands-on powerplant management experience, doesn't receive at least one note on how the *HRSG Users Handbook* helped in solving a problem. What follows is a chapter-by-chapter summary of the book's content. For more information, and to order, visit www.hrsgusers.org.

Content easy to digest

Chapter 1. Operational safety.

2. **HRSG design,** with subchapters on writing specifications and on vertical and small boilers.
3. **Commissioning and initial start-up,** including steam-system cleaning and initial performance testing.
4. **Steam system operation** has subchapters on best practices, steam bypass systems, duct burner operation, and attemperators.
5. **Performance monitoring** of the HRSG and of the steam turbine and condenser.
6. **Water treatment,** perhaps the most comprehensive chapter, has subsections on HRSG failure mechanisms, makeup water treatment, steam-cycle chemistry, HRSG layup, cooling-water treatment, and water-chemistry automation.
7. **Emissions control and CEMS.**
8. **Maintenance program development.**
9. **HRSG maintenance,** including standard practices, how to find and fix tube leaks, welding tube-to-header joints, NDE tools, special maintenance practices.
10. **Piping systems,** including the basics and special piping considerations.
11. **Valve maintenance.**
12. **Ductwork, dampers, and stacks.**
13. **Duct-burner maintenance.**
14. **Instrumentation and controls.**
15. **Plant staffing and organization.**
16. **Failure analysis.**
17. **Outage management.**

In addition, there are three handy appendices—including a directory of key industry suppliers and a glossary of acronyms and abbreviations.



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Preservation program works for outages from one month to several years

When Araucaria Power Station successfully completed acceptance tests in September 2002, no one thought the facility would spend the next four years in layup and, in the process, become a center of excellence for equipment preservation that would earn plant personnel the respect of combined-cycle owner/operators worldwide.

The 484-MW, 2 × 1, 501FD2-powered facility was built in southern Brazil, near Curitiba, the capital of Parana state, by a consortium consisting of El Paso Corp, Copel, and Petrobras. El Paso is the gas producer known to most readers, Copel is the state-owned electric and telecommunications firm known officially as Companhia Paranaense de Energia, and Petrobras is the semi-privatized oil giant controlled by the Brazilian government and known formally as Petroleo Brasileiro SA. El Paso later sold its 60% share in the facility to Copel, which now owns 80% and operates the plant; Petrobras holds the remaining shares and manages the gas supply and electric sales.

1. Marcos Freitas, operations supervisor; Fernando Albuquerque, operations manager; and Jean Ferreira, operations shift leader (l to r), are members of the team that developed the long-term preservation program for Araucaria

The hold-up in commercial operation had to do with contractual terms in the power purchase agreement that were not consistent with the intent of Brazilian laws.

Over the four-year layup, Araucaria's O&M team developed and implemented a comprehensive equipment preservation program for the outdoor plant. Operations Shift Leader Jean Carlos Nunes Ferreira, Operations Supervisor Marcos de Freitas, and Operations Manager Fernando Cavalcanti de Albuquerque (Fig 1) told the editors that OEM recommendations were strictly followed during this process.

Proof of the program's success was that recommissioning and commercial operation were achieved in only seven weeks following the long outage, and plant availability is consistently above 98%, except for a forced outage caused by a short circuit in the steam turbine's generator stator in early 2008.

Recently, the plant O&M team reviewed and improved the long-term program to enable faster installation and removal of preservation systems, thereby enabling their deployment for shutdowns of one month or more in duration when economical and consistent with grid requirements. In a typical year, the plant operates at or near base load in winter and as needed during the "hydro season."

Note that more than 80% of Brazil's electricity needs are met by hydropower, and when reservoirs are full, thermal generating plants may be in layup for months. To learn more about the country's energy sector, visit www.psimedia.info/handbooks.html and click on the "2010 Brazil Energy Handbook" at the upper right corner of your screen.

Program overview

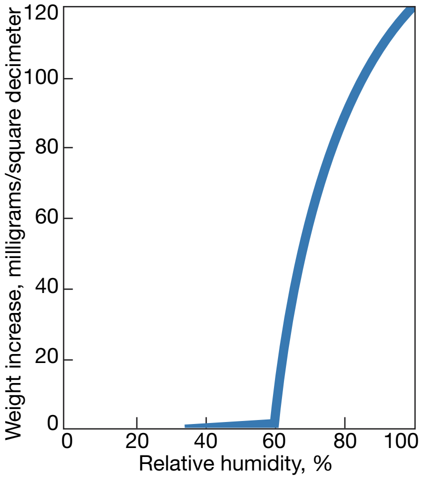
Albuquerque described plant preservation as a combination of protecting equipment against degradation—such as is caused by corrosion, erosion, sunlight effects, etc—and maintaining its operability through periodic operation and/or testing.

To achieve these goals, long-term preservation programs were developed for the gas turbine/generators (GTG), heat-recovery steam generators (HRSG), steam turbine/generator (STG), and balance-of-plant (BOP) systems.

The foundation for this effort was the experience Copel personnel had gained at other plants, assistance from NAES Corp (sidebar), and, as mentioned earlier, documentation from OEMs and service providers. Regarding the HRSGs specifically, some of the lessons learned and best practices described in the "HRSG Users Handbook," compiled by Robert C Swanekamp, PE, of the HRSG User's Group, were incorporated into the Araucaria plan.

Key features of the program included the following:

- Maintain relative humidity (RH) on the gas side of the HRSGs, and in the ST low-pressure (LP) section, at less than 40%. Fig 2, from



2. Relationship between corrosion rate and the moisture content of air shows the importance of maintaining relative humidity below about 40%

a maintenance guide supplied by STG manufacturer Alstom Power, shows corrosion products are produced at an exponential rate when RH exceeds about 60%.

- Analyze and maintain cooling-water chemistry on a regular basis according guidelines provided by the tower supplier and GE Water & Process Technologies.
- Protect exposed surfaces by painting in accordance with recommendations from Lactec, a local technology institute and formerly part of Copel.
- Perform tests and inspections according to long-term shutdown procedures provided by the manufacturers and conduct preventive, predictive, and corrective maintenance as recommended in the plant maintenance manual. The foregoing activities must comply with environmental, safety, and health regulations and are facilitated by use of Copel's computer-based O&M operations management system.
- Keep all space heaters for electric motors and generators on "automatic" when the equipment is not in service and check heater performance quarterly.

3. Dual-pressure HRSGs produce steam at 1465 psig/977F and 81 psig/507F

4. Curtains prevent air from entering the gas turbines' compressors

HRSGs, steam systems

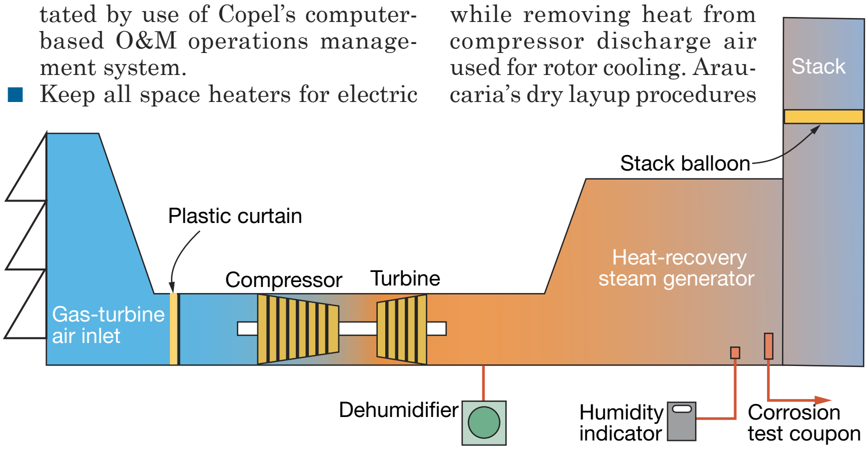
Each of the plant's two dual-pressure HRSGs (Fig 3) has a kettle boiler incorporated in the LP section. Its purpose is produce steam while removing heat from compressor discharge air used for rotor cooling. Araucaria's dry layup procedures call for first draining the (1) water side of the boiler, including superheater, evaporator, and economizer panels; (2) HP and LP steam piping, (3) kettle boilers, and (4) the water side of the fuel gas heater.

Step two: Backfill those sections with nitrogen and pressurize the inert atmosphere to about 7 psig. Finally, check the concentration of oxygen in the inert atmosphere quarterly, bleeding and filling with fresh nitrogen as necessary. Albuquerque mentioned the desire to reduce nitrogen pressure to decrease its consumption. Copel is investigating the installation of more sensitive pressure gages for this use during layups, as well as the advantages of a nitrogen generator.

A plastic curtain closes off the air inlet to the gas turbine (Fig 4). Initially, a curtain also was installed at the stack entrance to isolate the HRSG but that has been replaced by a duct balloon, which is easier to deploy (Figs 5, 6). Dehumidifiers installed outside the HRSG (originally portable and installed inside) condition the space from the turbine inlet to the stack balloon to 40% RH. Space temperature and humidity are monitored via the DCS and alarms sound when limits are exceeded.

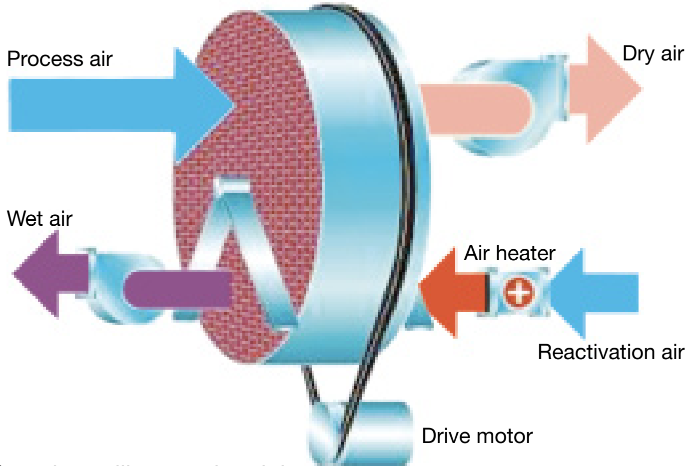
Such improvements have reduced dramatically the manpower requirements and time needed to install and break-down the preservation system. Specifically, the total effort now takes 25% or less time than was required originally, making the system viable for outages of about one month and longer.

To illustrate: The plastic curtain at the HRSG outlet took four people 16 hours to install, including erection of the scaffolding required, and four people 12 hours to remove it. Two people can deploy the duct balloon in about an hour, and take it out of the stack with the same level of effort. Also, it originally took four



5. Curtain and stack balloon prevent outside air from entering the gas turbine and the gas side of the HRSG. When the preservation system was first installed, there was a curtain between the HRSG and the stack and portable dehumidifiers were located inside the boiler casing. The arrangement shown is the optimum solution

6. Duct balloon is simple to install through manhole accessible from catwalk



7, 8. Dehumidifier located outside the HRSG casing (left) works as illustrated at right

man-days to install electric heaters and dehumidifiers inside the HRSG and another three to remove them. Both steps are avoided by use the permanently installed dehumidifier described in Figs 7 and 8.

Today the major effort in preservation system implementation is installation of the plastic curtain in the GT inlet, a task that takes two people about six hours to complete. Removal takes two people four hours.

HRSG and main-steam system fluid handling equipment operated or tested periodically are the following:

- Water-level control valves for the HRSG drums.
- Desuperheater spray-water valves.
- Blowdown valves.
- HP and LP superheater drain valves.
- Fuel-gas heater valves.
- All HP and LP steam-system valves.
- Blowdown-system sump pumps.

Gas turbine/generators

The preservation plan for the GTGs was based on the OEM's recommendations, which proactively guard against corrosion. The inlet curtain and stack balloon described in the HRSG section are the first line of defense against corrosion. In addition, compressor bleed valves, manholes, inspection doors and other openings were sealed to prevent atmospheric air from entering the dehumidified engine. Any leakage through seals, walls, roof, doors of the GTC enclosure were repaired to prevent contamination by outside air.

The following equipment was tested or operated weekly, according to the test schedule developed for Araucaria, except where noted:

- Main lube-oil (LO) pumps.
- DC emergency LO pumps.
- LO vapor extractors.
- Turning-gear motors.
- Control oil pumps.
- Evaporative-cooler pumps (every other day).
- Compressor washing systems (monthly).
- Igniters (command test).

The plant's valve test schedule called for periodic testing or operation of these flow-control devices:

- LO-cooler temperature control valve.
- Main-gas-line vent valve.
- Stages A, B, and C gas control valves (command).
- Pilot-gas control valve (command).
- Kettle-boiler air bypass valve.
- Coolant-flow control valve for disk cavities 2 and 3.
- IGV command.
- LP and HP compressor bleed valves (command).
- Instrument-air valve (command).

Steam turbine/generator

The 164-MW Alstom ST is comprised of HP and LP turbines arranged on one shaft. HP superheated steam flows through the former and into the latter, where it is supplemented by steam from the HRSG's LP superheater.

The condenser hotwell was drained in accordance with the OEM's recommendations and the ST LP section originally was separated from the condenser with a plastic curtain like that used in the GT inlet. Reason for the curtain here was that the circulating water system had to remain in service to prevent wood members in the six-cell mechanical-draft cooling tower from drying out.

Heaters and dehumidifier were installed at the ST exhaust to keep the moisture level below 40% RH. Air temperature and humidity inside the turbine were monitored continuously.

As was done for the HRSG, a ST dehumidifier was permanently installed outside the LP section (Fig 9) and arranged as shown in Fig 10 to eliminate the need for installing/removing plastic curtains and the scaffolding needed to accommodate their installation and removal.

ST auxiliaries operated or tested weekly:

- Main lube-oil (LO) pump.
- DC emergency LO pump.
- LO vapor extractor.
- Turning-gear motor.
- Control oil pump.
- LO purifier pump.
- Gland seal-steam condenser exhausters.
- Jacking-oil pump.

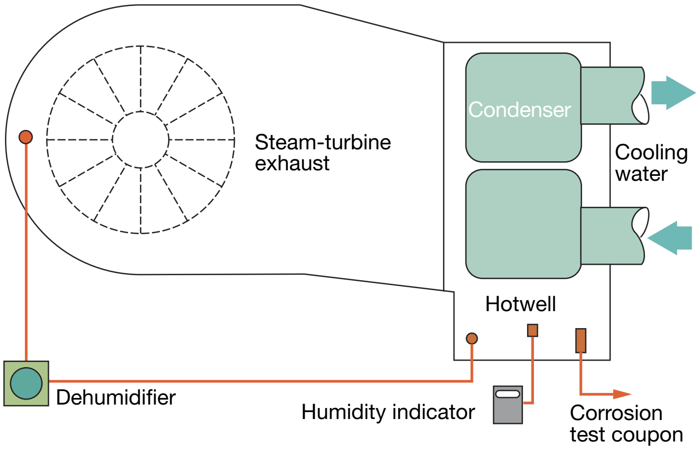
Condensate system

The condensate system has two full-size pumps, preserved as follows with motor and pump coupled throughout the layup period:

- Pump pit maintained dry.
- Pump shafts manually turned twice monthly.
- Bearing lube replaced semiannually.
- Condensate piping from the pump to the HRSGs was pressurized to about 7 psig with nitrogen.
- Suction and discharge piping was drained monthly.

Valves operated or tested as part of the preservation program were the following:

- Condenser makeup control valve.
- Condenser rejects control valve.
- Condensate minimum-flow control valve.
- HP and LP steam-bypass desuperheater spray-water control valves.
- Spray-water control valve for HP steam serving steam seals.
- Steam-jet air-ejector hogging and holding valves.
- Spray-water valve in condenser neck.
- Fuel-gas-heater temperature control valves.



9, 10. Steam turbine has a separate dehumidifier (left) which is located external to the unit (right)

- Backpressure control valve for STG seal water to the STG vacuum-breaker valve.

Boiler feedwater system

Two full-size feedwater pumps are provided with each HRSG. Each pump transfers water from the LP section to the HP section and is equipped with an auxiliary LO pump.

The boiler-feed pumps were drained and suction, discharge, and recirculation valves opened. This allowed nitrogen in the HRSG steam/water circuit to inert the BFPs and connecting piping as well. Pump shafts were manually rotated quarterly as recommended by Sulzer, the pump OEM. The BFP auxiliary LO pumps also were exercised quarterly.

Auxiliary systems

Fuel gas system piping was drained, vented, and pressurized with nitrogen. Valves were tested periodically.

