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# CCJ COMBINED CYCLE Journal

## User Group Conference Schedule

### 31st Annual Meeting

7F USERS GROUP

**World's largest frame user group**

**May 23 - 27**
Fairmont Dallas (Tex) Hotel
Contact: Sheila Vashi, sheila.vashi@sv-events.net
www.powerusers.org

### First Annual Meeting

**Legacy Turbine Users Group**

7EA Users Group

Frame 6B Users Group™

FRAME 5 Users Group

August 29 – September 1
San Antonio Marriott Rivercenter
Contact: Sheila Vashi, sheila.vashi@sv-events.net
www.powerusers.org

## User Group Reports



## Feature articles



## Miscellany

# Forced Outage Problem Solver

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# Power Users forms Legacy Turbine Users Group

In the world of power generation there is a significant number of mature frame gas turbines that are the backbone for industrial settings and power generation. There are several well-established user groups that support owner/operators by sharing lessons learned, technical knowledge, and troubleshooting support. It's critical that these groups maintain a strong presence in the industry to support and benefit both the users and suppliers that keep the equipment running. Combine that with a changing industry, a pandemic, shrinking budgets, and an aging workforce you now have challenges in keeping influential groups afloat.

With any challenge there is opportunity and that's why Power Users formed the Legacy Turbine Users Group. Currently, LTUG comprises the 7EA, Frame 6B, and Frame 5 Users Groups. In combining forces, the future for these organizations will be stronger and have opportunity to grow. Each group maintains an independent steering committee and user forum hosted by Power Users, but when conducting a technical conference, the groups will be joining together under one roof, each in its own meeting room. Power Users believes this combined group provides many benefits to the user community and suppliers.

The first LTUG technical conference will be co-located with Power Users' Combined Conference this coming August (see ad pages 92-93). For the first time, companies with a mixed fleet of these turbine types will be able to travel to one conference to gain the benefit of three. Additionally, companies that may not have such diverse fleets will be able to leverage the knowledge presented by these three groups with one trip. This addresses some of the challenges we are seeing that will likely to continue. Now companies can save on travel costs by attending an all-in-one conference and not have to choose which meeting to miss in a given year. All this without losing the benefit of training, sharing of lessons learned, building valuable networks, and meeting the supplier network that supports these gas turbines.

Suppliers also benefit from this merger of user groups. Their budgets are equally stretched, and the pandemic has made it challenging to share their services and build networks. The LTUG conference provides access to a diverse group of users that utilize a similar vendor base for support, parts, and services. This efficiency provides a budget-friendly opportunity for suppliers to build valuable connections to sell services and parts.

Our inaugural LTUG conference will be held in beautiful San Antonio (Tex), August 29 through September 1 (www.powerusers.org). Plan now to participate in this seminal event to strengthen your knowledge, build your network, share your experience, and find a supplier that can help solve problems your facility is facing.

Jake English, *Duke Energy*
Phyllis Gassert, *Talen Energy*
Sam Graham, *Tenaska*
Edward Maggio, TVA
Ben Meissner, *Duke Energy*
Peter So, *Calpine*


COMBINED CYCLE Journal

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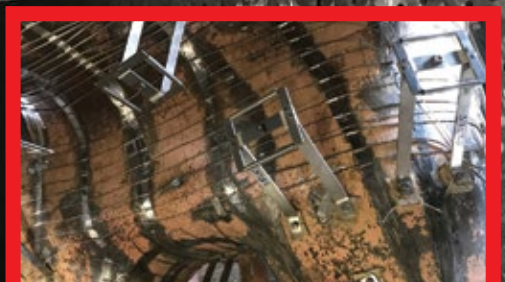
# NEXT GENERATION



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7F USERS GROUP

# 31st Annual Conference

## Fairmont Dallas Hotel • May 23-27

This year's vibrant, reconfigured 7F Users Group conference program promises a not-to-be-missed event. Two-dozen vendor solutions highlight each of the first two mornings—Monday, May 23, and Tuesday, May 24—with users-only sessions in the afternoons, and vendor fairs following. Wednesday is dedicated to engine components, each session featuring user presentations. Thursday is GE Day. Friday morning is reserved for the OEM's deep-dive knowledge-sharing program and hands-on live outage hosted by FieldCore.

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### SILVER PLUS

APG

The world's largest user organization supporting owner/operators of GE F-class gas turbines hosts the most robust in-person meeting of its type since the pandemic began two years ago, when the 7F Users Group meets at the Fairmont Dallas Hotel, May 23-27..

Here's an overview of the 2022 agenda:

**Vendor solutions presentations** are conducted Monday and Tuesday in four 30-minute sessions with four or five services providers presenting simultaneously in each session. Five platinum-sponsor presentations, aggregated in a fifth 60-minute session, conclude the morning programs. Access the conference mobile app for room assignments.

Monday, attendees can listen to half-hour presentations by AGT Services, Certrec, Flow-Tech Industrial, HRST, PSM, APG, CTTS, Cutsforth, Emerson, Independent Turbine Consulting, Core Tech, OILKLEEN, EthosEnergy, NEC, RelaDyne, and Tetra Engineering; plus, hour presentations by Arnold Group, Gas Path Solutions, MD&A, Shell, and TC&E.

Tuesday's half-hour presentations are by Camfil, GTC Control Solutions, ORR Protection, HRST, Integrity Power Solutions, MD&A, EagleBurgmann, JASC, Kinectrics AES, Koenig Engineering, Moog, PGAS, Lectrodryer, NEC, Riverhawk, and Sulzer; plus, hour presentations by AGT Services, Doosan Turbomachinery Services, ExxonMobil, IAFD, and PSM.


Fairmont Dallas Hotel

Content thumbnails of the vendor presentations are provided in the following section to help in planning your participation.

**The general sessions** include a world-class lineup of presentations and discussions by and among users on safety best practices and lessons learned, performance and controls, auxiliaries and generators, the compressor, combustion, and turbine sections of the 7F engine, rotor, and top fleet issues.

**Vendor fairs** will showcase the products and services from five- to six-dozen companies each night (p 13). The generous three-hour exhibit hall program allows you to visit all the companies on your punch list while taking advantage of the heavy hors d'oeuvres and open bar.

**GE Day topics** include safety; 7F fleet trends; outage planning and execution; GT systems reliability, controls basics, architecture, troubleshooting, and solutions; compressor/turbine/rotor; generator and electrical systems; parts and repairs; and combustion.

## SILVER

## BRONZE

# User presentations

User presentations and discussions dominate the first three days of the 2022 conference agenda, totaling 13 of the available 21 hours of program time. Details for the user-only portion of the agenda were not available at press time, only the overview below:

**Monday, May 23**
1:00 p.m. to 4:00—Compressor sessions I and II

**Tuesday, May 24**
1:00 p.m. to 1:30—Safety practices and lessons learned
1:30 p.m. to 2:30—Performance and controls panel
2:45 p.m. to 4:00—Auxiliaries and generator session I

**Wednesday, May 25**
8:00 a.m. to 8:30—Auxiliaries and generator session II
8:30 a.m. to 10:00—Combustion session
10:15 a.m. to 12:00—Turbine session I
1:00 p.m. to 2:00—Turbine session II
2:00 p.m. to 3:00—Rotor session
3:15 p.m. to 4:00—7F Top Issues

# Vendor solutions, May 23

## 8:00 a.m.

### AGT Services Inc

*GE stator-core looseness*

Jamie Clark explains how to inspect stator cores in GE generators and remedy issues, such as core looseness, to avoid in-service failures and emergent outage scope for repairs.

### Certrec Corp

*Pitfalls, risks, and solutions for proper setting of generator protective relays*

Understand the challenges of properly setting generator frequency and voltage protective relays and how to do it correctly to meet regulatory requirements (NERC standard PRC-024). Case study provides operating experience from dozens of generating units.

### Flow-Tech Industrial

*Electronic water treatment: How it works*

Electronic cooling-water treatment system is said to effectively protect against scale, biological growth, and corrosion while improving efficiency, maintenance, equipment life, and saving water. Case studies of a 7F plant provides real-world results.

**May 23, 8:45 a.m.** APG—Allied Power Group's Aaron Frost reviews the technical history of 7F first-stage bucket design to help you make better lifetime-assessment and repair decisions

### HRST Inc

*Coordinating HRSG advanced inspection techniques relative to major turbine overhauls*

Highlights several advanced inspection techniques and where they should be applied to allow good long-range budgeting and proper reliability for an aging HRSG. Includes photos of inspection techniques, significant findings, and the impact they have on outage planning.

### PSM

*Enhanced profitability and reliability: Operational flexibility through complete plant optimization*

Faster startups and higher ramp rates are among the significant improvements possible with modifications to existing controls logic and more intelligent operational limits, while not exceeding proscribed plant equipment limits. Case studies of recent commercially implemented plant-optimization projects involving gas and steam turbines and HRSGs illustrate what's possible operationally to improve profitability.

## 8:45 a.m.

### APG (Allied Power Group)

*7F, 7FA, 7FA+, 7FA+e, 7FB, and 7FA.04 first-stage bucket design history and evolution*

A complete historical design, materials, and coatings perspective concerning 7FA first-stage buckets from the early 1990s to today's 7FA.04 single-crystal parts. Aaron Frost reviews changes over the years and the way these changes have impacted design life and repairability.

### CTTS

*Compressor vane looseness: What to look for and what to do*

Presentation shows users how to look for indications that signal their machine may be at risk, before a significant problem arises (such as loose square-based compressor vanes), and

## 7F 2022 steering committee

**Chairman:** Justin McDonald, *Southern Company*
**Vice chairman:** John Rogers, *SRP*
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Kaitlyn Honey, *Xcel Energy*
Riz James, *Dominion Energy*
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Timothy Null, *Eastman Chemical*
Dave Such, *Xcel Energy*
Terry Toland, *Clark Public Utilities*
Zach Wood, *Duke Energy*

## Restructured agenda for 2022

Conference organizer Sheila Vashi, president, SV Events, says the 7F Users Group's traditional agenda was restructured for 2022 to expand the learning experience for attendees without sacrificing the number of user-only session hours. This is in response to feedback from gas-turbine owner/operators wanting sessions to end earlier each day and to have a free evening. Vendor feedback indicated a desire for more presentation opportunities. Some of the schedule adjustments implemented to achieve these goals are the following:

- User sessions end at 4:00 p.m. on Monday, Tuesday, and Wednesday.
- Vendor fairs are conducted on Monday and Tuesday, giving attendees an open evening on Wednesday.
- Vendor fairs start and end earlier than previously. Doors open at 4:00 p.m. and close at 7:00.
- The number of vendor solutions presentations has been expanded and these are conducted on Monday and Tuesday morning.

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**May 23, 10:15 a.m.** EthosEnergy shares solutions for maximizing plant performance while going green

then what to do if the risk is confirmed. Focus is on pinning as the optimal solution for loose vanes, based on more than 200 units modified over the last 15 or so years.

### Cutsforth Inc

*A case study on shaft ground and EMI monitoring*

Illustrates how multiple monitoring systems, specifically shaft ground monitoring and EMSA, were used to validate an event and prevent a failure. High-speed waveforms, spectrum scans, and data analyses enable SMEs to identify sources of high voltages and arcing, thereby allowing timely repairs.

### Independent Turbine Consulting

*Gas-turbine case studies and best practices*

Company's experts share gas-turbine lessons learned and recent experiences involving unit failures—including how and why they occurred, how they were corrected, and how most failures can be caught before they occur. Topics include machine alignment, vibration and soft feet, critical clearances, and casing internal alignment.

## 9:30 a.m.

### Core Tech Industrial Corp

*Protecting people and assets: Water mist fire protection*

Water mist is claimed to be the new industry standard for fire suppression, as it is the method typically selected for new units and for retrofit on in-service machines as their low-pressure $CO_2$ systems age out. LPCO2 can be replaced with a drop-in water-mist system during an outage. Features and benefits of water mist are reviewed.

### HRST Inc

*Impact of changes to Grade 91 ASME Code allowable stress values*

ASME recently reduced the allowable stress values for the design of Grade 91 materials typically used for HRSG high-temperature pressure parts. The new stress reductions should be combined with the original design and operating history when evaluating the remaining-life and reliability risk areas within an HRSG.

### OILKLEEN

*Keys to a successful conversion*

Focus is on conversion from one lube oil to another, and its impact on equipment reliability. How lab results help you determine if the conversion was successful, or not, is part of the discussion.

### PSM

*Advanced 7F retrofit solutions: Flexibility and performance improvements for current and future power market requirements*

Presentation introduces two proven retrofit solutions for 7F-powered generating plants that can be installed together or separately: (1) FlameSheet™ provides the ability to burn a wide range of gaseous fuels—including hydrogen—while maintaining exhaust emissions compliance and performance; (2) GTOP hot-gas-path performance upgrade can significantly improve plant output and efficiency while simultaneously extending required inspection intervals.

## 10:15 a.m.

### EthosEnergy

*Maximizing plant performance while going green*

This market outlook for gas turbines amidst the push to renewables highlights real results (including actual data) from operational solutions designed to accommodate the demands being placed on GTs—including improved operability, extended turndown, higher unit capacity, lower emissions, etc.

### Independent Turbine Consulting

*Vibration: What's wrong with my turbine?*

Provides turbine users a keener understanding of vibration and what vibration data mean, to help them expedite a solution to return a machine to service and avoid a lengthy outage.

### National Electric Coil

*Effectively rewinding high-voltage generator stators*

Critical quality factors for high-voltage stator coils are shared and explained, with recent technology advancements and tightening of technical requirements discussed. Hidden market misunderstandings that permit the use and application of inferior-quality coils are identified and explored.

### RelaDyne

*Predictive analytics and insights in the industrial age*

Speaker shares his company's perspective on what world-class predictive analytics look like in an industrial operation, shows how to use the insights the analytics provide to optimize your maintenance strategy, and explains how investing in this technology saves money in the long run.

### Tetra Engineering Group Inc

*Hydrogen for duct burners: Concept, issues, and deployment*

Presentation makes the case for plants with HRSG duct burners to capture an existing opportunity to burn hydrogen more efficiently and economically than in a gas turbine. Conclusion: Duct burners in a typical North American combined cycle can be converted to hydrogen (operation equivalent to a 30% hydrogen blend for the gas turbine on an energy basis) at lower cost and with less technical risk.

## 11:00 a.m.

### ARNOLD Group

*Advanced steam-turbine warming and casing-management system for increased and reliable IMA*

Discusses the advantages of a steam-turbine warming/casing-management system, the importance of insulation within the system, engineering and set-up of the warming system, installation, and I&C. Plus case studies.

### Gas Path Solutions

*7F filter house repairs and upgrades*

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**May 23, 11:00 a.m.** ARNOLD Group's Pierre Ansmann explains the value of the industry's premier steam-turbine warming and casing management system

Concentrates on issues facing the aging fleet of 7F filter houses and the life-extension retrofit/repair options available to mitigate them. Case histories cover complete filter grid replacement, weather hoods, doors, external shell plate replacement, evap media, ladders, and platforms.

### MD&A

*7FA rotor life assessment and improvements*

Reviews the design and plant-specific information required for a rotor end-of-life assessment—including materials properties, accurate dimensional characterization, operating history, site conditions, location and extent of any defects (as determined by a complete non-destructive inspection), and the expected profile of future operation.

**May 23, 11:00 a.m**. MD&A reviews the design and plant-specific information required for a rotor assessment

Goal is to replace weak-link components with better, more reliable, alternatives, thereby assuring long-term safe and reliable operation. Includes details of company's rotor life-extension solutions.

### Shell Oil Products

*Healthy machines through real-time lubricant condition monitoring*

Focuses on technology and case studies, with the company sharing its years of experience in lubricant management analysis and Industrial Internet of Things (IIOT) technologies to create an industry-wide system for reducing unplanned downtime and increasing maintenance efficiency.

### TC&E, a division of AP4 Group

*Performance evaluations and instrument calibration*

John Downing describes the components and devices most likely to degrade the performance and reliability of your 7FA gas turbine, highlighting the effects of gas-valve, IGV, and instrumentation calibration on the DLN 2.6 combustion system, firing temperature, and emissions.

## Vendor solutions, May 24

### 8:00 a.m.

### Camfil Power Systems

*An IOT approach to predictive maintenance*

Summarizes the methodology and benefits of IoT monitoring for analyzing the performance of the gas-turbine inlet filtration system and its impact on turbine performance under varying ambient conditions. Other insights include long-term maintenance recommendations for filter changeouts and offline compressor water washes to minimize operating cost. Incudes a case study and live demonstration.

### GTC Control Solutions

*Controls upgrade? Lessons learned as an owner's engineer*

The pre-commissioning and final commissioning associated with the upgrade of Mark VI EX2100 excitation control and LS2100 LCI control to Mark VIe EX2100e and LS2100e identifies details others should be aware of to assure they don't go unnoticed on a similar project and become expensive to correct. Focus is on loss of functionality, documentation issues, and errors in the drawings.

### HRST Inc

*Debottlenecking non-duct-fired HRSGs after GT upgrades*

Discusses approaches to debottlenecking non-duct-fired HRSGs that have undergone 7FA GT upgrades and were forced to reduce plant output to control heat input to the HRSGs. Presentation covers company's FlexTune® steam suppression and economizer bypass solutions to control system operating pressure and maintain optimal performance.

### Integrity Power Solutions

*Frame 7F exhaust-frame R3 (replace, refurbish, or repair) modifications and upgrades*

### MD&A

*Case studies on 7FH2 spring migration, changeouts of collector-ring and flex-link systems*

Springs located in each generator-

**May 24, 8:00 a.m.** GTC Control Solutions discusses lessons learned on a controls upgrade project (Mark VI/EX2100/LS2100 to their "e" versions) and why having an owner's engineer is beneficial

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**May 24, 8:45 a.m.** JASC's fuel-system expert, Schuyler McElrath, explains how ZEE can keep your liquid-fuel system ready to operate without test-firing—thereby avoiding coking

**May 24, 8:45 a.m.** MD&A provides guidance on how to extend the lives your high-value parts—in some cases beyond the OEM's established limits

field slot between the amortisseur and slot filler may migrate in service. When this happens, the spring blocks off radial cooling passages, thereby reducing the unit's cooling capacity. Possible result: The unit could develop thermal instabilities and cause excessive rotor vibration. Company's amortisseur spring migration repair is said to solve the problem.

## 8:45 a.m.

### Camfil Power Systems

*Inlet air-filter ratings: A new standard*

Presentation introduces a new test standard that consolidates existing standards into ISO 29461-1:2021, "Air Intake Filter Systems for Rotary Machinery—Test Methods." Goal is to reduce confusion among users when selecting filters.

### EagleBurgmann Industries

*Outage planning tools that can save you time and money*

New outage planning tool uses predicted and real-time data to accurately gauge the remaining lives of expansion joints, mechanical seals, and air inlet filters. Presenters also discuss seal modification kits for the 7FA that can upgrade your units by replacing wear components with flexible, gas-tight sealing solutions.

### JASC

*Zee: Zero-emissions equipment*

Schuyler McElrath explains JASC's product for exercising your gas turbine's liquid fuel system from the main tank up to the fuel nozzles. It simulates turbine pressures and flows on liquid fuel from light-off up to full-speed/no-load without burning oil. System can operate full-time or at selected intervals to ensure operational readiness. It eliminates coke formation while enhancing reliability. Plus, it's adaptable to existing fuel-system designs.

### MD&A

*OEM versus non-OEM parts: Extending the lives of components*

Process explains how users can screen their entire scrap warehouse and perform component repairs on particularly high-value parts, thereby extending their lives beyond the OEM-established limits. Example covers life extension of the 7FA DLN 2.6 fuel-nozzle end-cover insert—up to 125,000 hours, or nearly three times the OEM's limit.

### ORR Protection

*Improving the life safety of $CO_2$ fire extinguishing systems*

Even with all the new developments in fire-suppression technology, $CO_2$ still plays an important role in many vital applications. Presentation brings you up to date on the latest code requirements and mandatory mechanical upgrades specified in revised NFPA 12. It also provides hands-on experience with the products used to address personnel safety and reliability in new and existing systems.

## 9:30 a.m.

### HRST Inc

*HRSG steam-outlet management for uncoupling the steam turbine from a 7F for rapid start to full load*

Discusses two methods of steam conditioning—final attemperation and partial steam bypass of HRSG modules—to enable faster starts without damage consequences. Pros and cons, and limitations of both methods, are included; plus, their implementation.

### Kinectrics AES

*Offline PD testing: An essential element in condition assessment of high-voltage stator-winding insulation systems for rotating machines*

The magnitudes and locations of PD's effect on high-voltage insulation systems supports the need for evaluating an asset's condition by performing offline partial-discharge testing, as well as in-depth visual examination.

### Koenig Engineering Inc

*Turning-gear preventive maintenance and overhauls*

Turning-gear preventive maintenance and overhauls are critical to long-term reliability of these components. Company's recommended overhaul scope of work, failure modes, review of key findings during teardown inspections, trends in failure and wear, methods for repair of damaged components, etc, are included in the presentation.

### Moog Inc

*New extended life actuator bore coating.*

Content includes a description of Moog actuator/gas control valve lineage and model variations, control-system trends and their effects on the lives of fuel control valves, and life-extension considerations for actuator components.

### PGAS Inc

*Getting past the hype and dispelling the misconceptions of optical and laser alignment*

Dale Whorley, a GE retiree,

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shares his extensive experience on gas-turbine optical alignment (preferred), laser alignment, doweling, and casing modifications. Goal is to conduct an open forum to address user needs.

## 10:15 a.m.

### Lectrodryer LLC

*Operation of generator fast-purge package on a GE 7FH2 generator*

Operation of a Lectrodryer generator fast-purge package on a GE 7FH2 generator is the focus of this session. Recent experience shows the value of a fast-purge system when hydrogen leaks are found, and the generator must be purged immediately. Installation lessons learned and operational case studies are included.

### National Electric Coil

*Case study: GE 7FH2, Mitsubishi-manufactured stator core and core failure*

Presentation reviews the stator failure in a Mitsubishi 7FH2 generator and the repair executed just prior to the issuance of GE's TIL 2260 pertaining to core step-iron damage. (Recall that Mitsubishi was one of the alternative suppliers of 7FH2 generators during the "bubble" years.)

Failure-analysis findings, repair options, and the stator core and winding execution of the unit are part of the case-study discussion.

### Riverhawk Company

*Proper operation of the 7F coupling-bolt tensioning tools to include onsite troubleshooting and "tips and tricks" to assure the safest and most efficient use of the tools*

Discussion on the proper handling of the 7F load-coupling-bolt tensioning tool includes an actual demonstration with a real tool on a mocked-up coupling flange. Speaker reviews best practices and lessons learned to help you avoid damaging parts when using the tool.

### Sulzer Turbo Services Houston

*Emergency rotor support services case study*

Presentation chronicles an emergency outage caused by a component failure in a 7FA compressor. It covers onsite procedures to assess unit condition, plan to restore operations, rotor removal for post-failure inspections, findings of the shop rotor inspections, planning of steps forward, and unit repairs in the field and shop.

**May 24, 10:15 a.m.** Sulzer Turbo Services Houston chronicles an emergency outage caused by the failure of a compressor component—including inspections, findings, repairs

## 11:00 a.m.

### AGT Services Inc

*Generator bolted- and brazed-connection integrity*

Jamie Clark highlights problems often found with both bolted and brazed connections, factory/design defects, and maintenance issues that can cause extended or forced outages—the last often with significant collateral damage and repairs required. This is not a vendor-specific presentation.

### Doosan Turbomachinery Services Inc

*Fundamental repair processes: HGP, CI, rotor, and steam turbine*

Presentation and discussion cover these topics:

- Hot-gas-path repair fundamentals.
- Rotor repair, overhaul, and lifetime-extension fundamentals.
- Advanced-gas-path replacement and repair.
- Combined-cycle steam-turbine (D11 and Toshiba) challenges and solutions.

**May 24, 11:00 a.m.** Doosan Turbomachinery Services' rotor expert Scott Keller talks inspection, repair, and lifetime extension, plus steam-turbine challenges and solutions

### ExxonMobil

*Mobil™ Solvancer®: Improving turbine reliability and reducing the cost of operation through advanced cleaning technologies*

Discusses use of the solubilizing agent Solvancer for quickly dissolving deposits and varnish to help maintain the cleanliness of gas- and steam-turbine bearings, seals, and hydraulic systems. Solvancer promises to help owner/operators improve equipment reliability, reduce operating cost, and attain extended overhaul-to-overhaul goals. A case history is included.

### Industrial Air Flow Dynamics Inc

*Trough and round-duct liner overhauls and the value of HRSG inspections*

Liner plate systems for 7F and HRSG inspections are covered by two presenters. The first major piece of ductwork after the GT is the round transition duct, which has a series of overlapping liner plates to protect the outer casing. Upgrades to fatigued liner systems are a focus of the discussion.

Inspections downstream of this duct in the HRSG is the second topic. It can help users avoid and repair gas baffles, duct burners, pressure parts, etc.

### PSM

*Hydrogen F-class combustion retrofit solutions as a pathway to decarbonizing gas-turbine power generation*

Covers the practical and technical challenges of using green hydrogen as a fuel for gas turbines to reduce their carbon intensity towards zero, and gives an overview of the progress in designing, developing, and implementing retrofittable, technology-enabled hydrogen combustion-system retrofits for F-class engines—including commercial experience.

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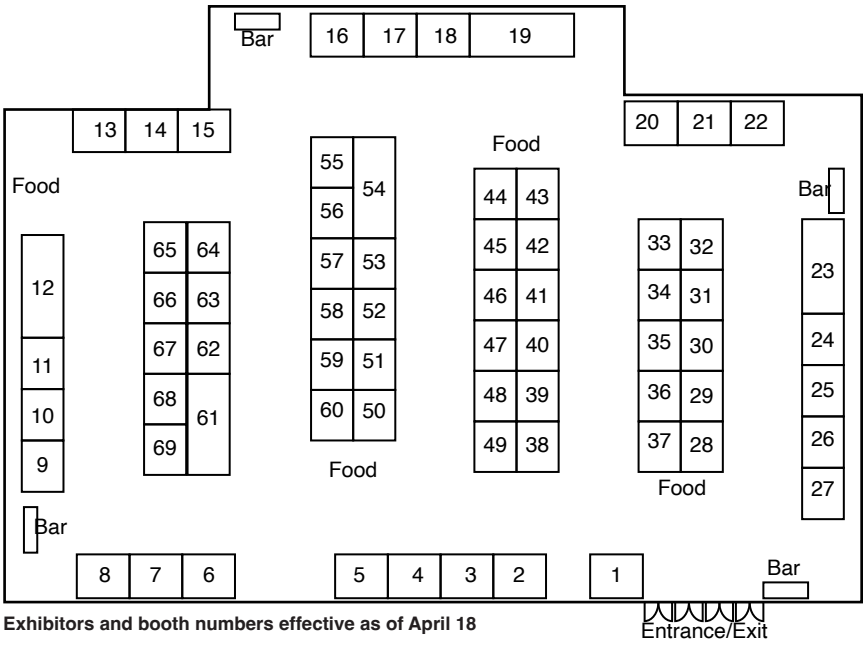
# Vendor Fair

## Monday, alphabetical order

| Company | Booth No. |
|---|---|
| 3angles Inc | 60 |
| Advanced Turbine Support | 18 |
| AGT Services Inc | 38 |
| Allied Power Group | 15 |
| AP4 Group | 54 |
| Arnold Group | 23 |
| Badger Industries | 55 |
| C C JENSEN, Oil Maintenance | 62 |
| Camfil Power Systems | 6 |
| Certrec Corp | 39 |
| Chanute Manufacturing | 59 |
| Conval | 52 |
| Core Tech and CTTS | 17 |
| Cutsforth Inc | 44 |
| Dekomte de Temple LLC | 67 |
| Doosan Turbomachinery Services Inc | 9 |
| EagleBurgmann Industries LP | 47 |
| Emerson | 28 |
| Environment One Corp | 32 |
| EthosEnergy | 51 |
| ExxonMobil | 20 |
| Falcon Crest Aviation Supply Inc/Zokman Products Inc | 13 |
| Filter-Doc Corp | 21 |
| Flow-Tech Industrial | 31 |
| Gas Path Solutions | 16 |
| HPC Technical Services | 53 |
| HRST Inc | 36 |
| Hy-Pro Filtration | 34 |
| IC Spares | 57 |
| Independent Turbine Consulting LLC | 24 |
| Industrial Air Flow Dynamics Inc | 27 |
| ISOPur Fluid Technologies Inc | 10 |
| ITH Engineering | 64 |
| JASC | 50 |
| Kinectrics | 30 |
| Koenig Engineering Inc | 58 |
| Lectrodryer LLC | 41 |
| MD&A | 61 |
| Met Weld International | 42 |
| Moog Industrial | 25 |
| National Electric Coil | 33 |
| Nederman Pneumafil | 45 |
| NRG Energy Services | 35 |
| OILKLEEN | 43 |
| ORR Protection Systems Inc | 68 |
| Pinnacle Parts and Service Corp | 48 |
| Pioneer Motor Bearing Co | 49 |
| Power Services Group | 26 |
| PowerFlow Engineering Inc | 56 |
| Precision Iceblast Corp | 4 |
| PSM | 19 |
| Rapid Belts | 40 |
| Real Time Power Inc | 7 |
| RelaDyne | 11 |
| Republic Turbines | 46 |
| Riverhawk | 65 |
| Rochem Technical Services | 29 |
| S T Cotter Turbine Services Inc | 5 |
| Schock Manufacturing | 2 |
| Shell Oil Products | 12 |
| Sulzer | 14 |
| SVI Industrial (Bremco/SVI Dynamics) | 63 |
| Taylor's Industrial Coatings Inc | 22 |
| Technical Training Professionals | 66 |
| Tetra Engineering Group Inc | 3 |
| Trinity Turbine Technology | 1 |
| TTS Energy Services | 37 |
| Veracity Technology Solutions | 8 |
| Viking Turbine Services Inc | 69 |