Instrument and service air systems remained in service during the layup. Use of the redundant compressors and dryers was alternated according to the Plant Equipment Test Schedule.

Closed cooling-water (CCW) system also remained in service and the use of redundant equipment alternated.

Condensate/feedwater chemical control system (amine and oxygen scavenger for condensate and phosphate for feedwater) was out of service and inspected and maintained according to the Plant Maintenance Program.

Steam and water analysis system remained in service with a continuous flow of demineralized water.

Demineralized water system was operated quarterly to produce boiler-quality water and maintain the normal level in the demin tank. All functions of all equipment in the two parallel trains were tested and verified—including demin-water production, rinse quality, regeneration, backwash, etc.

The circulating water system serves the surface condenser and CCW plate heat exchangers and provides quench water to the HRSGs' blowdown systems. Operation of the 3 × 50% pumps was alternated to assure one pump was on at all times to keep the cooling tower's wood members wet and to provide blowdown for the wastewater system clearwell. Operation of the six tower fans also was alternated weekly.

The raw water system remained in service to supply water to the GT evap coolers. Filter feed pumps and the filter backwash pump were run quarterly.

The wastewater system, including the sewage treatment system, operated continuously. The waste neutralization tank was operated quarterly (in concert with the demin water system), sump pumps and the oil/water separator whenever it rained.

Chemical feed system remained in service and chemistry was monitored daily.

Plant DCS and major equipment control systems were kept in service and exercised as recommended by the manufacturers.

The plant auxiliary electric systems, backfed from the grid, remained in service. The emergency diesel/generator also was maintained ready to enter service when required. CCJ

NAES forms company in Brazil

NAES Corp, Issaquah, Wash, recently formalized its presence in Brazil by launching NAES Servicos de Operacao e Manutencao Eletrica Ltda, with headquarters in Rio de Janeiro state. The company sees a bright future for Brazil, the world's fifth most populous nation and 10th largest electricity market.

NAES Corp is not new to international markets. It began working outside the US in the mid 1990s, following the lead of powerplant developers chasing promising opportunities in Latin America and the Caribbean. At one point, NAES had as many contracts in those markets as it had at home. Today the company provides O&M services for generating plants in Canada, Mexico, and Colombia, and recently signed an agreement to operate and maintain one Brazilian project as it actively pursues others.

NAES was working in Brazil prior to establishing NAES Servicos. Activities included participation in the development and implementation of Araucaria Power Station's long-term preservation program. Operations Manager Fernando Albuquerque said NAES advisors, who were onsite to assist in the development of O&M programs before plant commissioning, remained after the facility was placed in layup to share their preservation experience. Albuquerque recalled their significant contributions in the areas of valve and motor care and testing that were the first steps towards a more comprehensive preservation program.

NAES remains involved with the Araucaria project to this day, advising Copel on gas-turbine matters. NAES has deep experience in 501F technology, having operated and maintained more than two dozen of these engines.

CRV Plate helps protect servo-valve components against varnish

By Cary Forgeron, CLS, Analysts Inc

Since 2004, many articles have been published on the subject of varnish and related problems in gas and steam turbines. They have discussed the causes of varnish, tests used to measure varnish levels, and the technologies available to "solve" the problem. But six years later, the war on varnish continues.

What is known

Simply defined, varnish is a thin insoluble film known to form on bearings and servo valves. It is a high-molecular-weight substance and insoluble in lubricating oil (LO). The "insolubles" are made up of more than 75% soft contaminants less than 1 micron in size. They have polar affinities and migrate from the body of lubricant to machine surfaces over time—a process influenced by the "conditions" of the system and lube oil.

The $64 question: What are these "conditions"?

The answer: Lubricant temperature and flow.

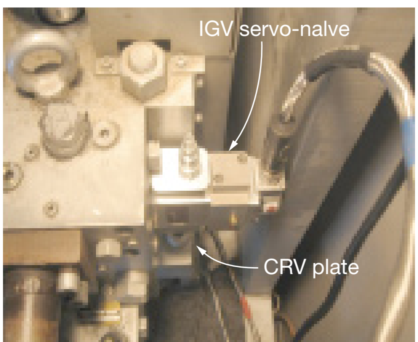
In a presentation at the 2008 meeting of the Society of Tribologists and Lubrication Engineers, James Hannon of ExxonMobil Corp presented a paper detailing the effects of LO temperature on varnish solubility ("Sensitivities in Turbine Oil Varnish Prediction").

ExxonMobil's research found that varnish goes back into solution as oil temperature increases; conversely, it becomes less soluble as temperature decreases. Some readers may recall Hannon as the author of a primer on LO sampling and analysis that appeared in the 2005 Outage Handbook (access www.combinedcyclejournal.com/archives.html, click 3Q/2004, click "Maintain lube oil within spec to ensure high reliability" on cover).

Additional research conducted in The Netherlands by Hans Overgaag and his colleagues at Ansaldo Thomassen (ATH), and made public last year, revealed that while temperature is a major factor in varnish plate-out on critical system components, insufficient LO flow is equally significant ("Up to Date Turbine Oil System Management"). For a backgrounder on the Ansaldo group of companies, return to the CCJ archives, click 3Q/2009, and click "Italian Power Generation" on the cover.

The ATH research demonstrated that when oil is stagnant (even at normal operating temperatures), conditions exist for varnish to agglomerate and plate out onto system components and surfaces.

Example: If a lubricating oil is at operating temperature and has been circulating through the system at the time of sampling, a QSA® varnish test performed onsite will report a low varnish potential rating (VPR). By contrast, the same sample submitted for QSA testing in the laboratory at ambient temperature (nominal 70F) that has been left standing for more than 72 hours could produce results indicative of a VPR "alert."



1. CRV Plate installed on the servo valve controlling the inlet guide vanes on a 7FA gas turbine mitigates varnish formation

The variability in results reflects the impact of differences in temperature and flow characteristics. Laboratory testing is important in that it clearly identifies the systems having high varnish potential and requiring intervention and corrective action—such as filtration, bleed and feed, or total fluid replacement.

References to terms like auto-degradation and thermokinetics, which imply a change in fluid chemistry, are incorrect. Onsite testing reflects the solubility of varnish particles at operating conditions, while QSA testing in a laboratory environment identifies the actual varnish potential.

To learn more about varnish in general, and QSA in particular, access the CCJ archives (see above), click 3Q/2006 (2007 Outage Handbook), and click the following articles on the issue cover: "Gas-turbine valve sticking . . . the plot thickens" and "Assess the condition of your oils, prior to the outage."

Addressing the symptoms

The major effects of varnish generally are identified with the hydraulic circuits for GT control systems. Inspections of circuit components have revealed plugged last-chance and pencil filters and lacquered servo-valve parts—conditions conducive to costly system flushes and unit trips, and possibly the inability to start the unit in the first place.

Focusing on the components most affected by varnish and the conditions that lead to varnish formation, Ansaldo Thomassen developed the Cross Relief Valve (commonly referred to as the CRV Plate). The operating principle of the CRV Plate is based on the creation of a controllable oil flow through the servo valve independent from control-system settings and commands, but without interfering with the principal control functions.

The nominal flow capacity of a servo valve rarely is attained. Most often, a steady-state or static condition exists and there is little oil flowing, perhaps none at all. Once installed, the CRV Plate allows oil to move through the servo valve up to the actuator, thereby assuring normal lube-oil operating temperature in the typically stagnant sections of the electrohydraulic control system.

This solution ensures that the control system is continually exposed to conditions that mitigate the formation of varnish on critical system components. The CRV Plate does not affect servo-valve operation and its installation does not require physical modifications to the control system. In some cases, minor modifications to the servo-valve conduit may be necessary.

Proof of the CRV Plate's value is illustrated in Figs 2 and 3, which show the last-chance filter for a gas splitter valve on a Frame 6 turbine. In Fig 2, varnish covers the filter inside and out. The operating time on the oil is approximately 4000 hours and QSA testing confirmed a VPR of 68 (an alert level).

The valve and filter were replaced and a CRV Plate was installed, but the LO was not changed-out. Fig 3 shows the filter after approximately 3000 hours of operation. Note that there is no agglomeration of varnish on the filter media, despite QSA results indicating an increase in the oil's VPR. Since installation of the CRV Plate, there have been no operating issues related to varnish formation in the corresponding servo valve.

2, 3. The positive impact the CRV Plate has on varnish mitigation is easy to see by comparing the two photos of the filter for a fuel splitter valve. At the left, note the extensive fouling prior to installation of the CRV Plate. Replacement filter at right has 3000 hours of operation on the same oil after the CRV Plate was installed

Continue the fight

The CRV Plate currently is designed for and applied on Moog Inc Type G771 and G772 servo valves used on GE frames. To date, the CRV Plate has operated over 50,000 hours at five sites problem-free. Extensive field testing over the past three years has revealed no sludge or varnish buildup in servo valves or last-chance filters in units where the CRV Plate is installed.

Important: The CRV Plate does not remove varnish from the system or reduce QSA VPR levels. However, it is an excellent tool for use as part of a comprehensive strategy to control the degradation of turbine lube oils and improve unit reliability. To date, there still is no silver-bullet fix for solving the varnish issue. Your best strategy may be a multifaceted approach incorporating the CRV Plate, fluid condition monitoring, and appropriate mitigation technologies (filtration, top-offs, etc).

In sum, the CRV Plate is a major advancement in the fight on varnish. It can mitigate immediately the effects varnish has on GT hydraulic control systems. Implementing the CRV Plate solution allows the time needed to properly evaluate the condition of your lube oil without risking a unit trip and to make the proper decision on how best to address the varnish issue in your system going forward. CCJ

Maintaining carbon-brush collectors

Clyde V Maughan, Maughan Generator Consultants

Carbon-brush collectors have successfully transferred current from excitation power sources to the rotating fields of synchronous generators for over a century. The basic principles of current transfer have remained the same over that time, although numerous improvements have been made in brush and collector-ring materials, brush-holder designs, and ventilation arrangements.

Still, carbon-brush collectors require ongoing attention from O&M personnel. While this work is of a relatively minor nature, the collector operates at 100 to 700 Vdc in a very noisy and windy environment. Thus there is an understandable reluctance on the part of plant staff to perform the necessary online service of the brushes and collector.

The result: Collectors are sometimes overlooked, and failures occur. Such failures can be severe and the resulting forced outage may be long and costly.

Rotating rectifiers have gained market share on carbon-brush collectors since the late 1970s because of the latter's need for ongoing attention, and the occasional failure. Rotating rectifiers generally have given good service, particularly on small generators. However, rotating rectifiers have inherent limitations and weaknesses, and carbon-brush collectors still are preferred for large machines. Remember, too, that carbon-brush collectors are installed on tens of thousands of generators in service.

Carbon-brush collectors will give high reliability, provided the generator OEM's recommendations are followed. Keep in mind that the O&M procedures summarized in this article apply to carbon-brush collectors in general; consult the OEM for information specific to your equipment.

Basic principles of collector operation

Generator performance is monitored by many devices. But even with state-of-the-art instrumentation, several important generator deterioration mechanisms are not monitored at all—including those associated with the collector. This means that collector condition must be determined by looking directly at the collectors and brushes themselves—a requirement often cited as the primary reason collectors sometimes are neglected and subsequently fail in service.

Collectors require continual minor attention, primarily because of brush wear. Although providing this attention may seem like an inconvenient chore, it is an extremely important function of the O&M staff. Fortunately, collectors almost never fail without ample warning, so regular observation allows plant personnel to spot and correct potential trouble long before a failure can occur.

Simply put, reliable collector performance requires the following actions:

- Making daily direct observations.
- Recognizing the warning signals of impending failure.
- Taking timely corrective maintenance action.

Keep in mind that dependable brush-to-collector current transfer relies on the following three conditions, which must he satisfied simultaneously:

1. Good collector surface film. Correct balance is needed between the film-forming and the polishing actions of the brush on the collector ring. Balance depends on the brush material (usually natural graphite with a small amount of abrasive material and suitable binder), and on the ring material (typically hardened steel on large generators).

Contaminants in the cooling air can adversely influence this balance, as can low humidity, since water molecules are a necessary ingredient of a good film.

2. Proper brush contact pressure. Satisfactory transfer of current between the brush and the ring demands that contact pressure be maintained within limits established by the manufacturer. This means that the brushes must not hang-up in the holder and that the spring pressure must be correct.

Early machines were supplied with a helical-coil-spring brush holder, which required periodic manual readjustment of the spring force to compensate for brush wear. Brush holders with a constant-pressure spring are now common, and they have virtually eliminated problems caused by improper contact pressure.

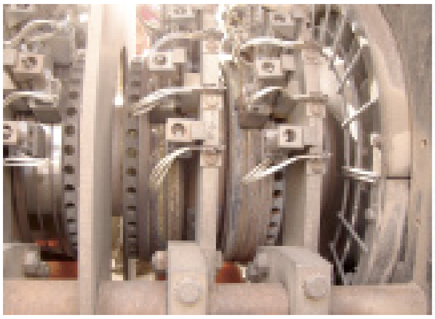
3. Continuous brush-to-ring contact. When a collector ring and its brushes are not in continuous contact, arcing results. Once arcing becomes visible, operating performance deteriorates rapidly. Thus arcing should be recognized immediately as a warning of impending serious trouble.

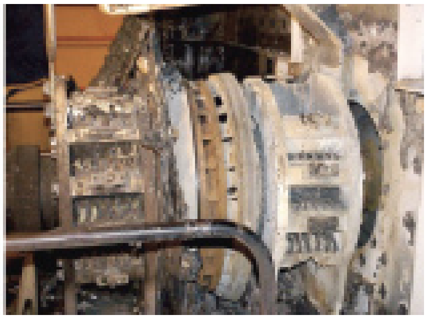
Loss of continuous contact is caused by excessive brush vibration, which can be cured only by reconditioning the collector-ring surface. This assumes that the shaft excursion caused by unbalance is acceptable.

Causes of collector outages

Collector outages usually are caused by (1) a planned outage to resurface the collector, or (2) a forced outage caused by collector flashover.

Flashover is a term that describes the opening of the highly inductive generator field circuit at either one





1. Flashover involving rings in only one polarity is shown at the left; that between rings of both polarities at the right.

or both collector polarities. Typical consequences of flashover are shown in Fig 1. Arcing between the brushes and the associated pair of rings of one polarity is evident in the left-hand photo.

The result is burning of the brushes and arc damage to the ring surfaces of the one polarity. The ring of opposite polarity—at left in the photo—remains undamaged.

In the right-hand photo, the flashover involved both polarities and the arc damage was great. The associated arc would present a severe hazard to any operator in the area. Temperatures were sufficiently high to distort the forgings of the fan between the polarities. The appearance suggests that shedding of rotating parts, with associated extreme hazard to personnel, was imminent.

Breakdown of the insulation separating the two polarities, which are at different but low electrical potentials, is a rare occurrence. The open circuit results from a progressive loss of contact between the ring and brushes which causes current transfer by arcing across the gap until the gap becomes too large for the arc to be sustained. This action is similar to very slowly opening a knife switch in an inductive circuit.

To compensate for the energy lost during heavy arcing prior to flashover, the automatic voltage regulator simply calls for higher exciter output to keep the generator terminal voltage constant. This action can be identified indirectly by the presence of erratic and generally higher-than-normal temperature indications on the generator field temperature recorder (because the recorder uses the quotient of excitation voltage to current, both measured on the brush-rigging side of the collector).

Lesson learned: Do not assume that erratic behavior of the generator field temperature recorder means the instrument is malfunctioning. If the temperature recorder is giving erratic readings, immediately check the collector for arcing.

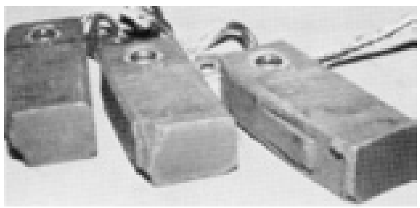
Identifying problems

As noted earlier, reliable collector performance depends on a good surface film, proper brush-contact pressure, and continuous brush-to-ring contact. What follows are several suggestions on how to identify an impending failure, as well as some guidelines—best practices, if you will—for corrective maintenance to help avoid a turbine/generator forced outage.

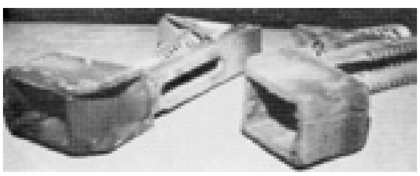
Ventilation. High-capacity collectors are cooled by forced convection, typically with ventilating air pumped by shaft-driven fans. Proper ventilation is important for preventing overheating, which can result from (1) blocked passages in intake or exit ducts, (2) plugged ventilation holes in the collector rings themselves, or (3) plugged filters.

The initial effect of overheating usually is increased brush wear, but high wear rates can lead to other, more-serious problems. Temperature of the collector inlet and outlet cooling air is monitored to gage collector ventilation performance. Pay close attention to the OEM recommendations on temperature-rise limits.

Surface-film contamination. Contaminants in the cooling air—such as oil vapor, ammonia, abrasive dust, insects, vapors from silicone rubber, etc—impede the formation of a good, stable film on the collector rings. The film, consisting of layers of metal oxide, graphite, and adsorbed water vapor, lubricates the contact surface. Without this lubrication, brush friction would increase dramatically, causing excessive wear, chatter, and brush breakage (Fig 3).



2. Brushes suffer excessive wear and breakage when the collector film does not adequately lubricate the contact surface between them and the collector ring



3. Good air filter maintenance is important to preventing damage to brush holders caused by oil and dirt

Film quality is not easily discernible by looking at a collector ring; plus, there often is more than one possible cause of any observable symptom. The search for answers is made more challenging by the simple fact that contaminants and their sources of origin typically are difficult to identify.

Solid contaminants usually can be removed from cooling air by proper filtration, and by sealing intake leaks around pipes and bus work. To avoid the potential for cooling problems caused by reduced air flow as the filters collect particulates, consider specifying an impingement filter. It will pass dirt along with air as the filter approaches its holding capacity, thereby avoiding plugging and consequent overheating. Regardless of the type of filter installed, focus on your filter's ability to maintain the level of cleanliness required.

Gaseous contaminants originating in the plant, such as oil vapor from bearings and pipe joints, can and should be eliminated at their sources. However, gaseous contaminants from sources external to the powerplant—such as a nearby chemical plant—generally cannot be eliminated and they require adoption of more rigorous maintenance practices.

When developing a collector-ring program to suit your situation, keep in mind that the residue of common cleaning solvents left on the rings itself is a serious contaminant. Suggestion: After cleaning rings with a solvent, clean the ring surface again with alcohol and carefully wipe it dry.

Another idea: Periodic application of a canvas wiper (one made from canvas not treated with chemicals) can, under some circumstances, prevent excessive buildup of contaminants on the ring surface.

Mixing or misuse of brush grades. The performance of an individual brush on a collector depends heavily on the brush's properties. Tight quality control is maintained by the brush manufacturer to hold the properties of each brush grade within a very narrow band. Despite such efforts, even brushes of the same grade will not necessarily share current equally—that is, they may exhibit some selectivity.

Mixing of brush grades on the same ring can lead to intolerable selectivity, which may cause a pigtail to burn off and make that brush inactive. The remaining active brushes will overload as a consequence, and a runaway condition may start. This could lead to collector flashover.

The original brush grades recommended by the turbine/generator manufacturer normally should be satisfactory. However, if difficulties are experienced, consult the OEM before finalizing your decision on a new brush grade.

Also, before installing brushes of a new grade, be sure to clean the ring surface down to bare metal, using guidelines provided in the generator manufacturer's instruction book. This allows the new brush grade to form its own characteristic film. After switching brush grades, discard all brushes of the old grade to avoid subsequent mixing.

Brush contact pressure. Failure to maintain correct spring pressure has been a frequent cause of collector flashover. Proper pressure is required to (1) keep brushes in contact with the ring, and (2) have all brushes carrying a near-equal share of the current. Brush holders using helical-coil springs require periodic spring tension adjustment to compensate for reduction in brush length because of wear; constant-pressure springs do not require such adjustment.

Brush current density. While often overlooked, incorrect brush current density can cause serious operating problems. Examples: Too-high density causes brushes to run hot; too-low density is conducive to high brush and ring wear.

Experience suggests that a current density of around 50 amp/in.^{2} of brush contact area is a reasonable rule-of-thumb target for typical brush grades. At 60 to 70 amp, most brush grades will operate too hot; at 30 amp, a poor film is likely to exist.

If brushes are wearing rapidly, or if they are running hot, operation may be improved by removing or adding brushes, respectively. However, before changing the number of brushes from the original design, contact the OEM for specific recommendations.

Brush hang-up and chatter. Brushes can hang up in their holders for various reasons, including the following:

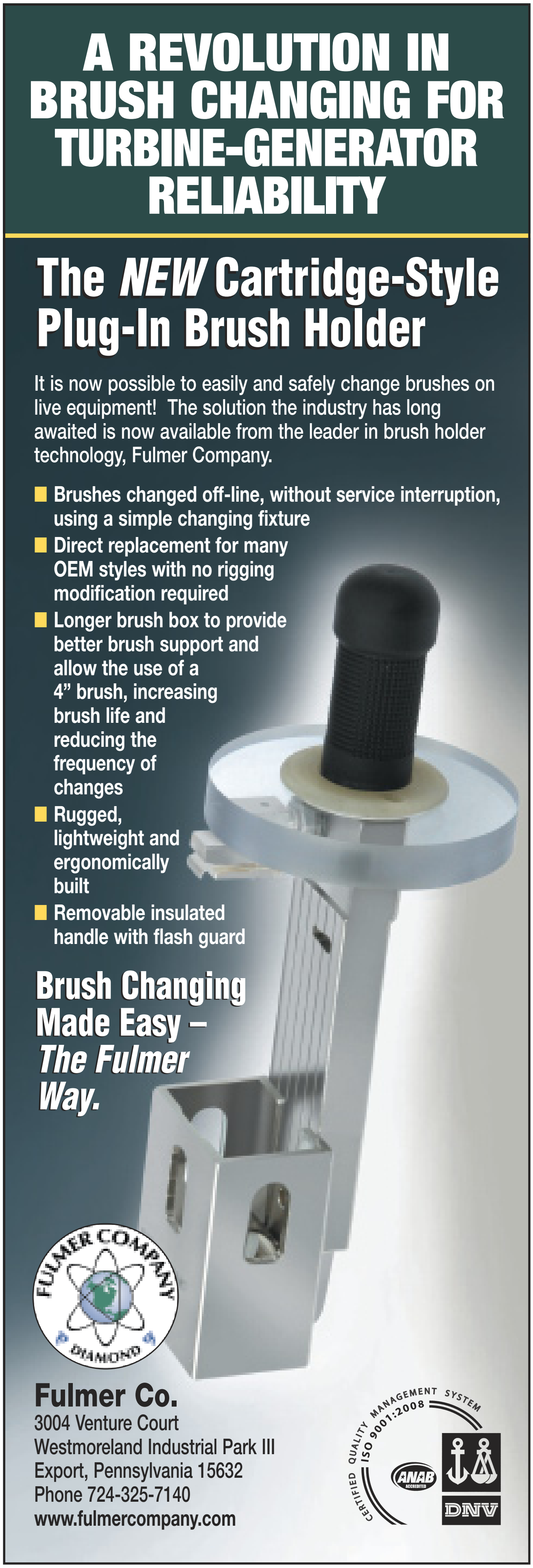
- A buildup of contaminants and/or carbon, restricting free motion of the brush (Fig 4).
- Brush worn too short, allowing the pigtail to rub against the box.
- Size incompatibility between holders and brushes.
- Brush chatter.

The most common cause of brush hang-up is chatter, a term that describes tangential brush vibration. It is attributed to high or non-uniform friction around the ring periphery—which, in turn, usually is caused by ring contamination.

Cutsforth Inc

4. Buildup of carbon inside the brush box can restrict brush movement

If the brush does not ride smoothly on the ring, and chatter results, the top edge of the holder can wear a ridge in the side of the brush. The brush may then sit on the ridge and not respond to spring pressure. Thus, the brush becomes unloaded electrically. If enough brushes hang up, arcing will start, and may eventually result in a flashover.

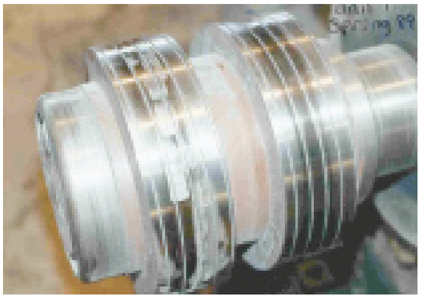


Practical idea: Detect hung-up brushes by visual observation, or by feel with an insulated stick. If vibration feels unusually low on an individual brush, it may not be riding on the ring surface.

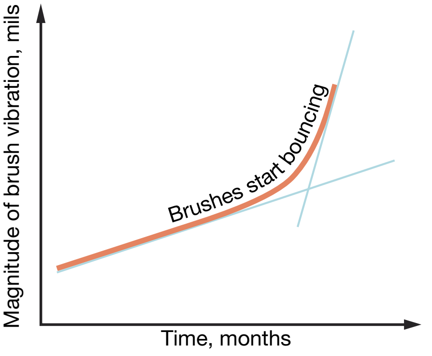
Short brushes are another major cause of flashovers. When brushes reach the end of their useful wear length, they must he replaced. Consult the OEM's instruction book for recommendations.

Continuous brush-to-ring contact. Excessive collector vibration can cause brush bounce, arcing, and ultimately, a flashover. Thus, it is important to monitor the magnitude of brush vibrations, and the dominant frequencies of several specific brushes. Assuming unchanged generator balance, expect brush vibration to increase slowly over a long period of time, because of collector-ring wear. Generally, a series of peaks and valleys form around the periphery of the ring (Fig 5); also, ring contour may vary from brush track to brush track.

If vibration increases to high levels, there comes a point when the brushes are no longer able to maintain contact with the ring around its entire periphery and they start bouncing and arcing. Under such conditions, arc erosion of the ring surface quickly deepens existing valleys. From this point, vibration increases much more rapidly with time (Fig 6), causing brush chipping and breaking, and ultimately, a flashover if it is not corrected.



5. Pattern of brush wear on collector generally is characterized by a series of peaks and valleys around the periphery



6. If brush vibration increases rapidly with time, the condition should be investigated immediately and the necessary corrective action taken

There is no characteristic level of brush vibration that signals the onset of brush bounce, because the outward radial force on the brush depends on brush mass and acceleration, not displacement. Fairly high radial displacements—that is, those attributed to shaft unbalance—can be tolerated on 50- and 60-Hz equipment.

But if peaks and valleys develop in the ring periphery, higher vibration frequencies will result and there will be higher forces on the brush. Since acceleration is proportional to the square of the frequency, these forces may become quite high.

The electric power industry generally accepts brush-vibration magnitudes of less than 6 mils for collectors on 3000- and 3600-rpm generators. Severe problems usually begin to occur soon after vibration-induced displacements increase beyond about 10 to 15 mils.

Best practice: Monitor the vibration of selected brushes weekly and plot vibration magnitude against time. If vibration begins to increase

Collector inspection, maintenance checklists

Carbon-brush collectors require daily observation as well as periodic maintenance. While the work is inconvenient, the effort involved is relatively minor. The checklists below are intended as a guide for reviewing present plant collector practices. A well-defined and well-executed inspection and maintenance program will help assure reliable collector operation for the life of the generator.

But before you rush off onto the turbine/generator deck, keep these pointers in mind:

- First and foremost, observe *all* required safety precautions. Never compromise personnel safety.
- Do not leave problem indications unattended.
- Maintain ongoing records of collector condition and problems.
- Do not mix brush grades, or substitute brush grades, without first consulting the generator manufacturer.

Daily inspections

- Look for sparking between brushes and rings.
- Listen for brush chatter.
- Check for any instability or increase in field-temperature-recorder readings.
- Look for any changes from previous conditions.

Action: Report any abnormalities to responsible plant maintenance and/or management personnel.

Weekly maintenance

- Check for dust or oil.
- Look for short brushes and check all brushes for hang-up in the brush holder.
- Look for loose, frayed, or blue pigtails; examine brush springs and pigtail connections.
- Observe brushes and pigtails with an infrared scope.
- On brush holders without constant-pressure springs, adjust spring pressures so they are all within proper range.
- Remove a brush at random and examine its wear face for evidence of pitting, edge chipping, grooving, and threading.
- Spot-check for vibration, and record/plot the levels on a long-term chart.
- Observe collector-ring surfaces with a stroboscope.
- Replace worn and/or deficient brushes—one brush (or magazine) at a time.
- Note the appearance of collector-ring surfaces, and of the brush films on the rings, for any change from normal.
- Inspect air filters. Replace or clean as necessary.

Action: Record conditions and correct any deficiencies.

At each shutdown

- Check insulation resistance and polarization index.
- Measure run-out in each carbon-brush track.
- Look for worn parts, and replace as necessary.
- Check clamps and bolts for tightness.
- Clean off dirt and dust and other contaminants.
- Inspect air passages.

Action: Report any abnormalities to responsible plant maintenance and/or management personnel. Record data and correct any deficiencies.

rapidly with time, investigate the condition immediately and take corrective action.

Ring resurfacing. Corrective action on collectors can include ring resurfacing by grinding or stoning. In extreme cases, machining is required before grinding. There are two acceptable methods for grinding and truing rings:

- On turning gear, with a rotating grinding wheel (Fig 7). The objective is to get the collector ring round, and if the shaft is balanced properly, that is how the ring will appear to the brushes at speed.
- At rated speed, with a rigid stone (Fig 8). The objective is to compensate for shaft vibration by making the ring appear round at speed. In other words, you "grind out" the vibration. However, any later changes in rotor balance also will change the effective ring contour.

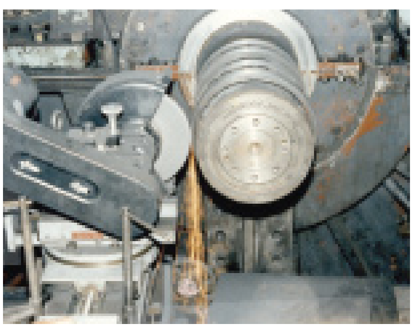
Both methods, when properly done, give the brushes a smooth, continuous, polished surface on which to ride.

Consider periodic collector-ring resurfacing routine maintenance. Collector rings have sufficient stock to last the lifetime of the generator. However, if you must resurface a ring more frequently than once every two or three years, it's a good idea to identify the reasons for the ring-surface deterioration and take corrective action. The penalty for not being proactive may be excessive maintenance and eventual collector replacement. If ring wear reaches a point where the spiral grooving must be re-established, this can be done with the field in place (Fig 9). Eventually, however, the ring must be replaced if mechanical stress limits are approached.

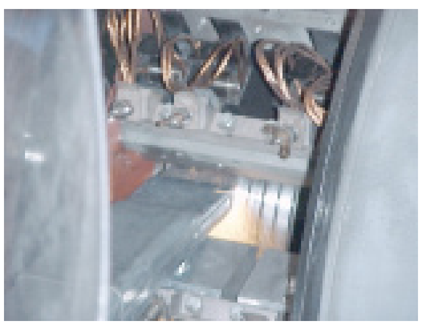
Retrofitting brush holders

A review of industry experience indicates that a primary reason for collector problems—flashovers in particular—is the failure to perform the relatively minor routine inspection and maintenance tasks required for reliable operation. There is legitimate concern with hazards to personnel and equipment because of the need to adjust and replace brushes while the generator is operating.

Though field voltages are relatively low and the field is intended to operate ungrounded, a possibility exists that a ground may have developed. Also, there still exists the volt-


AEP

7. Objective of grinding collector rings on turning gear is to get the collector ring round


Cutsforth Inc

8. Online truing, also known as stoning, essentially "grinds out" brush vibration


Cutsforth Inc

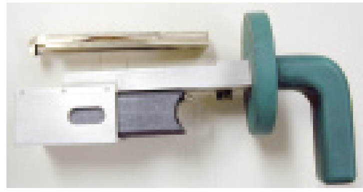
9. Spiral grooving is re-established when ring wear dictates. It can be done with the field in place age between rings. Furthermore, even if excitation voltage has been removed from the field, the ground detection voltage still may be applied—about 125 V.

However, reliability of the brush/collection system has been highest, and generally has met expectations, on generators equipped with brush holders (1) having constant-pressure springs and (2) being of the removable-cartridge (magazine) type.

10. Removable cartridge replacement (left) is for General Electric's helical-coil-spring brush holder

Cutsforth Inc

11. Replacement cartridge brush holder is removable, has integral handle



Fulmer Co

12. Replacement drop-in removable cartridge brush holder has two components and a removable handle

Such brush holders have been available for 45 years, particularly on very large generators. The removable holders allow close inspection and replacement of brushes with minimal personnel exposure to hazardous conditions. The constant-pressure springs eliminate the need for constant adjustments to the holders to compensate for brush wear, thus further reducing the need for contact with the excitation voltage.