**Exhibitors and booth numbers effective as of April 18**

## Monday, booth number order

| Booth No. | Company |
|---|---|
| 1 | Trinity Turbine Technology |
| 2 | Schock Manufacturing |
| 3 | Tetra Engineering Group Inc |
| 4 | Precision Iceblast Corp |
| 5 | S T Cotter Turbine Services Inc |
| 6 | Camfil Power Systems |
| 7 | Real Time Power Inc |
| 8 | Veracity Technology Solutions |
| 9 | Doosan Turbomachinery Services Inc |
| 10 | ISOPur Fluid Technologies Inc |
| 11 | RelaDyne |
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| 13 | Falcon Crest Aviation Supply Inc/Zokman Products Inc |
| 14 | Sulzer |
| 15 | Allied Power Group |
| 16 | Gas Path Solutions |
| 17 | Core Tech and CTTS |
| 18 | Advanced Turbine Support |
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| 44 | Cutsforth Inc |
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| 58 | Koenig Engineering Inc |
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| 62 | C C JENSEN, Oil Maintenance |
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| 64 | ITH Engineering |
| 65 | Riverhawk |
| 66 | Technical Training Professionals |
| 67 | Dekomte de Temple LLC |
| 68 | ORR Protection Systems Inc |
| 69 | Viking Turbine Services Inc |

## Tuesday, alphabetical order

| Company | Booth No. |
|---|---|
| AGT Services Inc | 38 |
| Alta Solutions Inc | 48 |
| American Thermal Solutions | 7 |
| AMETEK Power Instruments | 60 |
| AP4 Group | 54 |
| Arnold Group | 23 |
| AZZ Inc—The Calvert Company | 49 |
| Bearings Plus | 35 |
| Braden Filtration LLC | 37 |
| Chevron | 2 |
| Conax Technologies | 18 |
| Cust-O-Fab | 4 |
| Donaldson Company | 21 |
| Doosan Turbomachinery Services Inc | 9 |
| Durr Universal Inc | 14 |
| Emory Industrial/US Clean Blast | 63 |
| Enerpac | 57 |
| ExxonMobil | 20 |
| Fluitec | 52 |
| Frenzelit Inc | 69 |
| Freudenberg Filtration Technologies | 25 |
| Gas Path Solutions | 16 |

## Tuesday, booth number order

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- *Inlet Bleed Heaters*
- *Inlet Dehumidification Skids*

### Exhaust Systems
- *Fabric Expansion Joints*
- *Thermal Liner Repair & Replacement Kits*
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- *Exhaust Plenums*
- *Exhaust Ducts*
- *Exhaust Silencer Panels & Ducts*
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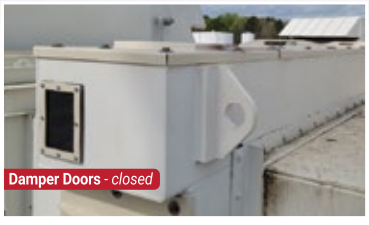
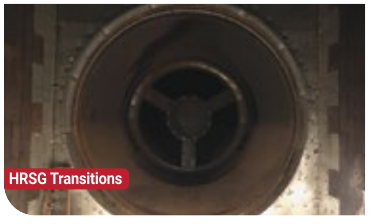
- *HEPPA Filter Grid Upgrades*


Damper Doors - *open*


Diffuser Liners


Damper Doors - *closed*


Flex Seals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Aft Expansion Joints

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# 2021 user presentations

Slide decks for presentations by owner/operators at the 7F Users Group's 2021conference and vendor fair that have been made available for viewing by registered users are posted on the Power Users website (https://powerusers.org). The thumbnails below can quickly point you to subject matter of interest.

## R9/S9 clashing damage during casing lift

Clashing, defined here as contact between adjacent rotating blades and stationary vanes, has been discussed in several CCJ articles over the last decade. The early work associated with defining the problem and when and why it occurred, and then figuring out how to avoid clashing can be found in the archives of the 7EA Users Group published by this journal and available via the online search function at https://ccj-online.com. Evidence of clashing has been reported by owner/operators of all common GE frames—5s, 6Bs, 7Es, and 7Fs.

The presentation at the 2021 meeting of the 7F Users Group focused on clashing that occurred in two 7FAs when their compressor casings were being removed during disassembly for a major inspection. Contributing causes, stated succinctly by the presenter, were the following:

- Rotor pushed aft to take closing clearances.
- As-found thrust was out of tolerance.
- Excessive clearance on casing-lift guide pins and location (body-bounds).
- Rotor blades in Rows 7 to 10 were migrating aft.
- Migrated blades were just above the horizontal split line during the casing lift.

Corrective actions suggested/undertaken by the OEM were these:

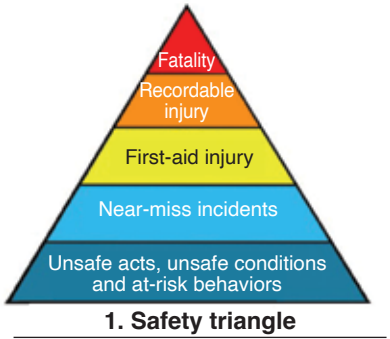
- Redesigned the guide pins (made thicker) to reduce clearance.
- Place all four guide pins in body-bound holes when possible.
- Lift compressor casings slower.
- Borescope under the compressor casing as it is being removed.

## Safety Roundtable: Top safety incidents

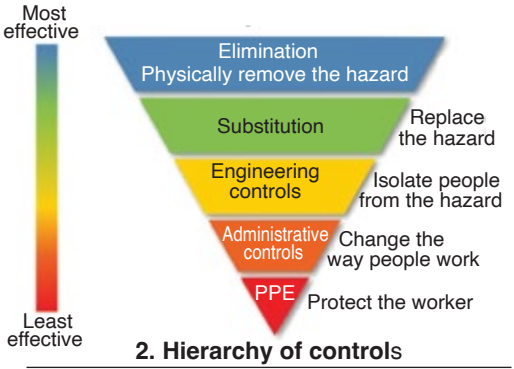
Discussion leader for the Safety Roundtable, a manager in the outage services group at a power producer with dozens of gas turbines, provided valuable perspective in his opening remarks. A basic tenet of accident prevention theory, he said, is that high-severity occupational safety and health incidents are preceded by numerous lower-severity incidents and near misses, such that the ratio of lower- to higher-severity incidents exists in the form of a so-called safety triangle (Fig 1). Further, that similar causes underlie both high- and low-severity events.

The discussion leader then defined the hierarchy of hazard controls—a system used to minimize or eliminate exposure to hazards where the controls in the hierarchy are in order of decreasing effectiveness as shown in Fig 2. He stressed that safety is not the absence of accidents, but rather the presence of defenses.

The first polling question: Which of the following do you think are where most incidents occur performing outage work? A dozen causes were offered. For the speaker's company the most incidents in the last five years were logged in the material handling/moving vehicle category, followed by rigging and lifts, tool use, and slip/trip/fall.



1. Safety triangle



2. Hierarchy of controls

Three incidents then were described along with the controls or tools that could have been implemented to mitigate their occurrence. At-risk behaviors also were identified. The three incidents: burn from a heated bolt contacting exposed skin, dropping of the upper half of a generator end shield improperly rigged for installation, cut forehead that occurred when a worker removed his hard hat then bumped his head while climbing into a combustion chamber.

These first-hand accounts, which preceded the open-discussion portion of the roundtable, are valuable for their learning experiences and certainly worth a read.

## Stage 5 compressor vane failure

The editors believe this to be one of the most thorough presentations on a failure presented at a user-group meeting and worthwhile reviewing by virtually all CCJ readers for how the inspection and metallurgical analysis were conducted, the conclusions drawn, and the recommendations made.

What happened: During steady-state operation, a 7F gas turbine/generator tripped offline as a result of a Mark VI "master protective trip," causing the 52G relay to open. A so-called enhanced borescope inspection of the entire engine was conducted by the OEM to provide a preliminary damage assessment. Severe damage was found in the compressor section (Fig 3). The No. 87 Stage 5 vane, located in the lower casing half one vane removed from horizontal joint on the right side of the machine (looking downstream), was liberated just above its platform.

Crack propagation occurred in two phases. The first was low-cycle fatigue, the second high-cycle fatigue—the latter causing the catastrophic damage. The metallurgical examination revealed crack initiation was at an area with surface damage, most likely caused by water-wash erosion of less than 0.5 mils of depth; the driving force was LCF. The fracture-surface photography provided enables a good understanding.

The vane material, Custom 450, was not at issue as the material was within specifications. Experts concluded that the failure was most likely caused by inadequate frequency response—the thought being that No. 87 could have been an outlier with respect to shape, weight, or another physical parameter not related to the material. Frequency response is considered the *probable* root cause because further analysis was not possible, the vane having been destroyed.

Finally, erosion pitting was ruled out as a root cause because the reference vanes had very minor indications of erosion pits, yet they did not develop into a crack. When compared to the reference fifth-stage vanes, the failed airfoil had a similar chemistry, hardness, and microstructure properties.

## 7F controls: Panel discussion

There is no way to summarize in a few words all that was covered during

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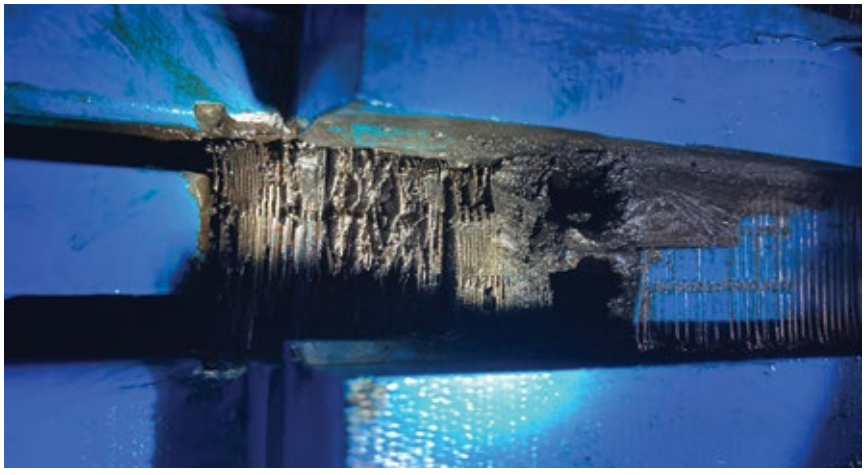
**3. Significant damage** was found in Row 5 of the 7F compressor; vane damage is shown here



**4. Damage to core iron** was significant

the controls segment of the meeting. A bullet-point list of the discussion topics follows; a summary slide for each was prepared by the session leader and these may be worth skimming, depending on your "need to know."

- Auto-Tune CDM (combustion dynamics monitoring) probe-failure mitigation.
- Fire protection, including discussion points on water mist systems.
- Online water wash and take-aways from a user's TIL 1603-R1 experience and reference to TIL 1323-3R1. Recall that TIL 1603 provides recommended time durations for water washing. An observation offered: Controls portions of TILs often are overlooked.
- Water-wash controller and other upgrades. Highlights include issues facing users equipped with a variety of PLCs (GE Fanuc, Allen Bradley, etc) and the benefits of replacing them with Simplex Mark VIe controls.
- An unintentional gas-turbine start without purge during an offline water wash (TIL 2289).
- Unnecessary exhaust-spread runbacks. Recall that exhaust runbacks are initiated when controls detect failed-low and failed-high thermocouples. Suggestion: Add a 1-sec time delay for high and low failure detection to prevent an erratic t/c from being counted as both failed-high and failed-low.
- Mods to consider for the OEM's original anti-icing program to reduce the possibility of compressor damage.

## Faulty CDM probes and model base control

Related to some material discussed in the controls panel (see above). This short presentation reviews how to identify a faulty CDM probe and disconnect it.

It also mentions the OEM's efforts in developing a logic fix to ignore faulty signals and the benefits of setting up alerts in monitoring software to review data on suspected faulty CDM probes

## Generator stator-core surprise

This is the case history of a 7FH2 generator minor in mid-June 2021 for a unit with no known operational issues. Background:

- Unit data included 224 MVA, 18 kV, 7200 amps.
- Last inspection in 2015 using the Magic robot from the collector end revealed no significant issues.
- With both endbells off during the minor, staff decided to pull the upper inner gas baffles on both ends to permit limited inspection of the stator-winding end turns and the rotor.
- Preliminary observations: Collector end of the machine appeared normal, but there were signs of oil ingress. Inspection of the turbine end revealed a mysterious object in the air gap between the stator and rotor. It was magnetic, possibly stator core iron.
- Action: Pull the rotor (unplanned).
- Findings included greasing of the stator core, dings and dents on the rotor body, damage to the turbine-end retaining ring, debris in hydrogen coolers, damage to core iron (Fig 4), and partially blocked cooling passage. Photos illustrate all of these findings.

The speaker reviewed the process used to determine the cause of the concern and what to do about it. This involved testing of stator core iron and a stator-winding hi-pot test. There were no red flags. A review of issues associated with the 25-year-old rotor, repair options/choices considered, and restoration decisions made are spelled out in the presentation.

The investigative effort revealed that the first two dozen machines of this type/size (identifiable by serial number) were assembled using a defective core-compression process wherein key-bar nuts were torqued to 2000 ft-lb but thermal cycling may have contributed to a loosening of the core iron.

Bear in mind that because the cores are stacked vertically with the turbine end up, the loose core-iron issue occurs only on that end. Suggestion to owner/operators was that because the area of concern is difficult to inspect with Magic, they might want to consider rotor inspections going forward.

Details on the repair of damaged core iron closed out the presentation (Fig 4), which qualified users can access in the 2021 conference files at https://powerusers.com.

**Several more presentations** were made by users at the 2021 conference, but they had not been posted to the Power Users website prior to press time. If the subject matter below is of particular interest, you might want to check back to see if those presentations are now available.

- Lube-oil detection software.
- In-situ fuel-nozzle flow testing.
- FlameSheet™ project update.
- 7FA.05 first HGPI experience.
- Rotor end-of-life maintenance considerations.

# 2021 vendor presentations

Slide decks for all vendor presentations made at the 7F Users Group annual conference in the Marriott St. Louis Grand, Aug 23-27, 2021, are available for viewing by registered owner/operators on the Power Users website (https://powerusers.org). The thumbnails below can quickly point you to subject matter of interest. Nearly 200 users attended this meeting; 104 equipment and services providers participated in the vendor fair.