Retrofit of existing collectors with removable brush holders is possible. One such retrofit has been available for 35 years (Fig 10). This early General Electric design was a little awkward to handle, not structurally solid, and used a helical spring. Other replacement cartridge holders have recently become available, including these:

- The Cutsforth Inc holder (Fig 11) requires change-out of the buss rings to implement. Once the new brush holders are assembled to the new busses, brush replacement is easily and quickly accomplished, although the pig-tail location requires use of insulating gloves. This design incorporates a new spring with each proprietary replacement brush.
- The Fulmer Co holder (Fig 12), by contrast, is a direct drop-in replacement to the existing holders, and does not requiring drilling of holes or change-out of the buss rings. Thus the conversion can be done during a short shutdown (one shift for a 48-brush collector). Brush replacement with this holder can be performed without insulating gloves.

Retrofit with well-designed, removable brush holders greatly simplifies brush replacement. Exposure to collector-ring voltages and high windage noise are significantly reduced. Attenuation of these hazards should result in much less reluctance by plant personnel to servicing a collector on an operating generator. In turn, this should appreciably reduce the likelihood of collector problems, including flashover, on the generator. CCJ

Clyde V Maughan is president of Maughan Generator Consultants, Schenectady, NY. He has 60 years of experience in the design, manufacture, inspection, failure root-cause diagnostics, and repair of generators rated up to 1400 MW from the leading suppliers in the US, Europe, and Japan. Maughan has been in private practice for the last 24 years. He spent the first 36 years of his professional career with General Electric Co.

This work is an updated and expanded revision of an article the author and his GE colleagues (H O Ohmstedt, J S Bishop, and W J McMillian) prepared for publication in Power magazine nearly 35 years ago. The editor who commissioned that piece currently is editor of the COMBINED CYCLE Journal.

WESTERN TURBINE Users

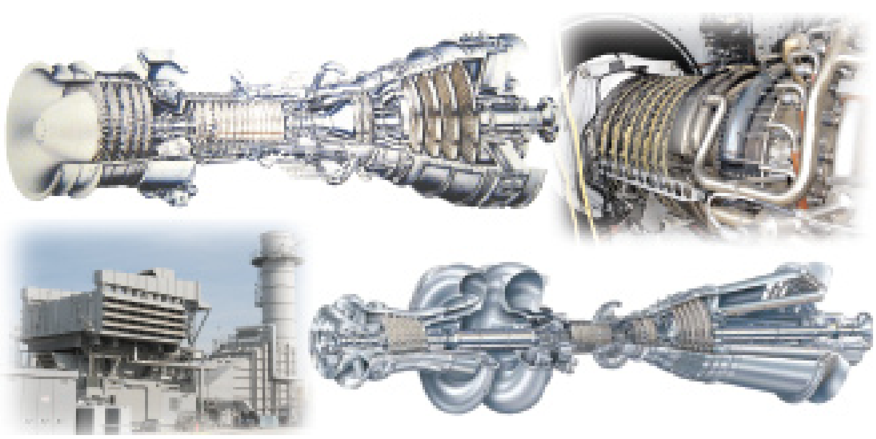
San Diego
March 2010

SPECIAL SECTION

20TH ANNIVERSARY CONFERENCE AND EXHIBITION

CELEBRATING TWO DECADES OF SERVICE TO OWNERS, OPERATORS OF GE AEROS

LM1600 • LM2500 • LM5000 • LM6000 • LMS100



W.T.U.I.
San Diego
1990 - 2010

20 and still growing

No headline can adequately describe what the Western Turbine Users Inc has accomplished in its 20 years of service to owners and operators of aeroderivative gas turbines (GT) manufactured by General Electric Co, and what it means to this community going forward.

Perhaps the best gauge of the organization's vitality and importance is the number of attendees at its annual conference and exhibition. The chart on p 116, compiled by Treasurer Wayne Kawamoto, plant manager, Corona Energy Partners Ltd, and an officer since the group incorporated in 1990, shows steady growth over the years. At press time, attendance for the 2010 meeting in mid March was expected to top last year's total.

No other GT user group can boast such a following. Perhaps the primary reason for Western Turbine's continuing success is continuity of a highly motivated leadership that remains focused on solving users' problems—period.

This report testifies to the important role played by user groups in the generation sector of the electric power industry. After reading through the "user remembrances," which begin on p 114, and the historical perspective offered by Sal DellaVilla, CEO, Strategic Power Systems (SPS, p 126), think for a moment about the O&M savings that have accrued because of the relentless drive of users to improve engine performance and reliability.

Add to this the benefits of the third-party market for products and services nurtured by user groups over the years and you quickly get to billions—perhaps even tens of billions—in savings that have been passed on to consumers of electricity and thermal energy.

General business, depot update

WTUI President Jon Kimble of Wellhead Services Inc opened the meeting at the San Diego Convention Center (Fig 1) with an outline of the two-and-a-half-day program and then introduced Kawamoto, who presented the treasurer's report. Kimble returned to the podium to acknowledge the contributions of the user group's officers and directors (p 133).

He also noted that Harry Scarborough's day job had changed, forcing him to resign from the Board of Directors, and that Dave Merritt's (GWF Energy LLC) three-year term was up. Merritt was appointed to fill the year remaining on Scarborough's term and John Baker, O&M manager at Calpine Bethpage Energy Center and chairman of the LM2500 breakout sessions, elected to fill Merritt's position. Brad Hans of Basin Electric Power Co-op also was elected to the Board.

1. WTUI President Jon Kimble opens the 2010 meeting in San Diego

Kimble next thanked the GE-approved engine overhaul depots for working collaboratively with the officers, board, and session chairs in the development of content for the technical program. Representatives of the five depots—TransCanada Turbines, Calgary; MTU Maintenance Berlin-Brandenburg GmbH, Ludwigsfelde, Germany; Air New Zealand Gas Turbines, Auckland; Avio SpA, Rivalta di Torino, Italy; and IHI Corp, Tokyo—then offered 15-min updates of their activities.

Air New Zealand once again treated attendees to a creative presentation that captured the spirit of New Zealand and its people, leaving details of the company's technology for discussion on the exhibit-hall floor. This year's "short subject" was a lighthearted comparison of the kiwi and the eagle.

In addition, ANZ's Rich Ison announced that GE has contracted with the depot to provide enhanced customer service for the distribution of LM5000 gas-generator unique replacement parts. Under the agreement, GE will continue to manufacture these parts while ANZ will be responsible for handling customer orders, forecasting, warehousing, and product delivery. ANZ has extensive experience serving the LM5000 fleet both as a licensed depot and as a spare-parts provider.

LM5000 owner/operators were asked to contact either Mal Waite, materials manager (mal.waite@airnz.co.nz), or Carolyn Paton, project manager (carolyn.paton@airnz.co.nz), with any questions.

TransCanada Turbines' Dale Goehring spoke briefly on the company's mission (to provide a first-class service that consistently exceeds customer expectations); commitment to safety excellence; efforts to achieve ISO 14001 certification (environmental management); quality certifications (ISO 9001:2000, Lloyd's Registry); customer support network (facilities, people), etc.

Of greatest interest to attendees, perhaps, was Goehring's progress report on TCT's new 225,000-ft^2 overhaul facility that will include the latest lean production methods. Grand opening: 2011. In related news, the company's Houston operation has moved north to Beltway 8 and I-249 to a 8700-ft^2 facility equipped with new cranes and tooling.

IHI Corp's presentation covered the company's deep experience in the repair of aero engines (more than 10,000 overhauls thus far, mostly for the world's major airlines), and its use of Kaizen principles to improve quality, cost, and delivery. Also discussed was the company's success in delivering more than 100 LM units of its design (with oversight by GE) over the years, plus package remodeling and uprate offerings.

IHI's control system and online monitoring services for LM engines seemed to generate considerable interest among attendees. The company provides a control system that integrates both the GT and balance of plant. Diagnostic capabilities for online troubleshooting also got attention.

Avio, still relatively new to Western Turbine members, introduced three key people in its service network: Claudio Vinci, general manager of the company's US operation, based in Englewood Cliffs, NJ; Luca Agliati, commercial operation manager, Torino; and Antonio Errico, who is responsible for LM2500 support and based in Brindisi, headquarters for the repair and overhaul of the LM2500.

An overview of the company's structure and various businesses—including space propulsion, advanced automation and control systems, modules and components for aero engines, etc—was helpful in understanding the skill sets of Avio's 5500 employees worldwide.

The company has extensive experience in the design and supply of marine propulsion systems, having started as a GE system supplier for that sector more than 40 years ago. To date, Avio has provided more than 100 LM2500 packages of its design. Avio also manufactures LM2500, LM2500+, and LM6000 components for the OEM—including turbine disks, inlet gearbox, accessory gearbox, compressor front frames, turbine rear frames, etc.

Independent depots. Within the last 18 months or so repair options for the LM2500 increased with Chromalloy and Wood Group Pratt & Whitney each announcing their entry into the market as independent depots—repair facilities not bound by the OEM's business practices. Interestingly, both companies are approved by the OEM to make many critical repairs to this engine. Both also were very visible in the exhibit hall.

The San Diego location allowed Chromalloy to show its repair facility to groups of conference-goers. The editors toured the Saturday before the meeting. John McKirdy, general manager of Chromalloy's LM2500 depot hosted the tour and reviewed the capabilities of the world's largest independent supplier of technologically advanced repairs, coatings, and replacement parts for turbine airfoils and other critical engine components.

McKirdy's shop, formerly known as the Pacific Gas Turbine Center, is an FAA/EASA approved MRO (maintenance/repair/overhaul) facility equipped with an engine test cell capable of supporting both aviation and land-based engines (Fig 2). The 110,000-ft^2 facility, authorized to dispatch field-service personnel worldwide, began offering LM2500 owner/operators a complete range of services last summer—including high-pressure-turbine module repair and overhaul, gas-generator and power-turbine overhaul, and high-performance replacement blades and vanes.

2. Engine test cell at Chromalloy's San Diego MRO shop can accommodate the LM2500

Tuesday lunch

The golf and tennis awards were presented during Tuesday lunch by the Golf Chair Jim Bloomquist of Chevron and Tennis Chair Jim Hinrichs of Fort Chicago Energy Partners LP. Details are provided on p 112.

The awards done and diners well into dessert, President Kimble dropped the bomb: Mike Raaker, president of the services company that bears his name, was retiring from his position as a WTUI vice president. The massive dining area went silent and Jim Hinrichs, who presided over the user group for 17 years prior to his retirement in 2008, stepped to the podium.

Hinrichs referred to Raaker, who was elected a director in 1994 and as VP in 2002, as Western Turbine's "conscience." The past president recalled, "He would interject himself into Board discussions when we veered off subject to remind us of what we were all about—namely, a quality technical forum for users to exchange information among ourselves and with vendors, GE, and the depots. He also gave sage counsel about the handling of members' money.

3. Mike Raaker calls it a day as an officer of WTUI, but he's not going away

"But while Mike kept us in line about our program, agendas, and money, he would not hesitate to 'go rogue' in front of the whole group and engage us in a story about a failure or repair gone wrong [usually hilarious], most often poking fun at, or sending barbs to, the OEM. More than once I received a call after the conference about Raaker's 'comments,' and 'couldn't I control that guy because he can't say that stuff.'

"I always took those comments as an indication that we were doing our jobs. We make every effort to be professional, but that doesn't mean we have to treat the vendors, OEM, and depots with kid gloves. So, sometimes feathers get ruffled . . . it's part of the business. And more often than not, once things cool down, improvements are made and all parties benefit."

Raaker earned his LM spurs years ago. He began his career in 1973 as a refrigeration engineer with Procter & Gamble Co. As the 1980s dawned, Raaker was appointed project manager for the installation of an LM2500 at P&G's mill in Oxnard, Calif. Primary product: toilet paper. The engine was licensed as a "Purpa machine," supplying power to the grid and heat to process. It was a good business provided you could keep the machine running and fulfill contractual commitments.

That was a challenge in the early years. The duty cycle proved demanding: Fuel nozzles suffered from wear and tear, igniters were going through the turbine, etc. Raaker recalled weekly shutdowns and proactive parts replacement to keep the machine "alive." Others faced the same challenges as Purpa fever spread.

In 1982, Raaker remembered, he and like-minded engineers from Federal Paper Board Co, Great Western Malting Co, and Willamette Paper Co began conducting informal self-help discussions in a plant conference room, offering guidance to the OEM on how it could make LM2500s more dependable.

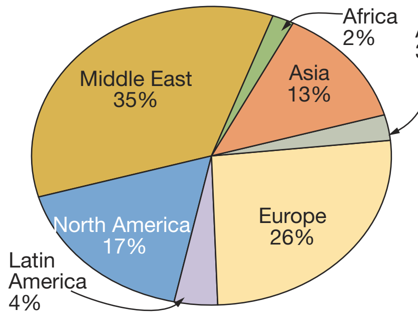
Those informal get-togethers attracted other users, and as the 1980s drew to a close the number of users knocking at the door, so to speak, dictated the need for a formal organization. The Western Turbine Users Inc was born.

Raaker was summoned to the podium when Hinrichs finished his tribute (Fig 3) and he didn't disappoint: "You guys are saying some pretty nice things about me but I'm not dead yet." Raaker was relieved he wouldn't have to worry about what color shirt he'd be wearing at future meetings, saying "I'm done with these shirts!"

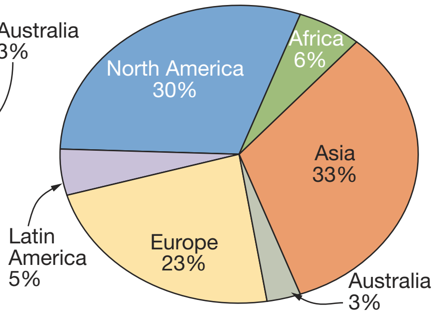
Then came the good news: "I'm just retiring from the Board; I'll still be around," he added, holding the lifetime membership card presented by Kimble. Why would anyone think otherwise? Wife Charlene continues to manage the group's hot line and administrative duties, and Raaker is still doing consulting work. He left the platform to a standing ovation.

Feature presentations

Mark Axford of Houston-based Axford Consulting LP, who prepared the history on LM engines beginning on p 123, and



4. Worldwide orders of GTs larger than 10 MW totaled 39,918 MW in 2009, down 42% from 2008



5. Worldwide orders of aero units totaled 5838 in 2009, down 34% from the previous year

SPS's DellaVilla are featured on every Western Turbine program. Axford presents on the state of the industry, DellaVilla on GT performance trends.

Axford began by recalling his predictions for 2009 orders made a year earlier. He told the group in Palm Springs that US orders for all makes and models of GTs would be down 15% compared to 2008; the rest of the world, down 20%. But the global recession clobbered the electric power industry and when the 2009 orders were added up, Axford reported, US orders were down 31% to 5684 MW, worldwide orders off 42% to 39,918 MW (Fig 4).

Global purchases of aero GTs totaled 5838 MW in 2009, off 34% from the previous year (Fig 5). Only 1594 MW of that sum was purchased for installation in the US. Perhaps of greatest interest to attendees: GE captured 72% of 2009 aero orders outside the US, but achieved only 38% market share at home. Rolls-Royce, which hardly has made a dent in the US generation market over the last several years, captured a whopping 52% on the sale of 13 Trent 60s. Pratt & Whitney slipped to third place with 10% share, according to Axford's numbers.

Predictions for 2010 orders of GTs rated more than 10 MW: US down 10% from 2009 (capacity basis); non US, up 10%. Axford's reasoning: Widespread demand destruction here at home; strong recoveries in countries such as China, India, and Brazil. Axford cited a few disturbing facts while making his predictions, including these two:

- It will be 2016 before electricity consumption in California matches 2008 levels.
- Cinergy's kilowatt-hour sales in 2009 were off year-earlier numbers by 6% and the company predicts "no growth" in 2010.

DellaVilla's presentation is summed up in Tables 1-7. The first five tables are for 60-Hz machines only. Table 2 shows the hours per start for F-class engines in cogeneration service has dropped significantly since the recession began, probably because of flagging demand for large quantities of thermal energy over a long period.

However, F-class engines are running longer at electric utilities (Table 3) because of the drop in gas prices (Table 7) and the ability of large, efficient GTs to dispatch ahead of coal-fired units. Likewise, the service hours per start of F engines in the merchant and industrial sectors (the latter for electricity production only) has increased because they too are more cost-effective to run than solid-fueled units in certain sections of the country.

Table 6 reflects the growing belief that units must be dual fuel to count their output as firm capacity. Historically, more than half of the robust E-class units have been dual fuel. But the costs associated with burning liquid fuel in large, high-temperature F-class engines and low-runtime aeros have militated against dual-fuel capability until recently. **CCJ**

Table 1: Key performance indicators for 60-Hz aero engines

Parameter	2002-2006	2007	2008	2009
Service factor, %	35.8	37.4	33.8	33.0
Service hours per start	28.3	21.9	22.4	24.5
Starting reliability, %	97.4	97.7	97.6	97.4
Output factor, %	79.5	78.6	78.0	76.0
Availability factor, %	95.3	93.4	93.5	93.7
Forced outage factor, %	2.0	3.1	2.2	1.8

The parameters above are defined in industry standards IEEE 762 and ISO 3977. For example, service hours is the elapsed time between breaker closed and open; a start is counted when the breaker is closed and the unit is being loaded; output factor is calculated by dividing the megawatt-hours generated by the product of the machine rating and service hours.

ORAP® data for the following industrial engines were used to compile this table: General Electric's LM1600, LM2500, LM5000, LM6000; Rolls-Royce's Avon, Trent, and RB211; Pratt & Whitney's FT4 and FT8.

Table 2: Service hours per start for GTs in cogen service

Engine class	2002-2006	2007	2008	2009
Aero	72	63	50	67
E	95	75	71	95
F	111	100	71	65

E-class engines included are Alstom GT11N and GT13E; General Electric 7E/EAs; Siemens W501D, SGT6-2000E, SGT6-3000E; Mitsubishi 501D. F-class engines included are Alstom GT24; General Electric 6F/FA, 7F/FA/FB; Siemens V84.3, SGT6-4000F, SGT6-5000F; Mitsubishi 501F

Table 3: Service hours per start for GTs in electric-utility service

Engine class	2002-2006	2007	2008	2009
Aero	15	10	10	11
E	13	12	12	14
F	40	33	38	52

Table 4: Service hours per start for GTs in merchant service (IPPs)

Engine class	2002-2006	2007	2008	2009
Aero	10	9	10	12
E	34	41	57	39
F	30	33	39	49

Table 5: Service hours per start for GTs in industrial service

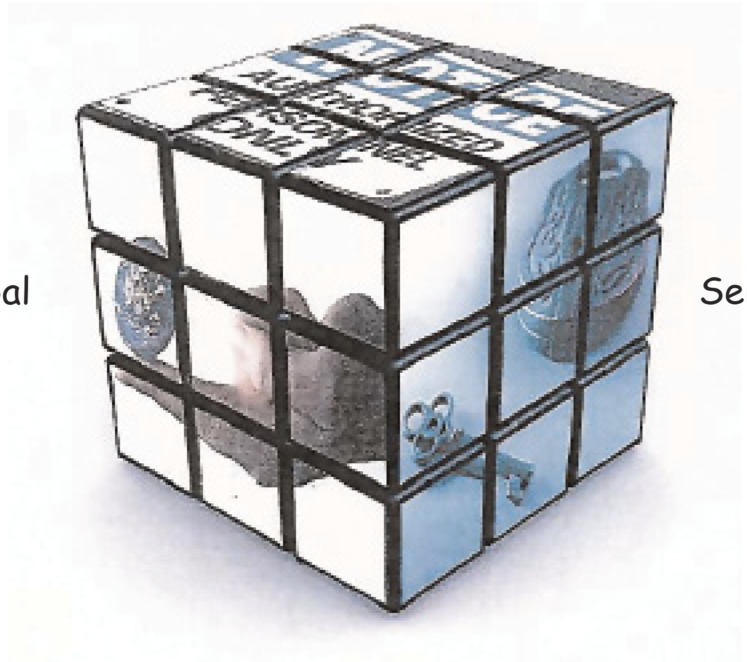
Engine class	2002-2006	2007	2008	2009
Aero	48	30	45	18
E	36	17	12	15
F	17	17	21	51

Table 6: Fuel capability for 50- and 60-Hz engines

Engine class	2002-2006	2009
Aero, dual fuel, %	25.5	32.4
Aero, gas only, %	74.5	67.6
E, dual fuel, %	57.2	56.9
E, gas only, %	42.8	43.1
F, dual fuel, %	33.0	42.7
F, gas only, %	67.0	57.3

Table 7: Gas prices, Henry Hub, $/million Btu

	2002-2006	2007	2008	2009
High	18.41	9.14	13.31	6.10
Low	1.97	5.30	6.18	1.83



Social events critical to networking

Social functions are important to the success of every user group conference because they enable people to meet in a relaxed environment and expand their networks for problem-solving. The Western Turbine golf and tennis tournaments, held on Sunday before the official opening of the exhibit hall in the early evening, are two events embraced by many attendees.

Golf

The 2010 golf tournament, chaired by Jim Bloomquist of Chevron (and a Western Turbine VP) hosted more than 30 foursomes at the Riverwalk Golf Club. Weather was brisk at the 7 am shotgun start, but it warmed up as the morning progressed into a thoroughly enjoyable day. Listed below are the most successful participants.

First-place team: Blair O'Neal, Aeroderivative Gas Turbine Support Inc; Wayne Feragen, Noresco (and the Western Turbine webmaster); Johnny Gilbert, Airgas Specialty Products; Mike Thawley, TurboCare.

Second-place team: Jeff Miladin, ChemTreat Inc; Anthony Plank, Industrial Cooling Solutions Inc; Scott McKenzie, Sulzer Turbo Services.

Third-place team: Paul Paxon, Thermo Cogeneration Partnership; Andy Stewart, A & I Accessory Ltd; Kenny Wirtjes, Camfil Farr Power Systems; Darren Leonard, Solberg Manufacturing.

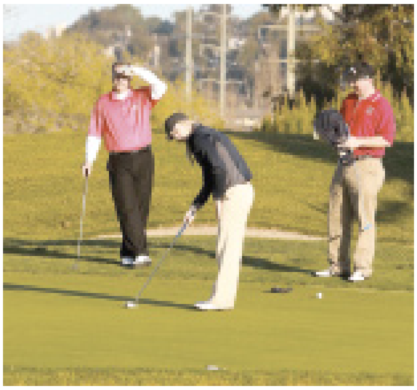
Longest drive, men: Keith Clardy, Puretec Inc.

Longest drive, women: Blair O'Neal, Aeroderivative Gas Turbine Support Inc. O'Neal has stroked the longest drive in the last four Western Turbine golf tournaments.

Closest to the pin: Bob Mass, Wood Group; Mike Kassner, GasTOPs Ltd; Jay Donkleman, Emerson Process Management; Jim Bloomquist, Chevron.

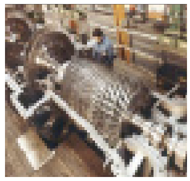
Tennis

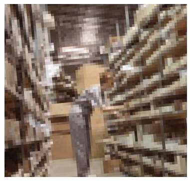
The 2010 tennis tournament, chaired by Jim Hinrichs of Fort Chicago Energy Partners LP (Western Turbine life member and former president), was held at the Balboa Tennis Club early Sunday afternoon. Eight players participated in the round-robin doubles competition. The top three finishers: Susan Hinrichs, Jim's better half; Jackson Chu, Chromalloy; and Hinrichs.



Blair O'Neal, Aeroderivative Gas Turbine Support Inc, sinks a birdie putt for the first-place team in the Western Turbine golf tournament. Wayne Feragen, Noresco (at right), and Johnny Gilbert, Airgas Specialty Products, look on

Jim Hinrichs, Fort Chicago Energy Partners LP, chairman of the tennis tournament, announces that his wife, Susan, won top honors



Participants laud WTUI's accomplishments, value to LM engine owner/operators

Jack and Gae Dow

Retired

Together, Jack and Gae Dow have put more hours into WTUI than they can count. It all started back in 1993 when Jim Hinrichs couldn't attend a meeting and asked Jack to go in his place. The board was looking for a president and since Jim wasn't there, Jack volunteered him. While Jim readily accepted the post, he decided to put Jack to work as well. In the many years since that fateful meeting, Jack has served as a board member, an officer, a conference speaker, and, most importantly, exhibit organizer, lining up vendors and planning the exhibit hall. But one of the most important tasks he performed was getting Gae involved as conference planner.

"Jack took care of the exhibit hall, the floor plan, and the vendors while I took care of the hotel and attendees. Although Jack was working long days, he'd put in the extra hours on nights and weekends to get the exhibition planned and to help me with computer glitches or data entry. Every February, during pre-conference crunch time, we lived the conference 24/7. We talked about it morning, noon, and night. Sometimes my phone would ring at 3:00 in the morning with a call from an attendee from Japan or Australia and we'd need to deal with it," Gae said. But it was always worth it, she added, because the "board and the officers were so wonderful and dedicated. They were the ones who really did all the work. All of them working 10, 12, 14 hour days and then putting in countless hours as WTUI volunteers."

It was in Palm Springs at one of the early meetings that Gae saw firsthand the type of hard-working volunteers she was working with. "Attendance at the luncheon was much higher than we had expected and people kept pouring in to eat even though there were no seats left. So the board, sitting up front with reserved seats, gave up their table so others could use it. They spread out around the room, waving their arms to flag down attendees and making sure everyone got seated as chairs became empty. For those guys, the meeting was always all about the members." Although Gae retired as conference planner in 2008 (but not before being treated to a standing ovation from conference attendees), she and Jack continue to consider themselves lifers in the WTUI organization.

Ronnie McCray

Senior Contract Performance Manager, Calpine Fleet
GE Energy Services

A board member from 2001-2002, Ronnie McCray got his start in WTUI in 1992 while working for Stewart & Stevenson at Sunlaw Energy in California. At the time, information about LM2500s was scarce and problem solving consisted of kicking around possible solutions with other operators.

One of Sunlaw Energy's LM2500s tripped during summer peak because of a malfunctioning fuel valve; the plant had no spare. Contractual obligations dictated that the unit be returned to service quickly. Plant Manager Gene Kelley called a Shell facility in Bakersfield which allowed Sunlaw to borrow a valve because their LM2500 had been removed for repair. Gene chartered a helicopter and flew to Bakersfield to pick up Shell's fuel valve. The helicopter landed in the parking lot of our plant, the valve was installed, and the unit returned to service. We were able to refurbish our unit and send Shell's valve back before their LM2500 left the Depot. We couldn't have done it without being connected."

When an LM2500 in Artesia, Calif, had a C-sump high-oil-temperature indication, it was Ronnie who answered the call for help. High oil pressure and temperature indicated a restricted oil-supply orifice. Plant Manager Doug Dowd had analyzed the information and asked if there was anything that could be done short of removing the engine for repairs. Ronnie went to the site with a vacuum pump, disconnected the C-sump oil-pressure line, connected the vacuum and, voila, 20 minutes later the unit was returned to normal operation.

As Ronnie puts it, "Participation in WTUI is invaluable. The camaraderie of the entire group, the ease with which the whole group welcomes new members, and how everyone is willing to share operational knowledge enhances one's own knowledge and experience in this industry and it makes you more qualified to do your job."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Jim Hinrichs

Vice President, Operations
Fort Chicago Energy Partners LP

Every engineer worth his salt wants to know how things work—and how to make them work better. For those whose job it is to keep a power plant running and electricity flowing, it is critical that they know how to keep the turbine turning. And that, according to Jim Hinrichs, is what WTUI is all about. He should know. He was not only a founding member, but he served as WTUI president for 17 years.

"When the first LM2500 packages were installed," Jim recalled, "the guys at the plants were facing similar problems, but there was no mechanism for sharing solutions or even determining if your problem was one-of-a-kind." At the time, the OEM wasn't providing all the guidance needed, so the LM2500 pioneers decided to do it themselves. Jim said, "At first we'd meet at the plants and sit around one conference table with one goal—to brainstorm, troubleshoot, share issues, and solve problems. Although GE had a service organization, these machines were brand new in land-based service and GE was on a learning curve just as we were. In 1991, the founders made the decision to incorporate with regular by-laws and membership procedures, and that decision set the tone for the future of the group. It started as an all-volunteer organization and is run by volunteers to this day.

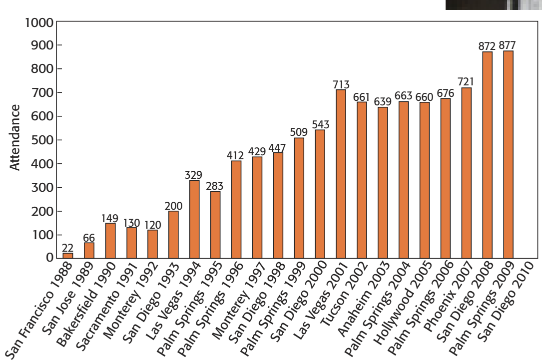
Another turning point resulted from GE's temporary withdrawal of technical support for the conference. That hole in our program was promptly filled by the licensed Depots. The Depots (volunteers again!) tackled the job of preparing detailed technical presentations to the users, a task central to the annual conference. The remarkable thing is that these guys and gals are all fierce competitors angling for user business. So witnessing competing Depot engineers sitting side-by-side editing each other's notes and PowerPoint slides is a phenomenal sight and a testament to the WTUI camaraderie. Still the heart and soul of WTUI is the dedicated users who understand that helping a fellow user is an investment in their own company and expertise because "what's Joe's problem today, could be mine tomorrow." Through the years, WTUI has grown beyond his expectations, but it remains true to its focus: solve users' problems, period.

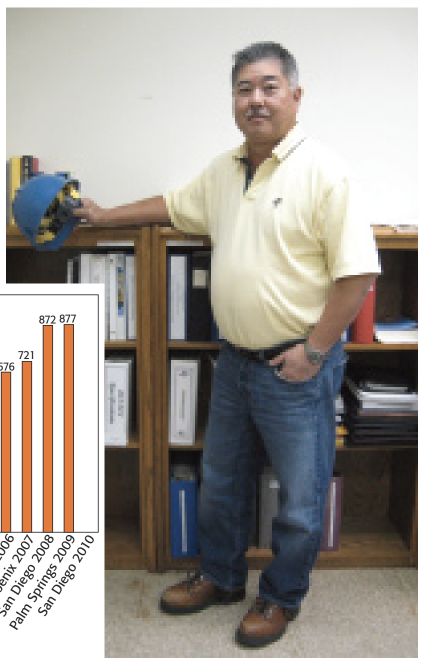
Wayne Kawamoto

Plant Manager
Corona Energy Partners Ltd

Wayne Kawamoto and LM2500s go way back; back to the beginning, in fact. Wayne was a young engineer when the first US Stewart & Stevenson package was installed in Hawaii and he's been working on them ever since—and working with WTUI. He has been active in the organization "since '86-'87, has served on the board of directors, and has been treasurer since day one of incorporation in 1990."

As treasurer, Wayne has tracked the growth of the organization since its inception (see chart). "It's amazing," he said. "In the beginning, our meeting would consist of a small luncheon and afterward I'd take out my calculator and divide the bill among the 10 or 12 people there. That would be our membership costs for the day's meeting. Now, we're collecting up around half a million dollars and our luncheon bill is a huge tab. At our first conference, we put out one 6-ft table and charged vendors around 40 bucks to put their business cards out. Now we've got 50,000 to 60,000 ft^2 dedicated to over 200 vendor booths. Our growth has just been tremendous."





What accounts for the organization's growth? "We started out trying to manage our issues outside of GE, and as the organization grew, our approach to problems became even more independent. We know the engine and we've got the experience in the field, so we can design our own solutions to the challenges we face. If we need something more rugged and we can't find it, we'll design the components ourselves. People may join thinking they're going to find out how GE wants them to use the turbine, but that's not what we're about. We're about solving problems the best way possible. Of course we take GE's views into consideration, but in the end, it's our members' design solutions that work best." Wayne said that while WTUI may have started out like a stubborn weed, it's been nurtured into an incredible robust, fruitful plant that has given back to everyone who has participated.

Ernie Soczka

Retired

"Y'a'll come." That was as formal an invitation as the original group of LM2500 users got, according to Ernie Soczka, now semi-retired, and the first chairman of the board of WTUI. "John Tunks was president," Ernie recalled, "and Steve Johnson was there at the beginning, too. At the time, we were trying to solve problems by exchanging information about the LM2500's technical issues and about working with GE and Stewart & Stevenson. We wanted to make sure we knew who was having what problems and figured that we could more effectively solve them and work with the OEM and packager if we worked together instead of one on one."