## MD&A

*Rotor life assessment*

Fred Willett, gas-turbine principal engineer, begins by walking you through MD&A's four-step assessment process: Disassembly/unstack, thorough inspection, engineering review and risk assessment, rebuild for continued operation. Inspections described and where used are these: Visual, ultrasonic phased array, eddy current test, hardness test, metallurgical investigation, alloy confirmation, dimensional inspection, and surface inspection.

Turbine disc problems associated with the first and second stages are identified, the benefits of MD&A's cooling-slot shape are described, dovetail modification and lockwire groove cracking are explained, and the 1-2 spacer issue is reviewed.

*Design enhancements: 7FA 1-2 spacer cracking*

Willett reviews in detail the 1-2 spacer issue identified in his earlier presentation. The findings from an analysis of a 9FA that tripped on high vibration were these: A section of the spacer rim had liberated, cracks initiated on the inner surface and propagated outward and circumferentially, and fatigue was exacerbated by hold-time crack growth. MD&A's solution was the spacer with improved stiffness described in the presentation.

*7F gas-turbine alignment*

Charles Monestere, operations manager, alignment services, reviews the component checks required to assure proper alignment of turbine bearing and casing; common problems are identified. Also, he explains the impact of casing distortion and bore positions relative to the machine centerline and their impact on tip clearances.

Three-dozen slides illustrate and explain how to align a gas turbine. This "how-to" presentation would be a valuable addition to most plant libraries for ready reference before an alignment project is undertaken.

*7F component life extension*

If you're having difficulty with your F-class gas-turbine OEM when it comes to repair of hot-gas-path (HGP) components, MD&A wants you to know they not only have the experience you are seeking, but also enhancements, which will extend service life, plus provide better transparency and customer oversight throughout the repair process.

Jose Quinones, PE, director of engineering, reviews the company's capabilities, experience, and customer-care process, most pointedly through examples including nozzles, blades, and shrouds for all three turbine stages.

*Gas-turbine thermodynamic analysis and performance testing*

James Miller, PE, manager of performance services, walks you through a CliffsNotes of sorts dedicated to calculations plant personnel and engineering staff should be familiar with, including the following:

- Gas-turbine performance calculations—generator, compressor, and turbine efficiency.
- Determining firing temperature.
- Tuning and combustion impacts on efficiency.
- Typical degradation and its effect on performance.
- Effects of turbine boundary conditions.
- Example of test corrections and reconciliation.
- Example of thermal survey findings.

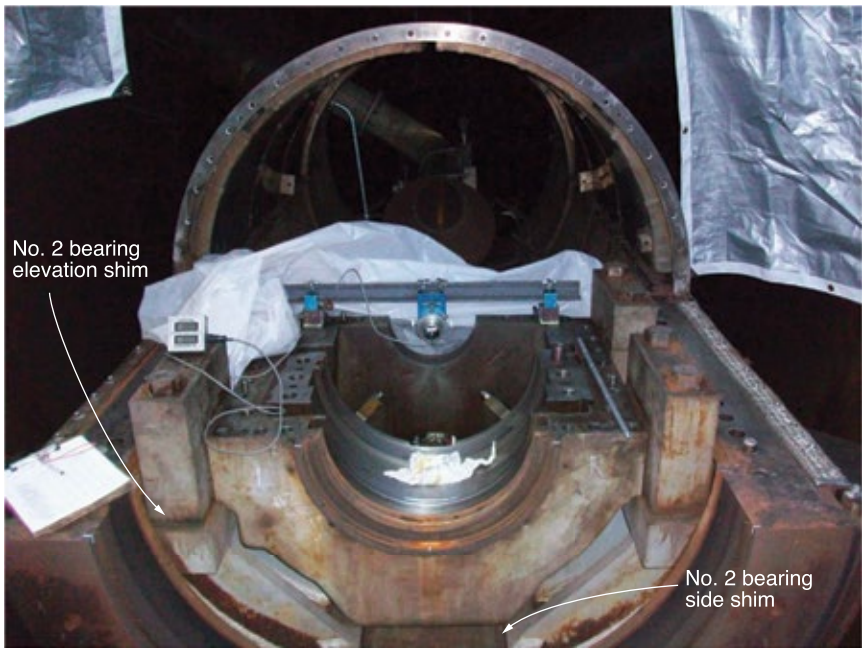
Equations and simple illustrations throughout make this a valuable addition to your analytical toolbox.

## PSM

Advanced *technologies for the 7F.03: Development a*nd implementation

Greg Vogel, manager of technology, offers the following view: To maintain relevance in the power generation merit order, F-class gas turbines must withstand higher firing temperatures, aggressive peak and turndown limits, quicker ramp rates, and maintain operations with varying fuels. Only new technologies enable these new requirements. The following are some effective upgrade technologies available to increase the output and flexibility of existing assets.

- Additive manufacturing, for example, opens the door to novel designs. One benefit is a direct-cooling efficiency improvement for increased performance and lifetime capability, allowing the gas turbine to meet new operational requirements while at the same time reducing overall lifecycle cost. In 2018, PSM said it was the first company to rainbow test and F-class HGP additive-manufactured component with improved capabilities.
- Superalloys. In advanced F- and H-class units, superalloy components allow higher firing temperatures. However, this technology also has posed problems to operators regarding maintenance and overall operability cost. PSM has developed and implemented advanced equiaxed and directionally solidified alloys and has completed several engineering studies on varying applications. Advantages and disadvantages of these were discussed from a technological and




**MD&A's** laser target bracket setup is shown in the alignable No. 2 bearing pedestal located in the exhaust casing

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# Sharp eye averts sharp rise in production loss

Specialist weld repair of a D11 L-0 turbine blade

**KEY POINTS**

- Tiny crack identified on D11 L-0 blade tip could have resulted in a lengthy outage and production loss costing millions of dollars.
- One of our specialist welders traveled from the UK to repair the blade, saving the client hundreds of thousands of dollars in capital expenditure.
- Major outage kept on schedule.

**THE CHALLENGE:** Eagle eye spots cause for concern

In engineering, as in life, it's often the small matters you need to be most concerned about. The tiny things with the potential to cause the most damage. Which is why, when our client—a municipal combined-cycle power plant—asked us to carry out a major outage on its steam turbine, we first went over it with a fine-tooth comb.

**1. A- ⅜-in. crack** was found on the tip of an L-0 blade in the LP

**2. Weld repair** complete

At EthosEnergy, we make a point of sending qualified engineers out on site for discovery. It's one of the things that differentiates us from other ISPs and OEMs. We want to make sure we identify each and every potential risk. And ensure our clients receive top-quality work.

If there was ever an occasion that demonstrated how beneficial this considered approach can be for a client, it was when our steam turbine application engineer detected a small crack— measuring just three-eighths of an inch—on the L-0 blade tip of the low-pressure rotor (Fig 1).

Considering the size of the rotor—which, at over 30 ft long and weighing around 90,000 lb, is easily one of the largest rotors in the world—this was a remarkable find. But one that gave our client significant cause for concern.

**THE SOLUTION:** Sending for a specialist welder

The only viable source for replacing a row of blades was the OEM. But it would have cost around $2 million to do so, with a significant lead time. And reconditioning the blades would have still set the client back in the region of $1 million.

Was there a better solution? One that would prevent the LP rotor from supplanting the HP/IP rotor as the critical-path item for the major outage?

The engineers at our Houston facility believed that something could be done to refurbish the L-0 blade but that it would require specialist expertise. That's where our global reach and OneEthos approach really shone.

Knowing we had the requisite expertise in the UK, we sent photographs, drawings, and materials analysis to our specialist steam turbine repair center in Worcester, England. While it would be an involved process, our team concluded the blade could be repaired.

So, one of our specialist UK-based welders traveled to the US and carried out a weld repair (Fig 2).

**THE IMPACT:** Weld repair proves crucial to staying on the critical path

Thanks to our engineer's eagle eye and our ability to weld-repair L-0 blades, we saved the customer a tremendous amount of money and kept the major outage on schedule.

Had the crack on the L-0 blade tip not been picked up, it would most likely have continued to propagate all the way to the rivet hole, leading to vibration issues or even catastrophic failure. With imbalance, there would have been a high risk of the unit crashing. It's likely the turbine would have been out of operation for at least three weeks. Potentially, it could have been down for as long as six months—at a production loss of around $750,000 a day.

On top of that, we saved the client the additional repair and capital expenditure costs.

This was an extraordinary and highly valuable identification by our application engineer. In addition, our team also spotted shroud lifting on the L-2 blades that was no more than around 40-thousandths of an inch. Because the lifting was on the closing blades, which were made out of titanium, we were unable to carry out a weld repair. But by replacing two groups of blades, we effectively wound the lifecycle back to zero hours again on those two groups.

Yet further evidence that having an eagle eye on site makes all the difference.

EthosEnergy

# **Turning on** steam turbine potential


SCAN ME

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Our steam turbine engineering solutions reduce the risk and operating costs of your rotating equipment, and help you to make energy affordable, available and sustainable for everyone.

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cost perspective. Unfortunately, PSM had not released a copy of the final presentation by press time.

- Fuel flexibility. In addition to new manufacturing techniques and advanced superalloy applications of rotating components, the industry has begun evaluating the ability to burn a variety of fuels—including hydrogen and shale gas—with the goal of lowering operating costs while keeping the gas turbine viable in a net-zero-carbon world. PSM's FlameSheet™ is part of this solution.

### AGT Services Inc

*7FH2 generators: Crucial spare parts and replacement components every owner must consider in your service provider*

Jamie Clark, well known to powerplant personnel for his generator knowhow, explains that while the 7FH2 fleet has a long history of comparatively reliable operation, age is catching up with these units, which also are being asked to run harder. There are critical components, parts, and pieces to consider, he continues, whether for your own stock or for your service provider. Speed and time are crucial in being able to get your unit back in service, whether from a planned or unplanned outage.

Unfortunately, contends Clark, many critical components aren't readily available. He then identifies these components—such as HV bushings and stator windings—and urges owner/operators to evaluate service providers and identify a pathway to access them in a timely manner and minimize your risk.

### Koenig Engineering Inc

*Turning-gear low-speed drive and maintenance*

The tag team of Tim Connor, manager of aftermarket sales and field service for Koenig Engineering, and Nick Fischer, GE's product line engineer and manager of overhaul/modifications, provide in-depth information on what they describe as the biggest design change to the 7F turning gear in more than two decades.

Specifically, the low-speed drive modification includes a new primary gear reduction and a second turning-gear motor to operate the TG at a fraction of an rpm. The low-speed drive saves power and is said to provide a 60-fold reduction in bucket-rock wear.

The presentation also discusses recent inspection findings and best practices.

### EthosEnergy

*7FA rotor lifetime extension*

Jeff Schleis, product manager, reminds owner/operators that many 7F gas turbines are approaching the OEM's 5000 factored-start/144,000 factored-hours limits requiring lifetime inspections and solutions to extend the run times of hours-based units. Presentation focuses on solutions that enable you to maximize the value of critical equipment, including the following:

- Compressor stages R0-R5 (flared and unflared).
- R0/S0 blades (original, enhanced, enhanced high output).
- R12-R17 wheels and blades (round-slot and flat bottom).
- R14-R17 wheels (original and robust-back-end designs).
- Turbine rotor (TIL 1937, cooling slot geometry).
- Distance piece (original and reverse-rabbet designs).
- Cooling slot (original symmetrical configuration, contoured design, enhanced design).

Schleis presents the inspection scopes for compressor and turbine wheels and distance piece/spacers/stub shaft. The good news when the inspection results say "no findings," your rotor is reassembled with new

bolts and is certified for a one-time life extension.

### Young & Franklin

*Benefits of electric gas control valves and IGVs*

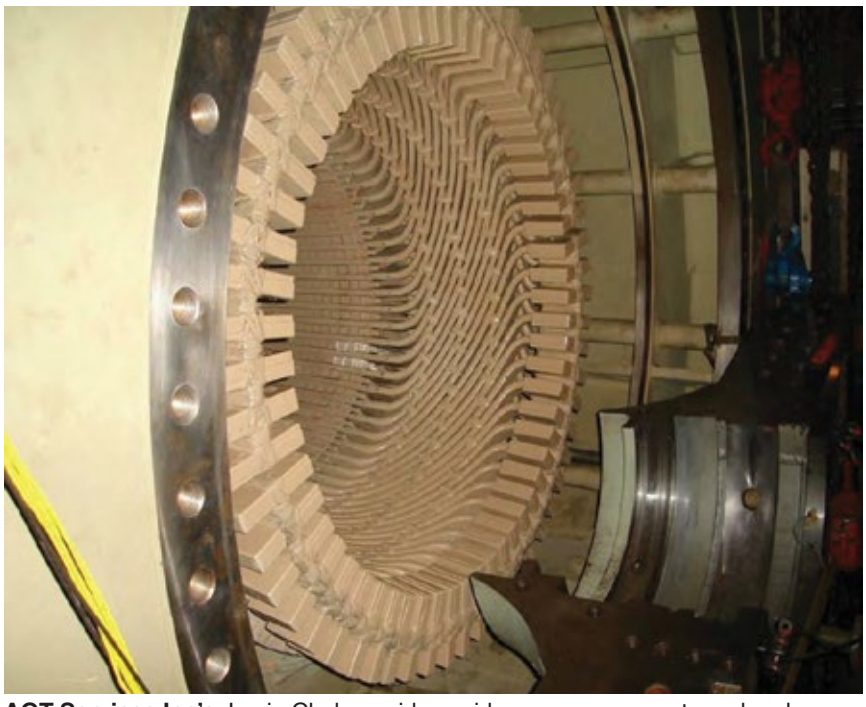
Andrew Dwyer explains the advantages and simplicity of replacing your legacy hydraulic gas valves and guide-vane actuators with their electric counterparts. In addition to eliminating all issues with hydraulics, the electric replacements are said to offer the following benefits:

- Maintenance intervals of 96,000 hours.
- Improved gas-pressure recovery.
- Diagnostic tools.
- Big savings in maintenance and insurance.

### JASC Controls

*Mitigation of combustion nozzle failures on a dual-fuel turbine: Case study*

Schuyler McElrath, respected by users for his knowledge of gas-turbine fuel systems, co-presents with a plant manager on the operational improvements made possible by installing water-cooled liquid-fuel handling equipment on a problematic 7F engine. The case history shared is for a unit that had experienced forced outages over a period of years because of combustion-nozzle and fuel-control-valve failures. Implementation of JASC's water-cooled 3-way purge valves eliminated six-figure repair costs, hundreds of lost manhours and annual valve failures/refurbishment attributed to coking.



**AGT Services Inc's** Jamie Clark provides guidance on spare parts and replacement components for 7FH2 generators that you should consider having available

### Integrity Power Solutions LLC

*7F exhaust-frame R3 (replace, refur-*

*bish, or repair) modifications and upgrades*

President David Clarida's presentation explains how to inspect and modify/upgrade gas-turbine exhaust frames while keeping in mind potential O&M budget constraints. He begins by looking at how to (1) proactively identify the most common problems associated with exhaust frames, (2) catch up on the latest designs and technology to help eliminate recurring repair jobs, and (3) examining case studies to illustrate lessons learned and possible repairs.