During the early days, Steve Johnson would charter a plane, pick up Ernie on the way and they'd fly down to meet with John Tunks and Wayne Kawamoto and a few of the other early participants. They elected officers and set up their first official meeting. The first meeting sponsored by WTUI as an organization was in Sacramento. We were nervous because we had to pay to guarantee the rooms and we wondered if enough people would show up. We planned for 100 and ended up with 120."

One of Ernie's favorite memories of WTUI was when he played his first ever game of "business tennis" with Jim Hinrichs. Asked what he missed about being involved with the group, he said, "I miss the technical problem solving. Because the LM2500s were designed for aircraft, they're very light and so we'd encounter problems you couldn't anticipate. For instance, brackets would break on the casing and so we'd replace those with brackets we'd make out of heaver material only to see them place increased stress on the casing itself.

"It was a great technical challenge figuring those things out. And, of course, I miss the people. There was always such an excitement, an eagerness, and camaraderie to put our heads together to solve problems and make a difference." With the strong foundation Ernie helped build, WTUI is sure to keep making a difference well into the future.

William (Bill) Caldwell

President/Owner
Independent Power Associates Inc

Although the official history of WTUI begins in 1991, the group actually started meeting in the late '80s and Bill Caldwell was there from the beginning. "This whole thing started in Northern California as a result of deregulation. Cogeneration plants were going in and guys from a number of industries—airline, pulp and paper, oil and gas—had these new engines and were trying to figure out how to keep them running. We were basically stumbling around trying to get our technical questions answered and to get and service parts. After a while, the guys down in Southern California heard about us and wanted to get involved. By around 1989-90, we had reached a critical mass and we realized the industry was growing. It was time to get organized."

Although the group may have had technical expertise, running a volunteer organization wasn't part of their skill set. "We didn't know what we were doing. One guy had to figure out the bylaws, one guy took care of finances, and somebody else had to learn how to actually host a meeting. We relied a lot on our secretaries and support staff because they often knew more about that stuff than we did." Bill was on the first Board of Directors and his company has been involved ever since.

"As the maintenance team at the United Airlines cogeneration plant, we faced problems we could not have solved without the other WTUI members. At one point, we were having trouble with the fans used in the Stewart & Stevenson package and we had to turn to the other users to figure out how to resolve the problems." Getting to know new vendors was an added bonus to WTUI participation, Bill said. "With assistance from the other users and the new vendors, our group was able to apply lessons learned, improve reliability and increase our capacity and availability figures." And that, at the end of the day, is what WTUI is all about.

Don W Driskill

President
Delta Power Services LLC, a Babcock & Wilcox company

Don Driskill's history with WTUI goes back to the early days when the meetings consisted of just a few tables of users who talked over technical issues and toured LM2500 facilities. "The meetings were quite small," Don recalled, "and unlike the packed exhibit hall we have today, there were very few vendors. Some of the vendors didn't even bother with tables; they just walked around meeting and talking with users. We were a pretty unsophisticated bunch back then." Unsophisticated or not, the group was full of smart, talented industry professionals many of whom have stayed active and connected to WTUI.

"It's amazing to me that so many of the same people have remained in the industry over the years. They may have changed companies and they may have different business cards, but there's a core group that is still around. In fact," Don said, "we need the WTUI meetings just to maintain and update our industry contacts."

For Don, it is the industry contacts that make WTUI such a valuable organization. "Being involved has impacted my business in so many ways. The sharing and openness as to what works and what doesn't work have been absolutely invaluable to my business. The face-to-face contacts make that critical phone call so much easier—the phone call you have to make when you need to solve a problem or borrow a part. It's the network of people who have the same issues and concerns you have that gets you through the challenging times. People are always willing to help because they know tomorrow they could be in the same situation."

Brian D Hulse

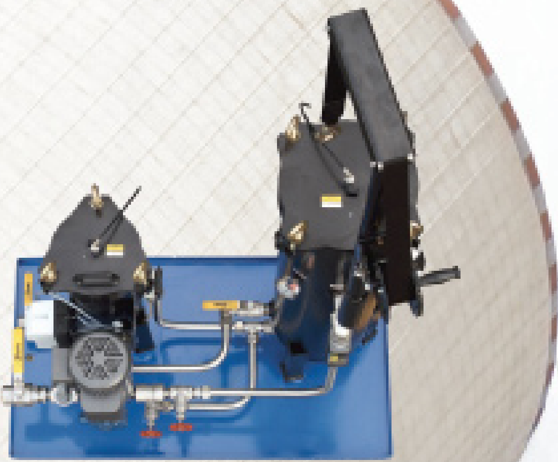
Engineering & Program Development Manager
Wood Group Pratt & Whitney LLC

Looking back at the 20-year history of WTUI and thinking about the organization's amazing growth makes Brian Hulse smile. "It's amazing to see all these people show up at the meetings and know they're doing the same thing we used to do in the front lobby of an admin building at a plant. Back then our whole group was able to drink coffee out of a 12-cup coffee maker. We brought in donuts and shared sub sandwiches. But despite all the growth, the board has worked to make sure that the focus has stayed true to the original goals: To share the information necessary for users to make better operational and maintenance decisions."

In the early days, open communication was essential as users were trying to learn as fast as they could and avoid replicating each others' mistakes. "We didn't want to go to the OEM with a problem," Brian said, "and have them say that was the first they'd heard of it even though we knew two other plants had experienced the exact same thing." Sometimes, however, sharing information wasn't enough and when crunch time came parts had to change hands, too. After a while, the team he was part of in Bakersfield started a maintenance practice and was doing third-party work. That meant he was often on the receiving end of an emergency call.

"Because of our depth of inventory, we could help other plants when the packager or GE couldn't," he recalled. "More than once, we'd head to the airport with a part and put it on an executive charter in order to get it over to the other guy as fast as possible so he could get up and running for peak time." At the time, Brian added, it was a matter of survival getting the plants running at peak performance. Today, the organization continues to help the users survive and, as always, keep their engines humming along.

Power Gen Solutions



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Mike and Charlene Raaker

President
Raaker Services LLC

"What the heck is 'Wah Tue eee'?" That s a question Mike (WTUI technical VP) and Charlene (conference administrator) Raaker have been answering for the past 20 years. The term Western Turbine Users (WTU) was actually coined by General Electric Co when referring to a group of folks on the West Coast who owned and operated GE LM2500 cogeneration packages. The "I" was added to the mix in 1990 when the group incorporated and became Western Turbine Users Inc. And the rest is history. Good history with constant growth and good friends.

"As a small volunteer organization in the 1980s," Mike said, "Charlene and I used up many of our frequent flyer miles, traveling back and forth from Cincinnati to attend the gatherings—first in plant conference rooms, then in hotel conference rooms, and finally, where we are today, filling huge hotels and conference centers, in all the warm cities on the West Coast. The growth of the organization wasn't envisioned or planned, it just happened. As Mike and Charlene put it, "The organization was, and is about the owner/operator and keeping our plants viable, and we have never waivered from that goal.

"We're sure the growth was helped along by the fact that meetings are held in March in a warm climate and they open with a round of golf, and that spouses eat free. The friendships made during the past 30 years are too many to count and our space here is limited, so we won't try." Although Mile plans to retire from his WTUI position this year, he says, "Charlene and I are not going away. If you have a need to call WTUI, in the future, one of us will answer. We are both very proud to be Wah Tue eees."

Frank Oldread

Manager, Turbine Maintenance Group
CAMS Bakersfield

The first WTUI meeting Frank Oldread was scheduled to attend, he had to miss—ironically—because of an engine failure at his plant. Since then, he's only missed one other time and that was because he was stuck in Shanghai during the SARS epidemic. Since his first meeting, Frank has worked with the same group of plants, which have had five different owners and six different names.

"I've attended a lot of meetings," Frank said, "but one of my fondest memories was at a meeting in Las Vegas when Gae (Gae Dow, conference organizer) hired a couple of show girls to act as greeters. Needless to say, there was a lot of greeting going on." According to Frank, the key to WTUI's success is the contacts. "You can always find somebody that has already seen the problem you're dealing with. With WTUI, it comes down to people and communications." Sometimes, though, sharing information isn't enough and you actually have to share parts. "We've got 12 operating units in California and two spare engines, so we end up sharing parts at least three or four times a year and we've done it with probably a dozen different companies—including competitors."

The camaraderie even among stiff competitors is yet another thing that sets WTUI apart. "I saw a customer approach a rep from a Depot with a problem. They talked for a few minutes and then the rep walked the customer over to another Depot's booth to find out if they'd had encountered the problem." When asked about the group's growth, he said, "At a conference in the mid 1990s, there were six vendors and eight or nine guys in the LM6000 room. Last conference, I stopped in to the LM6000 breakout session—it was in an auditorium with 100 people." Frank predicted that as long as there are engineers trying to keep engines running, WTUI is going to keep on going and growing.

WTUI 'steady as she goes' through a 'boom and bust' gas-turbine market

By Mark Axford, Axford Turbine Consultants LLC

The mission of the Western Turbine Users always has been to conduct a user-controlled forum for owners of General Electric Co LM-series gas turbines (see article, p 30). GE's TF39 aircraft engine was adapted for non-flight duty in the 1960s and named the LM2500. Recall that "LM" stands for "land and marine."

During the 1970s, GE sold its LM2500 "gas generators" to compressor manufacturers such as Dresser, Ingersoll-Rand, and Cooper Bessemer. These companies designed and built their own power turbines to match the speeds of their pipeline and process compressors. They then sold the complete turbine/compressor "package" to the customer. Selling gas generators to compressor packagers was a good niche business for GE.

GE's Aircraft Engine Div wanted to grow the LM business by offering aeroderivative power generation units—like Pratt & Whitney's FT4. But GE already had a Power Systems Div (Schenectady, NY) that sold heavy-duty frame gas turbines for power generation. Power Systems executives worried that a separate sales force selling LM engines would confuse the customer with competing GE products.

In 1978, Jack Welch, then a senior VP, settled the internal battle, deciding that the aircraft group could license a family of "package" builders to sell LM2500 generator sets. Companies such as Stewart & Stevenson, Ruston Gas Turbines, and IHI were signed up by GE as qualified packagers of gensets.

Welch also said that the Power Systems Div could build and sell LM gensets to customers who preferred to contract directly with GE. So Dick Cull and Brian Rowe of GE established the business framework and found visionaries like Joe and Carsey Manning and Paul Barron to pump up the entrepreneurial energy of their young sales teams.

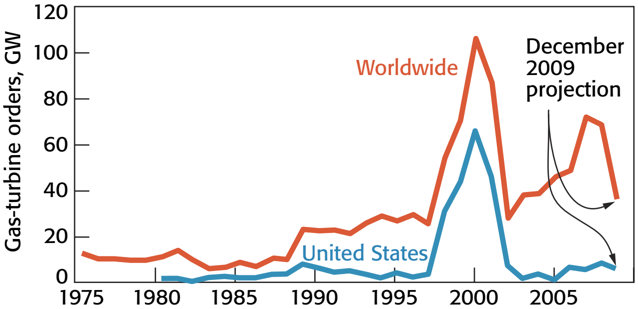
Cogen boom. Thanks to some favorable laws and tax benefits, the US cogeneration market became red hot during the 1980s. Installing a gas turbine with an HRSG was a concept easy to understand. Natural gas was cheap and the cogen plants were profitable.

Competition among gas-turbine manufacturers was fierce, but GE won the lion's share of the battles with ABB, Westinghouse, Rolls-Royce, and Pratt & Whitney. The toughest sales battles often were fought between the GE packagers of LM2500 and LM5000 gensets in competition with GE Power Systems, which was offering 6B and 7E frames.

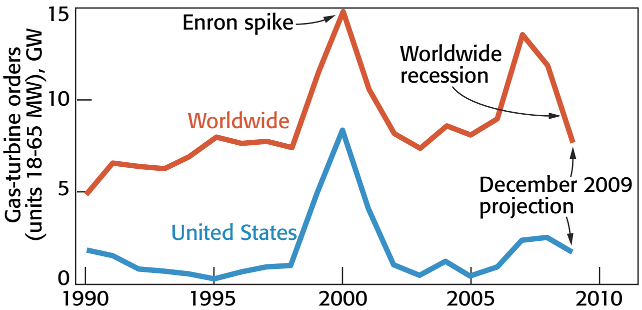
Some GE executives saw this as problematic, but Welch knew that the competition would ultimately strengthen both divisions, give customers more choice, and put two GE horses in every race. Sales of GE aeroderivative gas turbines grew rapidly.

Technically, customers liked the superior fuel efficiency of LM turbines and the availability of spare engines to minimize downtime needed for maintenance. Commercially, customers often preferred some of the business practices of GE's packagers, which were more willing to customize a design at a customer's request.

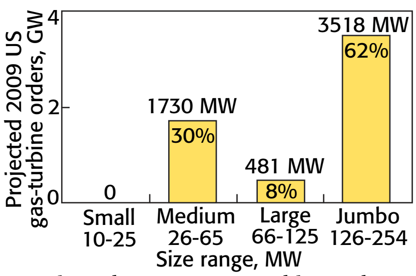
Plus, at least one packager, Stewart & Stevenson, tested each complete generator set at full power before shipment—a major value point for many customers. Most importantly, many customers liked the packagers because they were more flexible in negotiation of contract terms and conditions. Stewart & Stevenson took great pride in making its turbine operation feel like a small family business. As aeros



1. Gas-turbine orders reported worldwide from 1975 through 2009 (projected). Curves reveal a growing market characterized by considerable volatility since 1998. Note that orders reported for 1990 and later years are for units larger than 10 MW



2. Gas turbines orders for units rated from 18 to 65 MW reported worldwide since 1990 reveal dramatic impact of the recession



3. Projected 2009 US gas-turbine orders shows buyer preference for medium-size and jumbo units. Former would dominate in simple-cycle installations, latter in combined cycles

came into the mainstream of power generation, the gas-turbine business became much more competitive in the range of 20 to 50 MW.

In the 1990s, the GE heavy-duty frame business moved its focus to the largest GT models—such as the 7F and 9F. Introduction of the LM6000 and the Sprint™ power-boost option created a 50-MW peaking unit that was a perfect size for municipal utilities and cooperatives.

Even the larger investor-owned utilities found application for these quick-start units. In 1998, the US gas turbine market saw a surge of orders unlike any before. That was followed by a market crash of equal magnitude (Figs 1, 2).

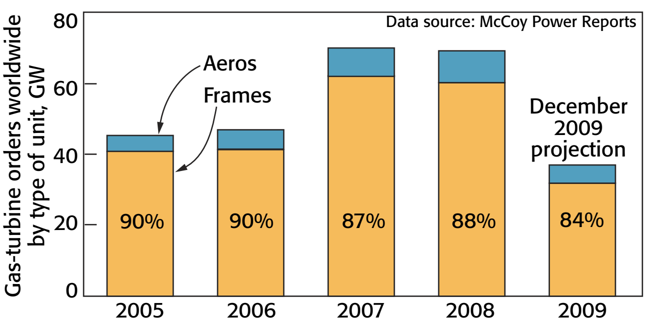
Today, the US gas-turbine market for power generation is concentrated in these two size ranges (Fig 3):

- 10 to 65 MW, satisfied mostly by aeroderivatives.
- 150 to 300 MW, all heavy-duty frames.

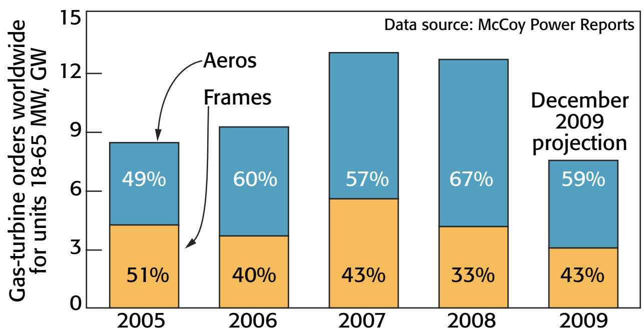
While overall GT sales in megawatts are dominated by frame units (more than 85% market share), aeros win a nominal 60% share in the range of 18 to 65 MW (Figs 4, 5).

Since the LM6000 was introduced in 1990, it has become the most popular aeroderivative engine in its size class; more than 800 units are now operating (Fig 6). The overwhelming majority of LM6000s are in electric generation service.