### Chevron

*Case studies in turbine varnish removal*

Paul Sly, technical advisor, shares the experience gained in removing varnish from gas turbines over a 15-year period—including both expected and actual outcomes. Several chemistries and technologies are reviewed: solvency enhancers, detergents, PAG cleaners, and varnish filtration systems. The positives and negatives of each approach are presented. Varnish chemical-cleaner bench-test data demonstrate the objective measurement of effectiveness, and turbine-oil compatibility with a variety of commercially available cleaners.

### Environment One Corp

*Hydrogen auxiliaries: Best practices for operation and maintenance*

Gus Graham, director of products and markets for Hydrogen Systems International, Environment One Corp, estimates that nearly 70% of all electric generators over 60 MW use hydrogen as the cooling medium.

He posits that hydrogen can pose significant challenges to owners, operators, and maintenance personnel from the standpoints of safety, risk mitigation, and increased-efficiency demands.

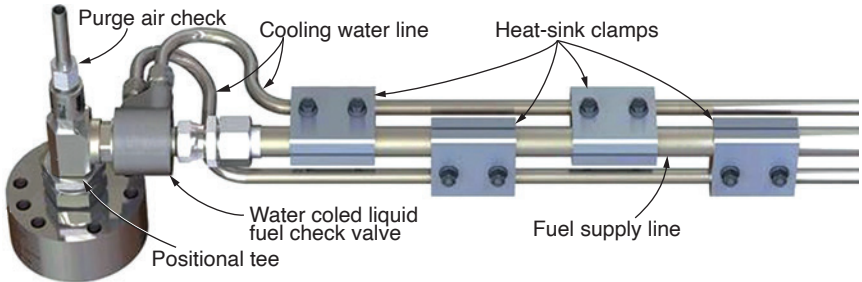
Thus, your generator's hydrogen auxiliary system requires close attention to monitoring and maintenance to ensure safe plant operation. Operational challenges—such as increased load cycling, shortages of well-trained and experienced personnel, and extended time between outages—place additional stress on these critical systems. Presentation provides a guide for best practices in the design, upgrade, and maintenance of hydrogen systems.

Specific topics include the following:

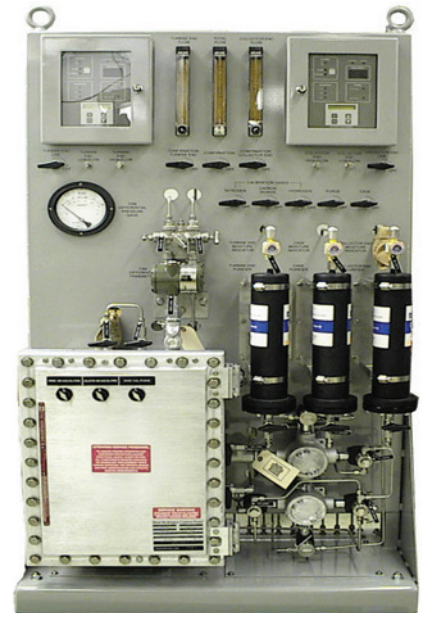
- Understanding hydrogen as a generator cooling medium.
- Hydrogen properties and associated hazards.
- Hazardous equipment design.
- Best practices for working in a hazardous area.
- Hydrogen purity monitoring.
- Hydrogen leak detection.

**EthosEnergy's** Jeff Schleis focuses on solutions that enable users to extend the lifetimes of their gas turbines. Photo is of a never-fired 7FA.03 rotor in the company's warehouse

**Young & Franklin's** electric stop/ratio valve (left), control valve (center), and inlet-guide-vane actuator (right) promote finer control than had been possible with hydraulic actuation without the headaches




**JASC's heat-sink device** is one of the company's third-generation improvements to prevent coking in gas-turbine liquid fuel systems



**E/One's dual hydrogen control** panel**,** a/k/a DHCP, designed for use on generators with scavenging seal-oil systems, measures hydrogen purity in four locations to ensure safety and helps maintain gas purity through control of scavenging flow rates

# 7F 2021 Best Practices

The 7F Users Group and CCJ are working together to expand the sharing of best practices and lessons learned among owner/operators of large frame engines. One of the user organization's objectives is to help members better operate and maintain their plants, and a proactive best practices program supports this goal.

Details for two of the four entries from 7F-powered plants judged Best of the Best in 2021—Effingham County Power and Green Country Energy—appeared in CCJ No. 68, published late last fall. The remaining two 7F plants receiving Best of the Best awards in 2021—River Road Generating Plant and Woodbridge Energy Center—are profiled on the pages that follow.

Other entries in the 2021 Best Practices program recognized with awards are listed in the index below. The more than two-dozen best practices shared by your colleagues at 7F facilities are likely to offer an idea or two for improving safety and performance at your facility.

The Best Practices Awards program for owners and operators of generating facilities powered by gas turbines celebrates its 18th anniversary in 2022. Over the years, more than 800 best practices entries have been received from more than 200 individual plants and fleets.

The most successful plant in the program's history is Effingham County Power, which has received eight Best of the Best awards. Its first came in 2010, seven years after COD. This year, General Manager Bob Kulbacki and his team shared two best practices, beginning on p 86 of CCJ No. 68. Particularly noteworthy about Effingham's run is that it has spanned four owners, four plant managers, and several teams of judges.

**Best Practices Awards presented to plants powered by 7F gas turbines in 2021**

# River Road

## River Road Generating Plant

*Owned by Clark Public Utilities*

*Operated by General Electric*

250 MW, gas-fired 1 × 1 7FA-powered combined cycle located in Vancouver, Wash

**Plant manager:** Robert Mash

## Steam-trap problem-solving begins with UT inspection

**Challenge.** Over the years, River Road Generating Plant had experienced several steam-trap failures. In sum, they negatively impacted plant heat rate and allowed condensate to back up in the associated piping systems, inviting the potential for water hammer and the damage it causes.

**Solution.** Plant personnel attended an ultrasonic-detection training program where they learned both how to properly operate UT equipment and analyze the data gathered.

Next, a monthly PM was created for UT inspection of River Road's steam traps. Ultrasound allows the inspector to listen to the work cycle of the steam trap (Fig 1). When a trap is not cycling it either is stuck open or closed. Inspection revealed many of the thermostatic steam traps were not cycling, even though they had been replaced recently. Recall that thermostatic steam-trap operation is based on the temperature differential between steam and condensate.

River Road technicians discovered that insulation had been installed over the steam traps and was negatively affecting their operation. The insulation was removed and expanded-metal cages were fabricated and installed over the traps to assure as-designed operating conditions. The cages protect staff from the high-temperature steam-trap body, thereby reducing the risk of contact burns.

**Results.** UT steam-trap inspection identified improperly installed insulation and prompted a creative solution to assure proper trap operation while ensuring employee safety.

**Project participants:**
Justin Hartsoch, operations manager
Jake Sanderson, operations

**1. Technician checks steam trap** for proper operation at left, views results above

## Use ultrasound camera to locate leaks of compressed gas

**Challenge.** Leaks of all types of compressed gases—plus air and vacuum—can be difficult to locate, often not found until the issue has progressed to an extreme condition or has caused a failure. Undetected leaks may cause heat-rate losses, system contamination, safety issues, and component failures.

**Solution.** Develop a leak-detection program using an ultrasonic camera. Recall that ultrasonic imaging allows visualization of sound; many sounds inaudible to human ears can be displayed on the device.

Ultrasonic imaging technology works by pinpointing turbulences caused by gaseous mediums escaping from either a pressurized or vacuum environment (Fig 2). The Distran Ultra Pro V2 acoustic monitoring camera used at River Road relies on 124 high-frequency microphones to stitch together accurate images of gaseous leaks using phased-array principles.

The plant team developed a periodic ultrasonic imagining inspection PM for these systems/components: Instrument air, natural gas, steam, gas-turbine doors/exhaust (Fig 3), boiler drums, HRSG fireside case/manways, lube-oil tank hatches, and generator hydrogen.

Inspection images upload automatically to Distran's Autolytic platform, where analysis and report generation can be completed. Work orders then are created to address identified issues.

**Results.** Air tubing and valve packing leaks were found easily; many were repaired immediately after discovery. An important benefit of the ultrasonic imaging tool is that you can see the results of your repair in real time. However, some items

**2. Pegging-steam leaking** from control valve


**3. Damaged gasket** allows air leakage at package door

identified required additional planning and downtime to address—such as turbine door seals and pneumatic valve actuators.

**Project participants:**
Justin Hartsoch, operations manager
Jake Sanderson, operations
Mike Buhman, maintenance

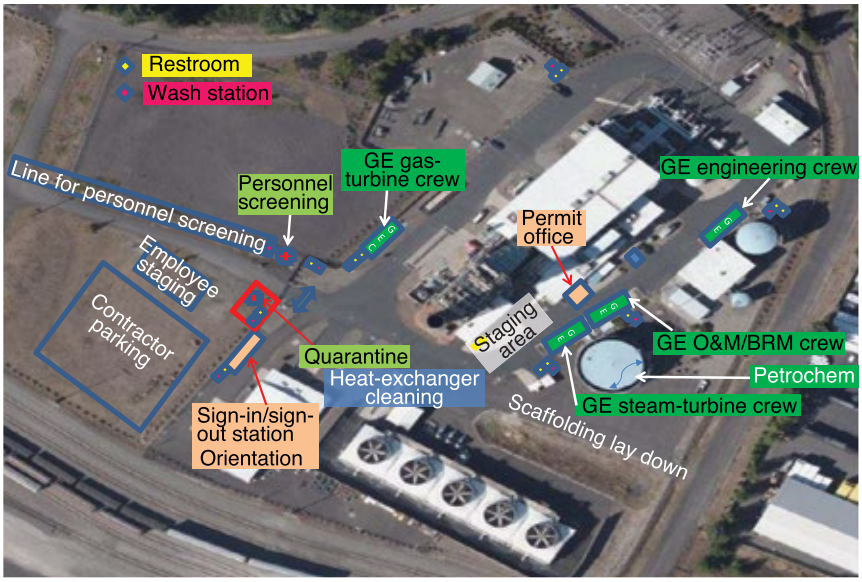
# Covid-19 and the outage challenge

**Challenge**. River Road Generating Plant was scheduled for a maintenance outage at the beginning of the Covid-19 outbreak in the state of Washington requiring both skilled site and contract workers. Staffing requirements would fluctuate throughout the month and the plant team had to develop a plan to complete the required work while protecting workers from the virus.

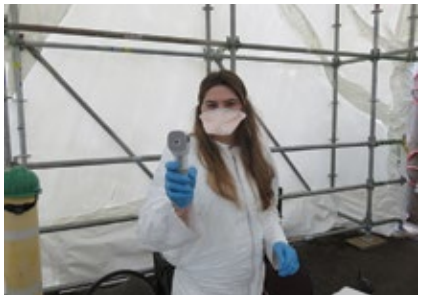
**Solution.** Virtual brainstorming meetings were held and ideas were captured from the entire team. Priority was given to ideas that could be implemented quickly, were endorsed by the employees, and allowed time to communicate the actions to contractors. The utility owner's energy resources manager assisted with the review and obtained a budget to acquire the protection measures required.

All site employees were involved in implementing the various ideas, including the following:

- Masks are required while working at the plant. Challenges here included the time required for workers to get used to a mask routine while dealing with supply shortages of quality masks. Plant employees constantly reminded each other, and contractor personnel, to wear their masks. Daily reminders also were made over the PA system and via signage with instructions on how to wear a mask and how to clean ones made of cloth.
- Touchless fixtures were installed in bathrooms and kitchen areas.
- Touchless garbage receptacles were staged in various plant locations.
- The number of outdoor bathroom facilities was increased and handwashing stations were installed at various points in the plant for ease of access and social distancing (Fig 4). Disinfectant cleaning was done daily with sanitizer readily available.
- Designed and constructed tents for the following purposes using scaffolding hardware and heavy-duty plastic shrink wrap:
  - Health check stations (read temperature) outside the plant fence. An occupational medical contractor was engaged to conduct the testing. Its employees were clothed in PPE




**4. Location of outage facilities** at River Road shows generous spacing between them



**5. Tents,** such as this one for taking temperatures, were built using plastic sheet and scaffolding


**6. Permit tent** was segmented to ensure proper distancing and minimal personal contact

to protect site employees against possible exposure (Fig 5).

- Orientation/check-in at the front entrance to the plant. Features: Sufficient space inside the tent to accommodate social distancing, a separate room for log-in/log-out activities, entrance and exit doors are at opposite ends of the tent.
- Permit tent (Fig 6) to eliminate use of the control room for planning work and permitting. It was attached to the administration building, which allowed the shift supervisors to use the plexiglass window for protection. This tent provided access to computers to communicate LOTOs, work permits, and conduct discussions of work activities with contractors. Staged lanes in the tent ensured proper distancing for opening and closing permits.
- Staged the quarantine tent outside the plant fence to keep possible symptomatic individuals at a distance and cared for by medical professionals until they could be relocated to permanent facilities.
- Increased the number of mobile trailers to keep the turbine maintenance crews separated. Also, a break trailer was provided for site employees to limit control-room traffic and provide a separate break space from contractor workers. Trailer occupancy limits were posted to keep gatherings at safe levels.
- Took a fresh look at administrative processes. Highlights: Contractors were scheduled to start at staggered times to reduce traffic at the permit tent; workscope activities were coordinated among contractor groups working in common areas to maintain social distancing; daily meetings were conducted inside and outside in small groups properly masked and separated, as well as virtually and via group phone calls.
- Rearranged some projects to complete them at the end of the outage when fewer workers were onsite.
- Deferred non-essential work.
- Assured supplies of hand sanitizer, bleach, water, and disinfectant wipes (or spray) were available to onsite personnel.
- Communicated with all contractors regarding site requirements. They were issued a map showing placement of tents, bathrooms, etc. Made clear was the expectation that breaks and lunch would be offsite or in vehicles parked outside the plant fence.

**Results.** The group had a short timeline to get all these actions completed, but staff and contractors worked together to complete the outage successfully. There were no confirmed Covid-19 exposures and no complaints were received regarding protection of all individuals working at the site. A critical review of the 2020 initiatives and actions identified improvements for implementation during the 2021 outage.

**Project participants:**
Margie Brice, EHS specialist
Operations team
Maintenance team

# Control access to transformer yard

**Background.** The transformer yard houses several critical power generation components: Generator breaker, step-up transformers, excitation system, and load commutated inverter (LCI); unit auxiliary transformer; and isolation/excitation transformer (Fig 7). Plant operators enter the yard,

**7. Transformer yard** is home to equipment critical to the operation of River Road

**8. Access to the transformer** yard is via one of two manway gates

located inside the plant's chain-link boundary fence, four times daily to monitor the assets within. Access to the yard is through one of two manway gates (Fig 8).