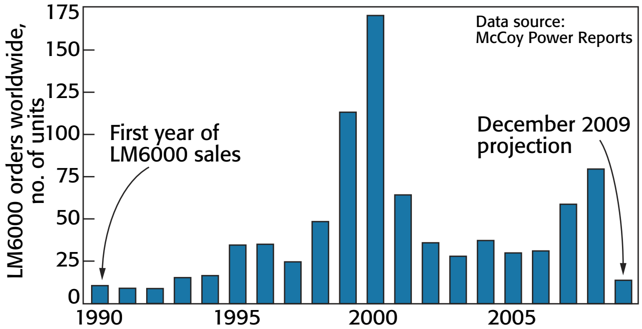
By contrast, more than half of the LM2500s sold today are for com-



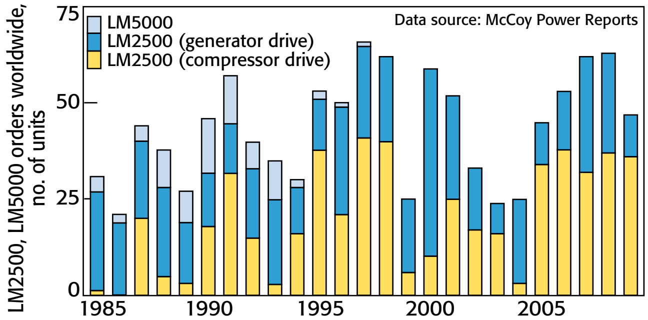
4. Aeros versus frames. Data on orders worldwide of gas turbines larger than 10 MW shows aeros taking a larger share (percentage basis) of the total market in 2009 than they had the previous four years



5. Aeros are clear winners over frames in worldwide market share for units in the size range of 18 to 65 MW



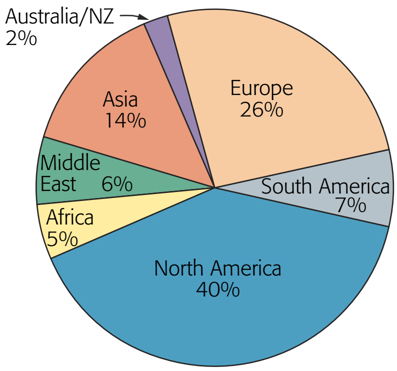
6. Orders worldwide of LM6000s in 2009 dropped dramatically from the 79 bought in 2008. Note that data for 2009 are based on projections made last December



7. As natural-gas pipelines get larger so do compressors. The LM2500 has been a popular compressor drive over the last five years—more than 25 orders annually. In the previous two decades, orders for LM2500 compressor drives topped the 25-order mark only four times

pressor-drive applications (Fig 7). As the chart shows, the LM2500 series of engines continues to attract a significant number of orders almost 40 years after the model's introduction.

The LM5000, which GE introduced in the early 1980s, lost favor among customers when the LM6000 was introduced. It is no longer manufactured by GE and only about 60 units remain in service worldwide.



8. LM gas turbine orders from 1985 through 2009 (based on December 2009 projections) reveal the popularity of these machines in North America and Europe. Percentages are based on numbers of units sold

Without a doubt, the Western Turbine Users' forum has had a profound positive impact on the gas-turbine industry. What started out as a casual meeting of plant managers in California has evolved into the most important annual meeting for LM users worldwide. The LM fleet is well represented on every continent except Antarctica (Fig 8).

Operators, vendors, and developers fly in for this meeting each year to get first-hand information on new technical developments and to share stories and lessons learned with the family of authorized Repair Depots and the GE team. No one ever could have predicted at the first meetings of the Western Turbine Users that the group would evolve into such a huge gathering of equipment and business professionals.

Looking back at two decades of outstanding service with an eye to the future

By Salvatore A DellaVilla Jr, CEO, Strategic Power Systems Inc

It is an interesting and challenging proposition to look back over time. Remembering and reconstructing events, like beauty, is in the eyes of the beholder—especially after 20 years. However, there are circumstances that demand a look back, and, typically, these circumstances are related to people whose contributions have made, and continue to make, a difference. And that describes WTUI to a tee. Since its inception, it has been a group of people with a mission and that mission has been all about adding value.

". . . to provide members a forum for the exchange of technical, operations and maintenance information and experience to improve reliability and economic viability of GE LM series power facilities."

The beginning

I will always remember the chain of events that led to the introduction of Strategic Power Systems Inc (SPS) to three of the founders of the Western Turbine Users: John Tunks, the organization's first president (California Cogeneration Operators Inc), Ernie Soczka (Destec's San Joaquin Cogen), and Bob Fields (Container Corp of America). Note: The company and plant affiliations identified in this article are consistent with the timing of the reference. In some cases, the individuals mentioned are still employed by those organizations, in others the companies may no longer exist, or plants have been renamed.

The meeting took place at Ricky's Hyatt in Palo Alto, Calif, in fall 1990, just prior to WTUI's incorporation. The number of GE LM units operating in cogeneration service, especially in California, was rapidly increasing because of the Public Utility Regulatory Policies Act (Purpa).

Existing users, who already were meeting at various plants, wanted a more formal structure to support the expanding base of operators. They understood new users would require operating knowledge and experience, and would share their desire for continuous product improvement.

They also understood the need to establish and follow a uniform process that the Western Turbine Users, as an organization, could use to track and report the availability and reliability performance of the LM5000 and LM2500 fleets. The objective was to have unbiased and accurate data to document the performance of their gas turbines and plant equipment. The users wanted data and metrics they could share among themselves, and with General Electric Co (GE), the manufacturer. SPS hoped WTUI would agree that ORAP® (for Operational Reliability Analysis Program) was the system they needed.

The first link in the chain of events was a call I received from Lou Pasquarelli, an old GE friend. Lou explained that both the Western Turbine Users and the GE Marine & Industrial business unit (today, GE Aero Energy) were interested in tracking the reliability and availability of the LM product family to support the expanding user base.

He suggested that I contact John Campbell (now deceased) who was GM of the Customer Service business unit to discuss the opportunity. John understood the market for the LM product line was growing and recognized that for continued success, product performance had to meet customer expectations. He recognized the benefits ORAP offered and invited me to Cincinnati to present the system. Afterwards, he decided that GE would fund and use ORAP to cooperate with and support the Western Turbine Users—cooperation and support that continues today.

In due course, John, Larry Lewis (then the GE point of contact, now retired), and I made several plant visits in California to introduce the LM users to ORAP. From the Shasta mountain range to Santa Clara, from Los Angeles to Bakersfield, the goal was to grow user participation on the ORAP system, and to begin the reporting and feedback process.

The objective was to obtain and process plant data as quickly as possible and to show meaningful results. We were on our way. We had the strong endorsement of GE and the Western Turbine Users, and our job was to demonstrate and add value for the users.

Sacramento to San Diego, and in between

If you have never participated in a Western Turbine User's Conference, it's difficult to imagine how much you have missed. Advice for first-timers: Attend the sessions and listen carefully, meet fellow users at social events, speak with vendors at the expo, and you'll leave San Diego with more knowledge than you ever thought you could absorb.

WTUI veterans know that the success of this conference did not just happen by accident. The word "serendipity" does not apply to WTUI. Its success has been built on the efforts of dedicated people with vision and a long-term commitment to their industry—and to each other. Now, after 20 years of hard work, a meeting that started out in a few plant conference rooms has been transformed into a world-class conference that attracts a global audience.

The first meeting attended by SPS staff was Sacramento, March 1991. There were 130 registered attendees—including users, vendors, spouses, and guests. The Board included Tunks (he had moved on to Stewart & Stevenson Services, S&S, by this time), Soczka, Fields, Jim Hinrichs (Sithe Energies), Wayne Kawamoto (Wheelabrator Norwalk and WTUI treasurer, an office he continues to hold), and Steve Johnson (ESI Simpson Paper, Shasta Mill).

At that meeting, Hinrichs became the WTUI president, a position he was to hold for 17 years. Other founding members of the organization who were present included: Mike Raaker (Proctor & Gamble), Jack Dow (Sithe Energies), Jim Bloomquist (Chevron), and Brian Hulse (Destec Bakersfield). Tom Christiansen of SPS was given the opportunity to present to the users and to solicit their participation on the ORAP system. The goal was to add more users on ORAP and to produce a formal data analysis and report as soon as possible.

The first ORAP report went out to both participating users and GE as a "Special Edition" in June 1991 (Fig 1). It included data from 24 operating plants representing 19 LM2500s and 14 LM5000s, and provided an overview of the reliability metrics that the users desired—including component causes of downtime and engine removal rates.

Interestingly, these LM units operated with very high service factors (greater than 85%), and had hours-per-start ratios ranging from 135 to 250—exactly what you would expect from cogeneration units. At the time, SPS had a commitment from an additional 20 operating plants to join and participate on the ORAP system. The goals and objectives, as set out in the WTUI mission statement, were now being realized.

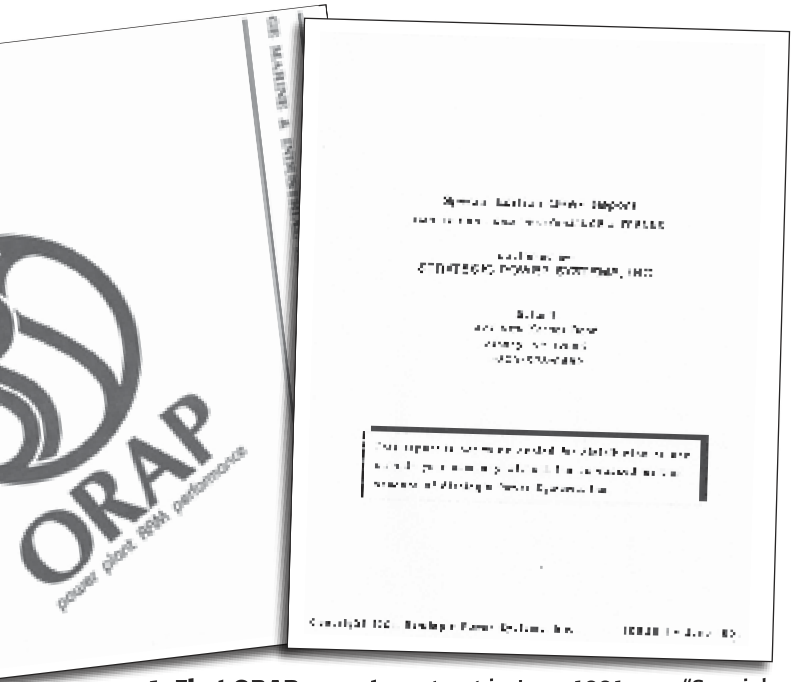
Newsletters. From January 1993 through February 1994, the WTUI board and SPS issued monthly newsletters to all participating members that discussed various technical topics or other items of interest (Fig 2). In the February 1994 newsletter, for example, Johnson wrote "LM5000 Compressors: Cold-End Problems." Steve had already provided an article of interest on "LM5000 Lube Oil Chip Detection," where he informed that "a chip detection system is a very vital tool" (Fig 3). Another article by Kawamoto on "Enhanced Steam Injection" addressed an approach that Wheelabrator Norwalk implemented for improved NO_x abatement.

In the early 1990s, "fall mini conferences" were held to address specific technical issues. For example, Hulse, who was a WTUI board member, arranged a conference at the Pacific Suites Hotel in San Luis Obispo, where issues such as gas-path coatings were discussed. The idea was to add value for the user community by publishing newsletters and conducting mini-conferences on a regular basis.

ORAP. By the time the first newsletter was issued, ORAP participation had grown to 40 plants and new people were getting involved. The January 1993 edition notes that Brent Newton had joined the Board, while the terms of both Soczka and Fields were ending. The visionary founders of WTUI had laid the groundwork for the inevitable changing of the guard. WTUI was preparing for change.

Looking through these newsletters offers a memorable trip back in time. To illustrate: In February 1994, items of interest included the following:

- Announcement that Hulse had submitted the winning design for the WTUI logo, which still is in use today.



1. First ORAP report went out in June 1991 as a "Special Edition." It included data from two dozen operating plants representing 19 LM2500s and 14 LM5000s


Western Turbine Users, Inc.
Monthly Newsletter

2. March 1993 newsletter featured a message from the Board touting the advantages of ORAP participation for LM users. Two-score ORAP members were listed on the first page

■ Jack and Gae Dow were identified as the "go-to" team regarding the 1994 conference in Las Vegas.

■ SPS would begin taking and issuing notes for each of the LM product line breakout sessions, a practice that continues today.

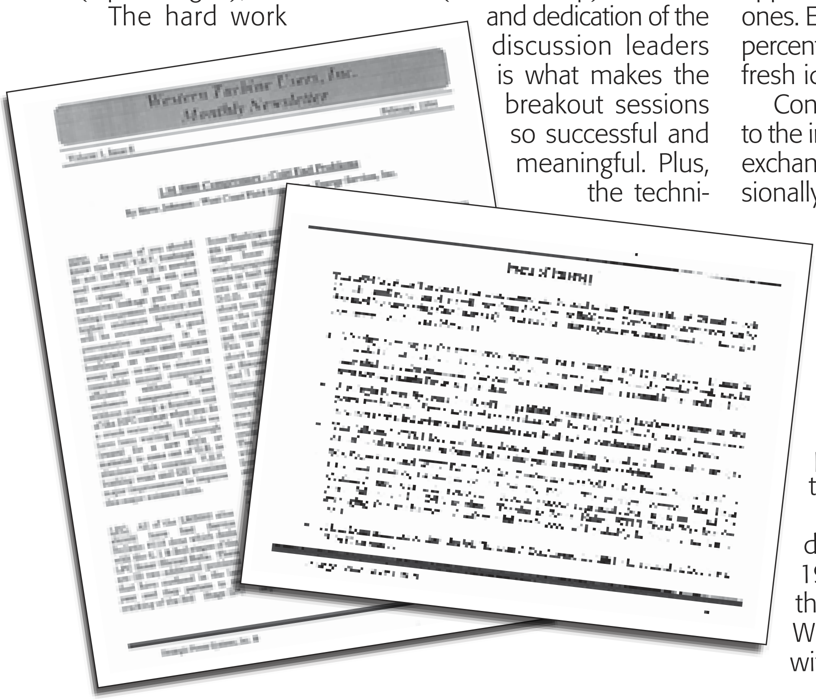
Breakouts. From the beginning, the two and a half days of breakout sessions covering each LM product line have provided the foundation for sharing knowledge and solving problems. These invaluable sessions provide the opportunity for users to openly discuss installation and commissioning issues, O&M concerns, lessons learned, and the opportunities for plant improvements.

Technical discussion covers the engine, package, controls and all ancillary systems. The intent is to share and document, thereby creating a history through the notes of relevant and meaningful "real life" experiences to help the operating community improve as a group.

Over the years, discussion leaders for the breakout sessions have included Jimmie Wooten (DPS Juniper LLC), Frank Oldread (Destec), Johnson (K&M Services), Grant McDaniel (SSOI, Stewart & Stevenson Operations' Carson Cogen), Joel Lepoutre (S&S), Roy Burchfield (Sithe Energies), Norm Duperron (Bonneville Pacific Services), Mel Murphy (Kingsburg Cogen), Bob Ander-

son (Florida Power Corp), Charlie Hoock (Calpine), Kevin Koszalka (TGB Cogen), James Hardin (El Paso Cogen), Bob Mason (Goal Line LP), Rich Frank (GECS Camarillo), Chuck Casey (Goal Line LP), Bob Nelson (SMUD, now deceased), Chris Kimmich (Nevada Cogen), Bill Lewis (PPL), John Baker (Calpine), Bryan Atkisson (City of Riverside), James Charles (Ripon Cogen), and Mark Breen (Wood Group).

The hard work and dedication of the discussion leaders is what makes the breakout sessions so successful and meaningful. Plus, the technical sessions have been strongly supported by GE, S&S (now GE), and the Depots, adding to their value.



3. Cold-end problems with LM5000 compressors was the feature article in February 1994

The winds of change

WTUI conferences continue to grow annually, providing opportunities to renew old friendships and establish new ones. Equally important, the conference attracts a significant percentage of new users and attendees each year who bring fresh ideas and perspective vital to long-term health.

Continuing growth testifies to the Board's hard work and to the increasing value and need for face-to-face information exchange. Such success, however, brings change and occasionally presents very real challenges to the relatively small group of volunteers who make WTUI happen.