One evening, an intruder climbed over the perimeter fence and entered the unsecured transformer yard. Next, he entered the generator excitation compartment, a modular building, and climbed up to the generator breaker and opened its local controls cabinet. The intruder did not sabotage any critical equipment or interfere with power production.

**Challenge.** Improve transformer-yard security to prevent entry to the area by unauthorized people. The belief that this area was secure because it was inside the plant's perimeter fence is no longer valid.

**Solution.** Install electronic card readers at the manway access points for the transformer yard and tie them into the plant's existing access control system. Also, install tamper-resistant emergency-exit crash bars to allow personnel quick egress in an emergency. A hydraulic gate closer ensures the locking mechanism engages after passage.

**Results.** There has been no unauthorized entry into the transformer yard since the improvements described above were implemented.

**Project participants:**
Jack Blair
Ken Roach

# Facilitating fan access to make maintenance safer

**Challenge.** The turbine-building MCC is home to 4160- and 480-V circuit breakers for various plant electrical equipment. Intake fans pull ambient air through penetrations in the building wall to maintain a slight positive pressure while also providing cooling air to prevent component overheating.

The intake fans are located inside the MCC and are secured to the roof of an adjacent battery room. The two fans sit side-by-side, essentially on a high shelf above the main MCC space, but still within the building. Access to the fans for filter changes and maintenance was challenging and posed several safety risks. Workers must climb up from the floor of the MCC room on an 8-ft ladder and transition off the ladder while leaning through an 11-in. horizontal gap between the edge of the roof and various conduit and cable trays (Fig 9).

Emergency egress, if required, would be very difficult from this location.

**Solution.** With working space limited, staff had to find a creative solution to gain safe access to the intake fans. Following several brainstorming sessions among plant colleagues, an out-of-the-box idea was proposed: Cut a hole in the wall and build a stairway for access. While this idea was attractive, entry from outside the building was encumbered by an existing stairway support structure that blocked the only possible location for a new access.

Personnel worked with a local structural engineer to help with a resolution. The existing staircase support structure was re-engineered to support an additional smaller staircase and landing that terminates at the ideal level for access to the intake fans through a newly cut doorway in the building wall (Fig 10).

A custom door was installed to allow direct access to the intake-fan area for maintenance activities.

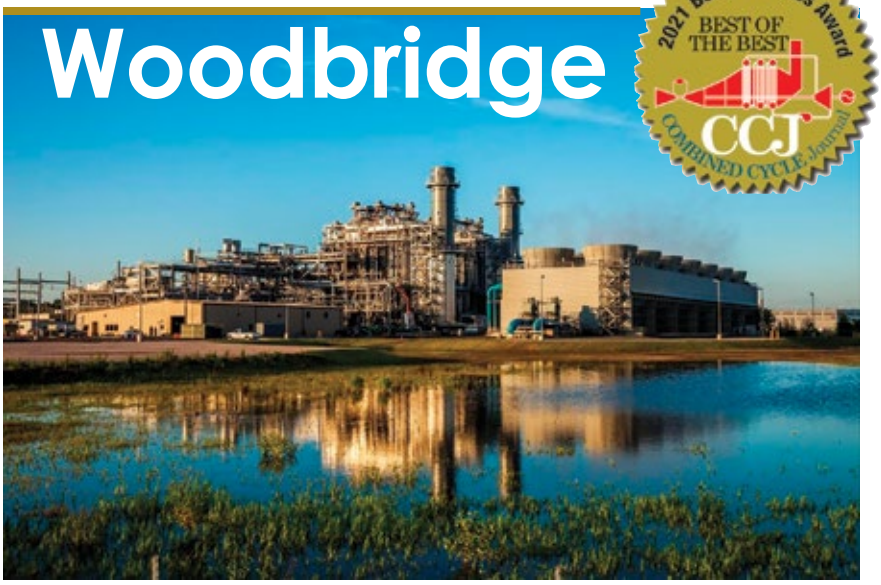
**Results.** Safe access and egress during intake-fan maintenance activities were achieved. Benefits include the following:

- Ability to walk into a fan location without climbing a ladder.
- Way to escape the MCC safely in the event of an emergency.
- Reduced risk of personnel injuries.
- Allows for the transport of filters and tools by one person.

**Project participants:**
Ken Roach, maintenance manager
Mike Buhman, maintenance

**9. The plant, as designed,** required a ladder to access the MCC intake fan and filter units


**10. New staircase** provides access to the intake fans via a doorway cut in the building wall




**Woodbridge Energy Center**

*Owned by CPV Shore LLC*

*Operated by CAMS*

725 MW, gas-fired 2 × 1 7FA.05-powered combined cycle located in Keasbey, NJ

**Plant manager:** Chip Bergeron

# Separating wastewater streams to reduce makeup, sewer costs

**Challenge** Woodbridge Energy Center has a Beneficial Reuse Gray Water Agreement for cooling-tower makeup, and a Sewer Agreement for all wastewaters produced by the facility. Each includes a dollars-per-gallon fee.

Wastewater collected from multiple sources—such as floor and containment drains, RO/EDI system reject, evaporative-cooler blowdown, etc—is aggregated and routed through an oil/water separator prior to its transfer to a storage tank and then discharge to the local municipal sewer authority.

This water, although described as "waste," is of significantly higher quality than the reclaimed gray water used for cooling-tower makeup. Yet, instead of earmarking it for reuse within the plant, designers sent it to the sewer at an average rate of 65,000 gal/day.

Finding a way to reuse this water to offset some portion of the cooling-tower makeup, while reducing the amount of water discharged to the sewer, would be highly beneficial—provided it could be monitored properly and controlled to avoid contaminating the plant's cooling-water system.

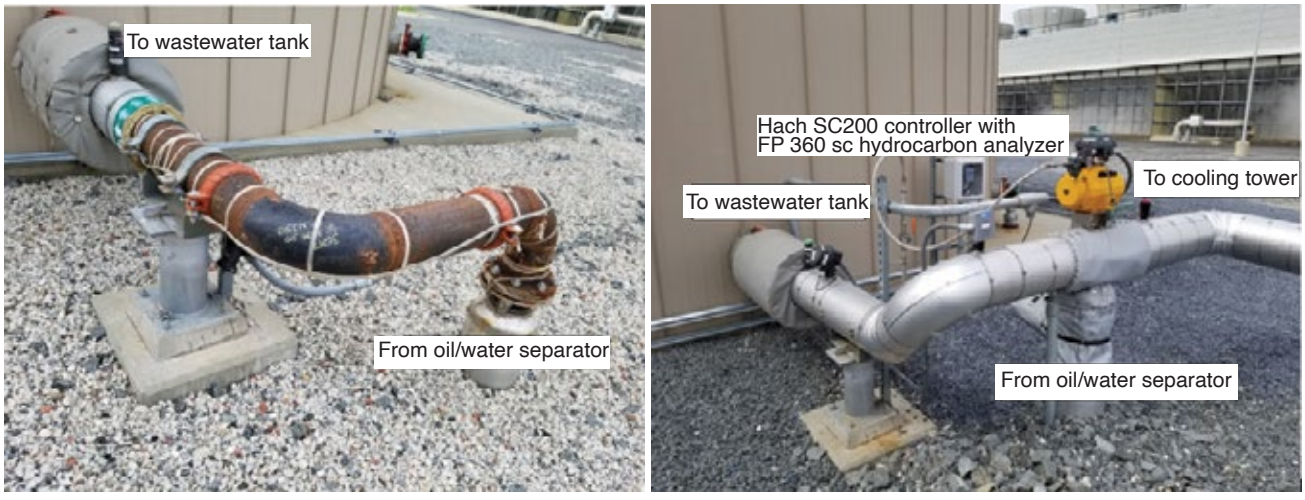
**Solution.** After reviewing all the wastewater sources, staff determined the only potential contaminates of real concern were hydrocarbons associated with the various transformer and turbine containments, plus a few floor drains near possible sources of oil.

Plant personnel contacted Hach Company for advice on available devices capable of measuring hydrocarbon concentrations in real time. The company proposed its FP 360 sc hydrocarbon analyzer, paired with an SC200 controller capable of generating a 4-20-mA output to drive a three-way ball valve. It would divert water from the oil/water separator outlet to either the cooling tower or the wastewater tank depending on the measured concentration of hydrocarbons.

When hydrocarbons are below the level of concern, all the water leaving the oil/water separator is sent to the cooling tower to offset gray-water usage and reduce sewer costs. Should the concentration of hydrocarbons rise above the programmed threshold level, the three-way valve would divert the oil/water separator discharge back to the wastewater tank and generate an alarm on the DCS. The alarm is a secondary benefit of this project and greatly increased visibility around any potential malfunction of the separator.

The final step in project implementation was to determine the best place to install the three-way valve without having to excavate the mostly underground piping between the oil/water separator and the wastewater tank. Fortunately, there was just enough above-ground pipe upstream of the tank to allow the removal of an existing 90-deg elbow that was nearly a match fit for the dimensions of the new three-way valve (Fig 1).

This saved the project considerable time and effort and avoided any unnecessary excavation and/or welding. The additional piping between the three-way valve and the cooling-tower basin was installed above ground to further reduce costs associated with excavation.




**1. Original piping** between the oil/water separator and the wastewater tank is at left, new arrangement with the three-way valve is at right

**Results.** In its first month of service, the three-way valve redirected to the cooling tower 1.5-million gallons of water that otherwise would have been discharged to the sewer. Taking into account the expected increase in throughput once the gas-turbine evaporative coolers come back into service, this system is expected to offset approximately 25-million gallons of gray water use annually while providing considerable additional savings on sewer-related charges. In sum, this project is on pace to save the facility $150,000 annually in water-related costs—equating to an ROI of approximately 13 months.

**Project participant:**
Justin Hughes, production manager

# Collector brush system upgrade slashes maintenance requirements

**Challenge**. Woodbridge was notified four months before the planned 2020 fall outage that the generator collector brush systems serving its gas and steam turbines soon would be discontinued by the OEM. Faced with the obsolescence of a critical high-wear system, plant personnel had to move quickly to plan for the upgrade while also capitalizing on any opportunity to eliminate the various issues that plagued the existing system.

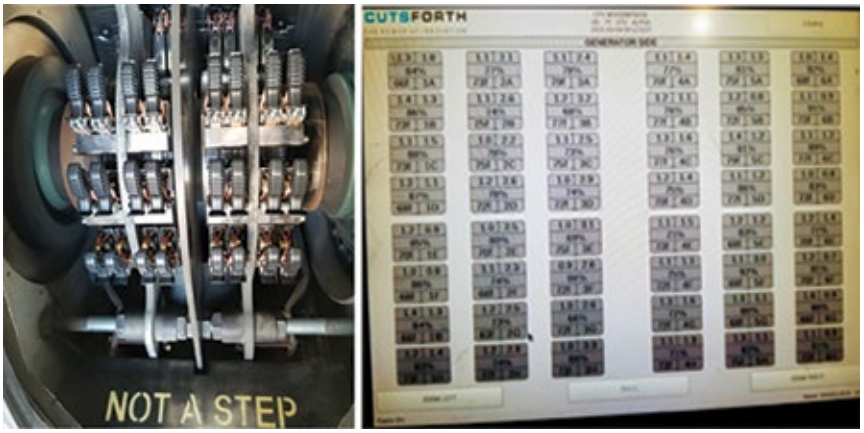
**Solution.** Having spent several years working with Cutsforth on the excessive brush wear and selectivity issues related to the OEM system, the company's input was sought on the pending obsolescence issue. While upgrading to a Cutsforth system is not new and something many sites might do in their lifetimes, the team need to go one step further and find a way to reduce the weekly labor hours dedicated to brush maintenance. The OEM collector system was costing the site approximately 900 man-hours annually to maintain.

To address this issue, Cutsforth proposed its most advanced brush rigging system available (Fig 2) which came complete with the company's Brush Condition Monitor (BCM). The latter gives staff a real-time view into the health of each brush by displaying vibration, usable life, temperature, wear rate, and location. These data are readily displayed on a local PLC, which eliminates the need to manually collect data for each individual brush. The site team also developed plans to bring the brush data directly into the control room where it can be recorded, trended, etc, using the historian.

**Results**. In its first six months of service, the benefits of the new collector brush system exceeded expectations. The brush selectivity and wear-rate issues that plagued the plant during its first five years of service were completely gone, along with any signs of vibration and/or collector-ring pitting. This meant that collector ring grinds, which had become annual affairs, would likely be required only once every couple of years. The saving from the reduction in ring griding alone will save the project $40,000 annually.

Additionally, the new system has reduced the man-hours required for brush maintenance by a factor of two-thirds (about 600 man-hours annually), taking what once was a significant weekly effort and reducing it to minor-task status.

**Project participants:**
Justin Hughes, production manager
Michael Armstrong, plant engineer




**2. New collector brush system** for Woodbridge's steam turbine/generator is at left, companion brush conditioning monitor from Cutsforth at right

# Downsizing makes calibrations easier

**Challenge.** Two years ago, Woodbridge personnel began taking deep dives into recurring maintenance activities with the hope of reducing the man-hours required to perform these tasks. They started with the "heavy hitters" (high frequency/high man-hours) and worked their way down to the less-frequent jobs.

One task that kept coming up in discussions was the biannual Dual Hydrogen Control Panel (DHCP) analyzer calibrations. Reason was the cumbersome cylinder and sample-line setup used to perform this work. It was a leftover from commissioning and the first year of commercial operation, when the DHCPs had to be calibrated almost daily, consuming a high volume of the required calibration gasses. With early lifecycle DHCP issues in the past, this was an opportunity to develop a new procedure that could be performed easily

**3. Original arrangement** of calibration-gas cylinders is at left, new portable kit at right

**4. Portable calibration-gas kit** in service illustrates the ease of use

and in significantly less time.

**Solution.** DHCP calibrations require high-purity hydrogen, nitrogen, and carbon dioxide. The high volume of gas needed early in the plant's life suggested use of 300-ft$^3$ cylinders which had to be transported together on a portable storage rack. However, th size of the storage rack dictated use of a forklift for moving it around. Once in place, sample lines had to be run from the rack to the DHCP being calibrated.

To eliminate the large, and now unnecessary, cylinder arrangement, staff identified a portable kit capable of holding three 103-liter bottles, one each for the required calibration gasses, along with a copy of the DHCP calibration procedure (Fig 3). Thus, one person now could quickly and easily go from one generator to the next to perform the calibrations without need to string sample lines or use a forklift (Fig 4).

**Results.** Prior to downsizing the calibration kit, this task would take approximately three hours to complete per generator, for an annual total of 18 man-hours. This time has been cut in half with use of the portable kit while also eliminating the hazards involved with transporting large gas cylinders.

**Project participant:**
Himansu Patel, senior technician

# Small jib crane makes a big difference

**Challenge.** Woodbridge Energy Center's closed cooling-water system delivers a glycol/water blend to various users (hydrogen coolers, oil cooler, etc) plant-wide after passing through two large plate-and-frame heat exchangers arranged in parallel. Cooling medium for the heat exchangers is treated gray water from the local municipality. Each heat exchanger has an integral inlet strainer located behind a large cover plate—a 12-in., 150# blank flange—in the upper portion of the unit (Fig 5).

Given seasonal variations in gray-water quality, these strainers may be removed and cleaned as often as every other day. While the job of cleaning the strainer backets is relatively easy, physically accessing them proved difficult, time consuming and less safe than desired for a repetitive task. The cover plates were not engineered to support frequent maintenance. To illustrate:


**5. Removal of the strainer basket** for the plate-and-frame heat exchanger was a difficult task before modifications were made

**6. Jib crane,** installed between both heat exchangers, facilitated removal of the blank flanges to access the strainer baskets

**7. Blank flange** is lowered to floor level using the jib crane

They were located 7 ft above floor level, weighed over 100 lb, and were awkwardly placed between the plate retaining bolts for the heat exchanger.

**Solution.** To significantly improve job safety and decrease the man-hours required to clean strainer baskets, the task of unbolting and removing the access cover plant was top priority. To correct safety and ergonomics issues, staff developed a system focusing on installation of a jib crane between both heat exchangers (Fig 6). The crane can be swung into position for rigging and to help safely remove and lower either of the cover plates (Fig 7).

Once removal of the cover plate was addressed by installing the crane between the heat exchangers, ErectaStep was contracted to design and build custom working platforms to address the issue of the high flange height and awkward ergonomics. The new working platforms fit between the retaining bolts for the heat-exchanger plates while also placing personnel at a safe and ergonomically friendly working height for removing the fasteners and handling the access cover plate while attached to the jib crane.

The new platforms are a bolted assembly to facilitate their removal when the heat-exchanger plates must be disassembled for cleaning or repairs.

**Results.** Prior to installing the jib crane, the job of cleaning the two strainer baskets required two man-hours each to complete. Therefore, when the incoming gray water quality was low, the site team was spending up to 16 man-hours weekly and roughly 520 man-hours annually on strainer cleaning alone. With the jib crane and platforms installed, the time to perform this work was cut in half, leaving 260 man-hours that could be dedicated to maintenance activities of higher value.

**Project participant:**
Justin Hughes, production manager

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# Offline circ-water treatment greatly improves cooling-tower/ condenser performance

**Essential Power Newington**

*Owned by Essential Power Investments*

*Operated by Cogentrix Energy Power Management*

565-MW, dual-fuel, 2 × 1 combined cycle located in Newington, NH. Plant operated baseload from COD in 2002 until it began cycling in 2008

**General manager:** Tom Fallon

**Background.** Essential Power Newington (EPN), a merchant facility that primarily runs on natural gas, has over the past decade transitioned from consistent daily cycling to more seasonal operation. The plant's 10-cell mechanical-draft cooling tower takes brackish makeup water from the tidal Piscataqua River. Two 50%-capacity main circulating-water pumps serve the steam turbine's main condenser and Newington's closed cooling-water system. These pumps are protected by primary and secondary removable debris screens located between the tower basin and the pump pits.

**Challenge.** During long offline periods, EPN experienced more frequent and more severe fouling of the circ-water pumps' debris screens than previously. Plus, staff observed appreciable sediment and microbiological fouling of the condenser. Further, during online periods, especially on hot summer days, condenser backpressure increased, reducing steam-turbine output when most needed.

The site's debris-screen cleanings require contracting for mobile-crane and vacuum-truck services—an added cost, along with the increased potential for personnel injuries during the cleaning process.

Root cause of the fouling: Excessive biological growth in the cooling-tower basin and circ-water system. The site's policies and procedures had been to dose the basin with sodium hypochlorite while the plant was online. But with operation curtailed, personnel realized a different approach was needed.

**Solution.** A comprehensive study determined the existing online dosing regimen needed augmentation with offline dosing. This would allow the presence of a measurable chlorine residual in the circ-water system when EPN was not operating. Subsequently, personnel began a thorough review of the procedural, administrative, and engineering changes required to allow for the successful implementation of new practices.

Of primary concern was ensuring that no measurable amount of chlorine would be discharged inadvertently (a violation of the plant's environmental permit) over a potential offline period of several days and multiple shift changes.

Operationally, this presented some very real practical concerns and adjustments: Cooling-tower basin level would have to be reduced significantly during offline dosing to accommodate the approved low-volume waste streams plantwide while keeping permit-limited tower salinity at manageable levels without the option of tower blowdown, and being more conservative with sodium hypochlorite dosage—all while maintaining Newington ready to run.

An operating procedural update was made to account for the new shutdown dosing regimen, as well as an associated checklist that would remain active for the dosing period. This allowed site personnel to have an identifiable point in the process at any moment, as well as a guidance on what steps were next.

Conspicuous signage now is displayed at the control-room console prohibiting the operator from opening the tower blowdown valve from the commencement of dosing until free chlorine is below the detectable limit, which might be days later.

In addition to these administrative controls, an engineering control was implemented through the use of a DCS software lock (inhibit function) on the cooling-tower blowdown valve, which is enabled at the start of a dose, creating an additional step to reduce the likelihood of inadvertently opening the valve when chlorine is still present.

Once these processes were fully in place and personnel trained, a steady program of cooling-tower dosing began during the offline periods when the plant was not selected to run in the market.

**Results.** One of the first things staff noticed was the significant reduction in chlorine consumption, residual chlorine being more effective with the new dosing system because it remains in the system longer than previously. This allowed operators to reduce the chlorine dosing-pump run times from what was once typically up to an hour, down to as little as 10 to 15 minutes for the same measurable residual.

Also found was that during the first outage after implementation, a full cleaning of the cooling-tower basin was no longer needed. This was a significant savings on contractors, pressure washers, rented vacuum trucks, and outage timelines.

The number of cooling-tower-pump debris-screen cleanings also went down to just infrequent occasions in the fall when leaves are introduced into the basin. This was an enormous cost saving.

The other benefit noted was a consistently lower backpressure on the condenser while online in summer. During the high demands of the summer peak season, that can really make the difference in meeting the plant's dispatch targets.

During these periods of change in powerplant operational profiles, it's the realization and implementation of the simple changes that can make a significant difference to the material and economic condition of the plant. Although the change described above

was quick to identify, it was fully studied and implemented to comply with all environmental permitting and operational requirements associated with the systems involved.

Overall, the new dosing process has realized significant cost saving for the plant, with no impact to the environment and with minimal investment. While a change such as dosing time may seem minor, sometimes it really is the small changes that make the biggest impacts.

**Project participants:**

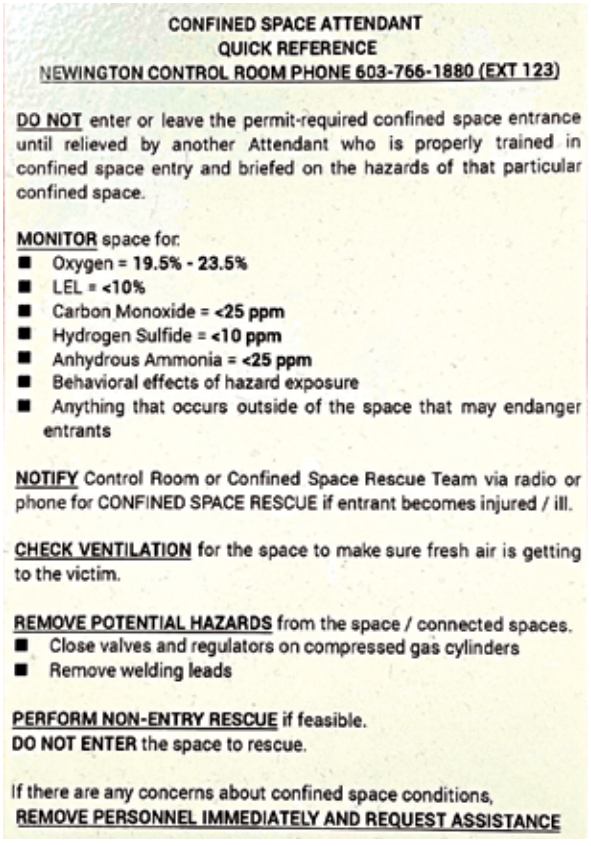
Operations staff: Bob Crawford, Tyler Engelhardt, Jason Gilpatrick, Mike O'Brien, Tom Paterson, Eric Pearson, Scott Roy, Paul Shanley

Joshua Leighton, operations manager

# Taking confined-space precautions to the next level

**Challenge.** Although contractors are trained on confined-space entry and the use of CSE permits, there are occasional gaps in knowledge or understanding regarding OSHA and site-specific responsibilities. Most contractors work at many different facilities and CSE permits from one site to another may have different layouts and context, which can lead to confusion. Many times, although required to be trained in confined-space entry and in the duties of a CSE attendant prior to coming onsite, the duties required of that critical attendant position may be difficult to recall.

**Solution.** Essential Power Newington (EPN) staff developed a confined-space-permit job aide to provide CSE attendants a quick-reference summary of responsibilities and actions in the event of an emergency. The quick-reference summary was printed on a large label and placed on the red clipboards used solely for CSE permits. The clipboard and permit are



CONFINED SPACE ATTENDANT
QUICK REFERENCE
NEWINGTON CONTROL ROOM PHONE 603-766-1880 (EXT 123)

DO NOT enter or leave the permit-required confined space entrance until relieved by another Attendant who is properly trained in confined space entry and briefed on the hazards of that particular confined space.

MONITOR space for:
- Oxygen = 19.5% - 23.5%
- LEL = <10%
- Carbon Monoxide = <25 ppm
- Hydrogen Sulfide = <10 ppm
- Anhydrous Ammonia = <25 ppm
- Behavioral effects of hazard exposure
- Anything that occurs outside of the space that may endanger entrants

NOTIFY Control Room or Confined Space Rescue Team via radio or phone for CONFINED SPACE RESCUE if entrant becomes injured / ill.

CHECK VENTILATION for the space to make sure fresh air is getting to the victim.

REMOVE POTENTIAL HAZARDS from the space / connected spaces.
- Close valves and regulators on compressed gas cylinders
- Remove welding leads

PERFORM NON-ENTRY RESCUE if feasible.
DO NOT ENTER the space to rescue.

If there are any concerns about confined space conditions,
REMOVE PERSONNEL IMMEDIATELY AND REQUEST ASSISTANCE

**1. Summary of responsibilities** for confined-space entry attendants is affixed to the plant's signature red clipboards for quick reference

turned over to the CSE attendant once a permit is opened by an authorized EPN employee.

The CSE attendant's quick-reference summary (Fig 1) has the following information:

- Control room phone number and extension.
- A quick reminder of when the attendant may leave the space being monitored.
- The atmospheric conditions and action levels to be monitored continuously by the attendant.
- Instructions reminding the attendant to contact the control room or confined-space rescue team via radio or phone if the entrant becomes injured or ill.
- Guidelines for verifying proper space ventilation.
- How to remove potential hazards from the space and connected spaces.
- Instructions for performing a non-entry rescue, if feasible. Important caution: The attendant shall NOT enter the space for rescue.
- Finally, if there are any concerns about the confined-space conditions, remove personnel immediately and request assistance.

**Results.** Implementing the quick-reference job aide for CSE attendants should help reduce confusion regarding what an attendant's responsibilities are as well as what he/she should do in the event of an emergency. The attendant's clear understanding of his/her duties, and a constant reminder regarding their critical role, creates a safer confined-space work environment.

**Project participants:**
Eric Pigman, engineering manager
Ted Karabinas, O&M technician
Tom Paterson, shift supervisor
John Pierce, EHS manager

## Eliminating manual processes with electronic recordkeeping

**Challenge.** At the onset of the Covid-19 pandemic in early 2020, it was clear that in-person meetings would cease and the ability to communicate effectively in a remote fashion would be required. Many manual processes handled through the years would have to become automated and the need to digitize certain aspects of communication in a power generation facility became increasingly important, especially in remote settings.

**Solution**. Essential Power Newington (EPN) had been using eLogger for electronic recordkeeping for several years. Staff realized this tool could be further harnessed to capture information that otherwise an e-mail or spreadsheet would capture manually. The following are a few examples of changes made using the eLogger application since the pandemic began.

- Contractor safety orientation. Pre-Covid, contractors and visitors would watch a short safety video onsite, read and sign a form, and then proceed to their plant contact, who would enter the visitor's information into a Microsoft Access database for tracking. During the pandemic, the video is sent electronically to contractors/suppliers beforehand; they sign and return the form and the site then enters the completion log into eLogger for tracking and recordkeeping. An easy search function provides quick access to records.
- Night orders for operations staff. Pre-Covid, as night orders/direc-

tives were warranted, a Word document was created manually, converted to Adobe, and emailed to the night or weekend shifts. During the pandemic, staff found eLogger much better suited for this function. A PI connection string was created and important PI information is populated easily, night orders drafted as needed, acknowledgers assigned, and once complete, log entry saved. Once the log is saved, an e-mail is generated automatically and assigned staff can review directives at will and append logs with work statuses.

- Maintenance staff plan of the day (POD). Pre-Covid, the entire maintenance staff would attend a 30- to 45-min in-person meeting with the maintenance manager to develop the POD, which he would e-mail to the entire facility staff for situational awareness purposes. Under the pandemic's social-distancing protocols, the meetings ceased but the need to communicate plant activities remained very important. eLogger allows technicians to enter their PODs into the application for review by the maintenance manager. The log entries are saved and the log entry report is e-mailed to the plant staff for viewing.
- Generation outage/potential limitations report. EPN is occasionally under a planned outage, output limitation, or must-run potential with local authorities. Communicating these scheduled events is important for both plant and offsite staff—such as energy marketers and corporate executives. Remembering whom to notify and manually sending e-mails when notified of such conditions was very cumbersome. By contrast, eLogger allows a single log entry with all necessary information. When the log is updated by anyone with recent information, and saved, an e-mail is generated and a log report is automatically sent to a list of recipients.

**Results.** The aforementioned practices immediately led to time savings and efficiencies for individuals responsible for administering the listed processes. Eliminating manual processes is beneficial and the ability to substitute existing tools for them is the true benefit. Spreadsheets, manual e-mails, documents, and databases all were eliminated and streamlined through the eLogger application.