President Jim Hinrichs and the Board in place during the first few years of the new millennium faced significant challenges as the need for WTUI's services increased markedly while the duty cycle for the LM sector of the industry was migrating from base- to part-load generation and there was a question as to whether GE could continue to support WTUI with the same commitment as it had in the past.

The good news was growing conference attendance, which went from an average of 470 in the 1996-2000 period to 667 from 2001 to 2005. In the last four years, the average attendance was 787. With this success came the difficulties associated with venue selection; relatively few locations can accommodate groups of this size. Plus there were the additional work loads associated with registration, meeting attendee expectations, etc.

More hands were needed; the volunteers could no longer do everything.

Both the organization and its owner/operator members were forced to adjust to market influences. The once dominant cogeneration market was contracting; units were operating fewer hours per start and they were beginning to cycle. SPS verified the market shift using ORAP data that the company provided for the COMBINED CYCLE Journal's report on the 17th annual conference in Phoenix.

SPS stated in that report, "Two operating profiles are distinctly visible: A base-load duty between 1995 and 1999, and a cycling duty between 2002 and 2006. The years 2000 and 2001 appear to be a transition period where the shift in duty cycle began." ORAP data also indicated that annual service hours had decreased by more than 40% comparing the new paradigm against the old. Further, that service hours per start had decreased by about 60% and the number of annual starts had increased—all as gas prices were spiking.

As the duty cycle was changing, the LM6000 and LM2500 solidified their positions as the product lines for growth, and component life, coatings, and emissions were the issues that had to be addressed.

Growth of Depot support. It was during the market evolution that GE communicated to the Board that it would not be able to sustain WTUI support at the same levels as in the past. The Board took that in stride, solidifying its relationships with the Depots and redoubling its efforts to assure that the annual meeting's technical content, and the currency and relevancy of issues covered, would continue to meet expectations.

Larry Flood (EPCO), Rich Recor (Sithe Energies' Greeley), Mike Horn (Calpine), Mike Pankratz (FPB Cogen), Joe Campanelli (Air Products), John Cates (Globeleq), Robert Kofsky (Modesto Irrigation District), and others put in extra hours to ensure that WTUI's mission would be sustained.

Always all about people

When SPS was located in upstate New York, a major benefit of the conference's timing was the opportunity to fly to the West Coast for a week and leave the bitter cold behind. Often, we would leave in a snow storm and return to a snow storm. The opportunity to participate in the Sunday golf or tennis event coordinated by the users (Hinrichs, Kawamoto, Bloomquist, and Ronnie McCray) always was a highlight.

My golf was bad (and still is), but the chance to catch up with old friends and the opportunity to make new acquaintances made it easy to laugh off the comments on my game. Golf with guys like Mark Dobler (Fulton Cogen), Jim Murray (Fulton Cogen), Tony Thorton (Turbine Technology Services), Ron Brooks (United Cogen), Don Haines (City of Santa Clara), Roy Davis (GE), Wayne Feragen (City of Colton), Mike Kolkebeck (City of Colton), Don Driskill (SSOI), and others always provided the welcome opportunity to mix business with pleasure.

The formal event begins Sunday afternoon with the New User Orientation, which is followed by the opening of the exhibit hall. Jack Gunsett (Kinder Morgan) conducted the orientation for years, eventually passing the baton to Oldread. The goal of the session is to introduce first-timers to LM engines, terminology, nomenclature, and other hands-on knowledge and experience to prepare them for the discussions that would take place during the breakout sessions beginning Monday morning.

SPS, represented primarily by Bob Steele today—and formerly Steve Hartman and Kevin Licata (both now with

GE)—also participates in the New User Orientation to introduce ORAP.

Monday morning the conference begins. Members look forward to the first session and to the ritual handing-out of much-desired WTUI jackets awarded to those users at the session whose names are pulled from the fish bowl (Fig 4).

The months of preparation by the Board, the breakout-session chairs, and the Depots (Air New Zealand, MTU, TCT, and more recently Avio and IHI) kick the conference into high gear. This year, WTUI officers Bill Lewis and Chuck Casey have filled the exposition with a record number of exhibitors.

The conference is about organizations and people who see value in what WTUI offers and provides, and they want to be a part of it. As the exhibit hall fills with friends, family, and colleagues, the mood is good-spirited, and all are ready for business and a fun time.

WTUI President Jon Kimble and the Board work diligently and effectively to keep "the shine on the apple." Speakers like Mark Axford (Axford Turbine Consultants LLC), who probably sold or directed the sale of most LM units when he was with S&S, and for a time at GE, provides a "Worldwide Gas Turbine Business Update" that is second to none. Other presentations from the depots and GE provide product updates that are both informative and responsive to user needs and interests.

In our industry, there are many conferences and user groups, all founded with a desire to add value. And they do. But WTUI is special. It is celebrating its 20th year not just because of the desire and need to share information and knowledge, but rather because it is genuinely focused on the user.

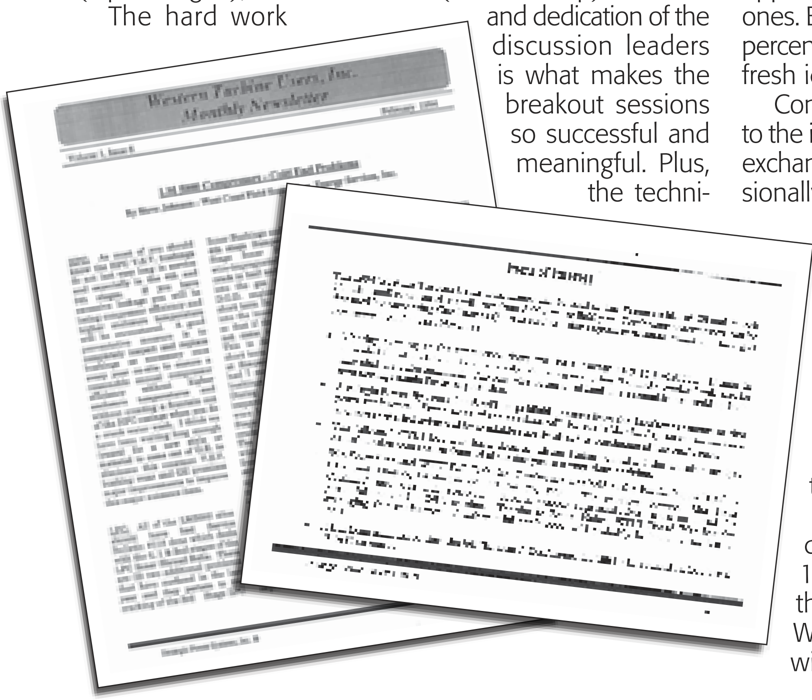
4. Jim Hinrichs, former president of WTUI (left), holds bowl of business cards while Bob Steele of Strategic Power Systems picks the prize winner. Rewards assure users get to the sessions on time

There is a strong sense that the full WTUI membership is interested in fleet performance. By helping to drive improvement fleet-wide, they improve their own plants. Competition among users exists, to be sure; however, there is a very real sense that the WTUI membership wants the term "best in class" to apply to the whole fleet. And they want "unbiased" third-party data—data available through ORAP.

The hard work and effort that has carried WTUI to its 20th year is a significant feat, and SPS has had the pleasure of supporting the group for most of those years. It is clear that WTUI has a strong commitment to excellence, and a clear vision for continually adding value for its membership. In sum, WTUI is special—not only for its service to the users, but for the users' service to it.

son (Florida Power Corp), Charlie Hoock (Calpine), Kevin Koszalka (TGB Cogen), James Hardin (El Paso Cogen), Bob Mason (Goal Line LP), Rich Frank (GECS Camarillo), Chuck Casey (Goal Line LP), Bob Nelson (SMUD, now deceased), Chris Kimmich (Nevada Cogen), Bill Lewis (PPL), John Baker (Calpine), Bryan Atkisson (City of Riverside), James Charles (Ripon Cogen), and Mark Breen (Wood Group).

The hard work and dedication of the discussion leaders is what makes the breakout sessions so successful and meaningful. Plus, the technical sessions have been strongly supported by GE, S&S (now GE), and the Depots, adding to their value.



3. Cold-end problems with LM5000 compressors was the feature article in February 1994

The winds of change

WTUI conferences continue to grow annually, providing opportunities to renew old friendships and establish new ones. Equally important, the conference attracts a significant percentage of new users and attendees each year who bring fresh ideas and perspective vital to long-term health.

Continuing growth testifies to the Board's hard work and to the increasing value and need for face-to-face information exchange. Such success, however, brings change and occasionally presents very real challenges to the relatively small group of volunteers who make WTUI happen.

President Jim Hinrichs and the Board in place during the first few years of the new millennium faced significant challenges as the need for WTUI's services increased markedly while the duty cycle for the LM sector of the industry was migrating from base- to part-load generation and there was a question as to whether GE could continue to support WTUI with the same commitment as it had in the past.

The good news was growing conference attendance, which went from an average of 470 in the 1996-2000 period to 667 from 2001 to 2005. In the last four years, the average attendance was 787. With this success came the difficulties associated with venue selection; relatively few locations can accommodate groups of this size. Plus there were the additional work loads associated with registration, meeting attendee expectations, etc.

More hands were needed; the volunteers could no longer do everything.

Both the organization and its owner/operator members were forced to adjust to market influences. The once dominant cogeneration market was contracting; units were operating fewer hours per start and they were beginning to cycle. SPS verified the market shift using ORAP data that the company provided for the COMBINED CYCLE Journal's report on the 17th annual conference in Phoenix.

SPS stated in that report, "Two operating profiles are distinctly visible: A base-load duty between 1995 and 1999, and a cycling duty between 2002 and 2006. The years 2000 and 2001 appear to be a transition period where the shift in duty cycle began." ORAP data also indicated that annual service hours had decreased by more than 40% comparing the new paradigm against the old. Further, that service hours per start had decreased by about 60% and the number of annual starts had increased—all as gas prices were spiking.

As the duty cycle was changing, the LM6000 and LM2500 solidified their positions as the product lines for growth, and component life, coatings, and emissions were the issues that had to be addressed.

Growth of Depot support. It was during the market evolution that GE communicated to the Board that it would not be able to sustain WTUI support at the same levels as in the past. The Board took that in stride, solidifying its relationships with the Depots and redoubling its efforts to assure that the annual meeting's technical content, and the currency and relevancy of issues covered, would continue to meet expectations.

Larry Flood (EPCO), Rich Recor (Sithe Energies' Greeley), Mike Horn (Calpine), Mike Pankratz (FPB Cogen), Joe Campanelli (Air Products), John Cates (Globeleq), Robert Kofsky (Modesto Irrigation District), and others put in extra hours to ensure that WTUI's mission would be sustained.

Always all about people

When SPS was located in upstate New York, a major benefit of the conference's timing was the opportunity to fly to the West Coast for a week and leave the bitter cold behind. Often, we would leave in a snow storm and return to a snow storm. The opportunity to participate in the Sunday golf or tennis event coordinated by the users (Hinrichs, Kawamoto, Bloomquist, and Ronnie McCray) always was a highlight.

My golf was bad (and still is), but the chance to catch up with old friends and the opportunity to make new acquaintances made it easy to laugh off the comments on my game. Golf with guys like Mark Dobler (Fulton Cogen), Jim Murray (Fulton Cogen), Tony Thorton (Turbine Technology Services), Ron Brooks (United Cogen), Don Haines (City of Santa Clara), Roy Davis (GE), Wayne Feragen (City of Colton), Mike Kolkebeck (City of Colton), Don Driskill (SSOI), and others always provided the welcome opportunity to mix business with pleasure.

The formal event begins Sunday afternoon with the New User Orientation, which is followed by the opening of the exhibit hall. Jack Gunsett (Kinder Morgan) conducted the orientation for years, eventually passing the baton to Oldread. The goal of the session is to introduce first-timers to LM engines, terminology, nomenclature, and other hands-on knowledge and experience to prepare them for the discussions that would take place during the breakout sessions beginning Monday morning.

SPS, represented primarily by Bob Steele today—and formerly Steve Hartman and Kevin Licata (both now with

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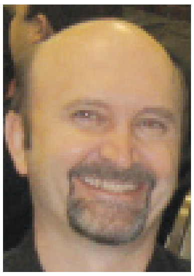

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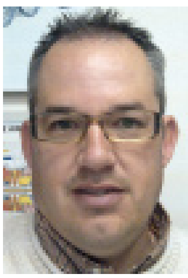

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Mark Breen, *Director of O&M Support, Wood Group Power Plant Services*

Don Haines, *Plant Manager, Panoche Energy Center, Wood Group Power Operations*

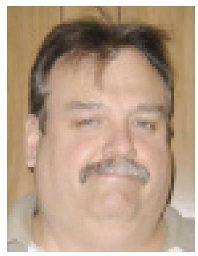
Alvin Boyd, *Power Production Superintendent, Pasadena Water & Power Dept*

Webmaster

Wayne Feragen, *Senior West Coast Plant Manager, Noresco*

Breakout Chairs

LM2500
John Baker, *O&M Manager, Calpine Bethpage Energy Center*



LM5000
Chuck Toulou, *Ripon Cogeneration Inc*

LM6000
Bryan Atkisson, *Riverside Public Utilities*

LMS100
Don Haines, *Plant Manager, Panoche Energy Center, Wood Group Power Operations*

BUSINESS PARTNERS

Company news

Johnson Matthey Plc reports that its SCR experience worldwide now totals 78,000 MW, including 2900 MW of simple- and combined-cycle installations. The company's SCRs on 45 gas turbines reduce NO_x emissions by more than 98% with a validated ammonia slip of less than 5 ppmvd at 15% O_2. JM's CO catalyst, installed on 2000 MW of simple- and combined-cycle units, also is reducing emissions of that pollutant by more than 98%.

The company offers a variety of emissions control solutions for stationary, locomotive, and marine diesel and gas engines, as well as gas turbines, boilers, and a wide range of industrial processes. Johnson Matthey's roots go back to 1817. It has 8500 employees serving customers in 30 countries; annual sales top $12 billion.

Strategic Power Systems Inc, Charlotte, establishes a strategic alliance with Sciemus Ltd, a UK-based technology-led insurance company "that prides itself on understanding risk through the generation of intelligence and knowledge using proprietary analytics to drive a unique value for its clients and the market."

SPS CEO Sal DellaVilla told the editors that Sciemus has a large and growing presence in the power insurance market through a partnership with Hannover RE. The company has a unique approach for quantifying and understanding risk by working with its clients to analyze plant and loss prevention data through proprietary modeling capability, he added.

The strategic alliance enables Sciemus and SPS to work together in supporting their clients through participation on the ORAP® system. "This will provide a significant opportunity to increase ORAP participation levels," continued DellaVilla, "and broaden coverage by driving value and benefit to the owner/operators of the plants."

Allied Power Group, Houston, hosts a ribbon-cutting ceremony on May 7 at its new Houston facility—a 75,000-ft^2 building that centralizes the company headquarters, sales, repairs, and warehousing in one location. Allied's product line now includes steam turbines and the firm extends its repair capabilities to W501F and GE 7FA+e gas turbines and parts for a worldwide customer base.

Engineering Manager Alan Lovelace, PE, says "The new facility will allow Allied to control all of its repair operations under one roof, thereby reducing customer turn times. One of the core values for Allied Power Group is customer responsiveness, and the new facility will enhance this key attribute even more."

Pratt & Whitney Power Systems, East Hartford, Ct, achieves two new milestones in delivering its 400th FT8® engine to Tampa Electric Co, Tampa Bay, Fla, and in surpassing 3 million FT8 fleet operating hours worldwide. The first FT8 went into power generation service in June 1991.

Product/services update

ESCO Tool, Holliston, Mass, reintroduces an ID clamping and welding end-prep tool with an optional 1.25-hp motor for work on stainless steel and other highly alloyed boiler tubes with overlays. The Mongoose Mill-hog® is a self-centering right-angle-drive air-powered tool capable of handling tubes with diameters ranging from 0.75 (inside) to 3 in. (outside). Mongoosel, which doesn't require cutting oil, features a chip breaker that directs the chip away from the tube and minimizes heat generation.

Braden Manufacturing LLC, Tulsa, announces a new series of cartridge filter elements for gas turbines. ExCel™ premier web filter employs a new generation of nanofibers specifically engineered to enhance the forces of pulse cleaning. Media is stronger and more durable than previous generations of electrospun nanofibers, providing extended filter life and longer service intervals.

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