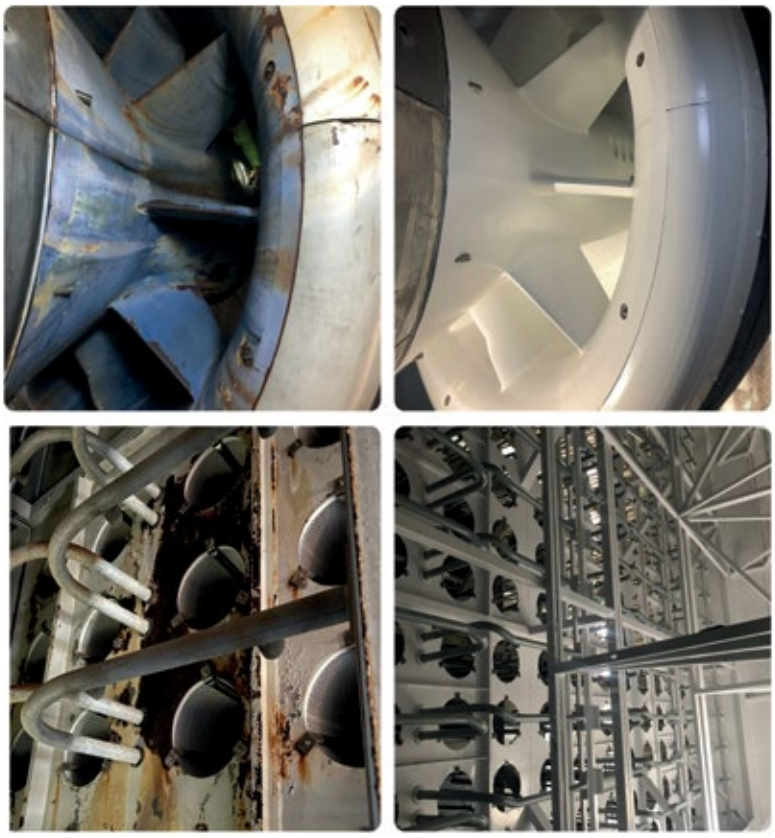
These were just a few of the many uses of eLogger EPN used last year. Further efforts always are investigated strategically to use this tool to the site's advantage.

**Project participants:**
Joshua Leighton, operations manager
Chad Harrison, maintenance manager
John Pierce, EHS manager
Maria Vitone, site administrator

## Quiet time to update health and safety procedures a benefit of working remotely

**Challenge.** Essential Power Newington (EPN) maintained 34 reference health and safety (HS) procedures detailing protocols implemented to demonstrate compliance with applicable federal, state, and/or local OSHA regulations and company requirements. In several instances, guidance provided by HS procedures had become outmoded through changes in equipment, evolving regulatory or industry practice, and/or ownership transition.

Historically, EPN had relied on "manual" curation of HS procedures as "controlled documents" via standard



## Qualtrax MOC workflow

Management of change (MOC) is an important process for the safe and reliable operation of a powerplant. The typical MOC approval process required an in-person meeting, document review, and change-approval signatures. When Covid-19 disrupted normal business processes in early 2020, a new solution was necessary to ensure that proposed changes could still be documented, reviewed, approved, and communicated when in-person meetings were not possible.

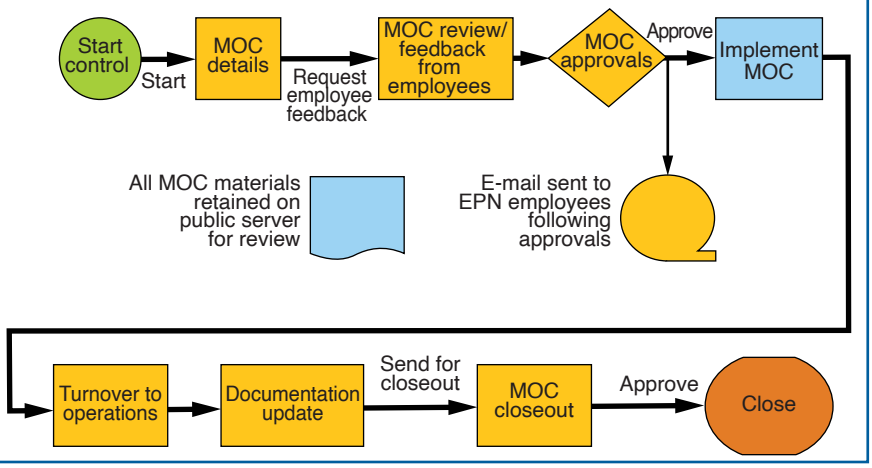
In 2018, the site implemented Qualtrax® compliance software to provide document and workflow management for NERC CIP compliance. The site's CIP subject-matter expert (SME) already was skilled at the development and use of workflows. When the challenge was presented to develop a paperless MOC approval process, he quickly recognized that Qualtrax would be the perfect platform.

The SME developed a workflow to document basic information about the proposed change, including: description of change, reason for change, work-order reference, and personnel designated to review the proposed change prior to approval.

The workflow directed reviewers to the site's document server, where all additional documentation for the proposed change is maintained. Once initial review was completed, the workflow routed through approval checkpoints, including the following: MOC approval, turnover to operations, documentation complete, and MOC closeout (diagram). The approval of each stage by multiple individuals is recorded electronically in the workflow; no paperwork is passed from individual to individual nor does it require approval at team meetings.

The workflow process is a proven paperless document management tool that provides excellent visibility on the approval status of all MOCs. The workflow record also is useful when auditing for documentation evidence. In 2020, 23 changes were processed through the new workflow system. An added benefit has been to enhance employee involvement through the use of MOC reviewers. This step provides an opportunity to engage site employees to review and comment on the proposed change, modify the proposed change if appropriate, and route it for approval.

**Management of change workflow**



document creation and spreadsheet products.

Use of Covid strategies for maintaining critical infrastructure operability included reducing day-to-day staffing levels onsite to protect personnel by minimizing contact to the degree possible. Additional O&M personnel were provided with the technological capability to work from home and assigned administrative tasks.

**Solution.** During 2020, the O&M staff reviewed HS procedures for current applicability, obsolete references, actions, and/or forms no longer used in practice—for example, references to previous owners/contractors/technologies included throughout appendices.

Employees provided comments and suggested edits to identify potential changes and updates. Prescribed requirements or actions (that is, periodic reviews, audits, preventive maintenance activities) and associated time periods (annual, semiannual, for example) were identified for vetting current compliance regimes associated with OSHA or industry standards, company requirements, or best practices.

In addition to the gap analysis described above, O&M staff analyzed HS procedures within the context of these questions:

- Was the incorporation of risks and hazards appropriately addressed throughout the procedure?
- Are past events and accidents regarding the topic/procedure considered and incorporated?
- What changes or modifications to the program details/personnel/vendor systems since last revision are not covered in the procedure?

After O&M staff review and analysis of HS procedures, comments and suggested edits were reviewed by management and revisions implemented as warranted.

In 2018, EPN implemented Qualtrax® software to provide document and workflow management for NERC CIP compliance (sidebar). Following the staff HS procedure review initiative, HS procedures were relocated to Qualtrax with the software acting as an electronic document management system (EDMS). This ensures all documents managed by the EDMS are captured, stored, retrieved, and accessed in a manner that guarantees the archived document is an authentic rendition of the original document for the duration of preservation.

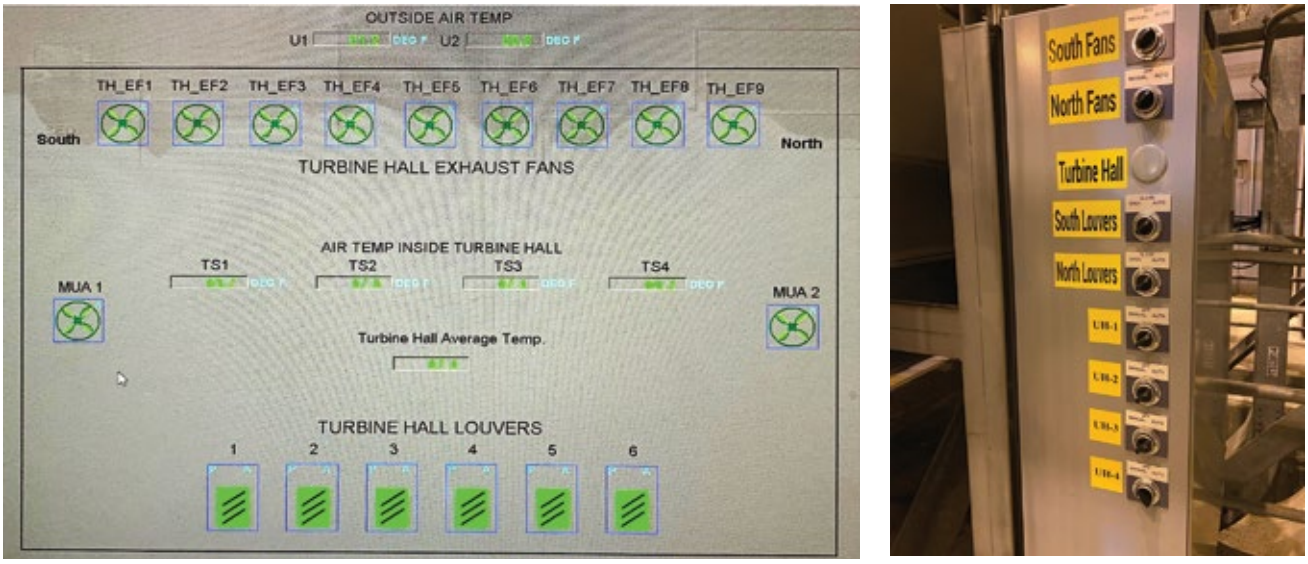
Authentic rendition means that the rendered document corresponds to the source document as it was at the time of input in the information system, in terms of fidelity and integrity, and that this state is maintained for the duration of preservation (ISO 14641:2018).

**Results.** Inherent in the review process was a progressive development of O&M staff familiarization with current OSHA, NFPA, industry, and company safety standards. Employees spend productive offsite work hours revalidating and improving the working functionality of the HS procedure compendium.

The set was restructured into 32 active, controlled HS procedures in Qualtrax; updates to prescribed guidance, compliance regimes, applicable references and appendix forms generated consistent procedures.

Restrictions on the use of HS procedural guidance from prior databases (for example, inspection forms used in preventive maintenance activities), coupled with use of the Qualtrax EDMS, ensures use of an authentic rendition of the original document.

**Project participants:**
John Pierce, EHS manager
Eric Pigman, engineering manager
Joshua Leighton, operations manager
Supported by the entire plant staff




**2. DCS operator screen** (left) and local control panel (right) facilitate control of turbine-hall HVAC equipment

# Control-system upgrades improve reliability

**Background.** The gas-turbine packages at Essential Power Newington (EPN) are located in a building. The original turbine-hall air-handling and environmental-control equipment is as follows: four gas heaters spaced along a common wall, two makeup air handlers on opposite ends designed to replace air removed by GT-package cooling fans, one outside/four inside ambient temperature sensors, nine cooling fans at roof level, and six sets of louvers around the building.

**Challenge.** A dedicated PLC controls the equipment described above in groups through relays inside the turbine hall. The only access to the control parameters was through a modem and HyperTerminal, or through a very non-user-friendly programming panel on the PLC.

There were no operator screens or other means of operator access for controlling this equipment, and no way for a user to access the ambient-temperature information for the turbine hall. PLC failures led to such problems as the turbine-hall fans starting and the louvers opening in the middle of winter, with no operator visibility to conditions in the turbine hall unless an employee happened to be walking through.

As the plant operating profile changed from baseload to cyclic, additional gas heaters were added throughout the turbine hall to meet northern New England weather conditions: The original four heaters could not keep critical equipment from freezing in winter when the turbines were offline. These heaters only had individual local thermostats. Adding heaters helped mitigate controls issues associated with the original equipment, but the original controls were a constant source of problems, and PLC programming became even more difficult because of obsolescence.

**Solution.** Staff decided to remove the PLC and migrate control of the HVAC equipment to the plant's DCS. Spare wire pairs into the DCS control racks, plus some additional wiring and spare DCS I/O were used. The original relaying was connected to the DCS, along with new inside ambient-temperature RTDs to replace the thermistors.

Fire-panel digital outputs also were connected, enabling the programming of automatic HVAC system response to fire, fuel-gas leaks, and hydrogen leaks in the turbine hall. Three-way switches were installed so equipment could be controlled locally or remotely through a DCS operator screen.

**Results.** Currently, the original four heaters are controlled individually by on/off switches, or as a group by their own local thermostat. Remainder of the HVAC equipment is controlled by local switches, or when in remote, by the distributed control system. The DCS control can be by an operator in manual through an operator screen (Fig 2) or automatically by DCS logic.

The control logic in the DCS looks at inside and outside ambient temperatures, whether or not the turbines are running, and at any active fire panel alarms to determine how to operate the equipment. There are now alarms to tell operators when ambient temperature in the turbine hall is too cold or too hot—such as when a rollup door has ben left open in winter. All of this work was completed by staff, from development to implementation. Cost to implement the project included new RTDs and transmitters, a small amount of control wiring, and about 120 man-hours of labor.

The enhanced visibility and control could save equipment trips and startup delays caused by frozen critical instruments. It has the ability to prevent equipment damage by not triggering fire-protection sprinkler systems when piping is frozen, and has the potential to prevent an injury by vending flammable gas leaks before they have a chance to build up and possibly create an explosive atmosphere.

**Project participants:**
Chad Harrison, maintenance manager
Scott Courtois, ICE technician
Kyle Malenfant, ICE technician
Mike Dill, ICE technician

# How to remove air from your GT water-injection system

**Challenge.** Essential Power Newington (EPN) operates primarily on natural gas with sporadic operation on fuel oil in winter. When running on oil, demineralized water is injected into the combustors to reduce $NO_x$ emissions. Water is supplied at up to 250 gpm per unit from the demineralized-

water storage tank to a high-pressure, variable-speed injection pump located alongside each gas turbine.

The water-supply piping system, approximately 1000 ft long, has over a dozen elevation changes from 6 ft below grade to 70 ft above, between the forwarding pumps and the inlet flange to each injection pump.

During long offline periods, air accumulates in the piping and is trapped at numerous high points in the system. When water injection is initiated, air is carried into the injection pumps, causing pressure transients that have, at times, shut down the water injection system and the gas turbines.

Over the years, personnel have added numerous manual vents, as well as several small automatic air-release devices. However, access to and operation of the vents has been problematic, especially in winter, given their number and the outdoor location of several.

While manual venting had reduced the frequency of events, it had not eliminated the problem and numerous manual operations were required to complete fuel-oil transfers.

The vents also had to be left open for extended periods as the entrained air traveled through the system. As GT load and water-injection flow increased, new pockets of air would appear at vent points. Despite an intricate procedure and numerous vent points, it was still commonplace for water-injection pressure transients to disrupt operation after long periods of system layup.

**Solution.** Staff elected to install a high-volume vortex air separator, with an automatic air release, in the demin-water forwarding piping at the inlet to each water-injection skid (Fig 3). Detailed engineering was performed by site and corporate field services personnel. The vessel and piping were sized for 96% air-removal efficiency at full flow. The majority of the piping was prefabricated and the separators were installed in four days during a planned outage. Operating procedures and applicable drawings were updated and operations staff was trained in the revised operating procedures.

**3. Vortex air separator** is located in the demineralized-water forwarding piping at the inlet to each water-injection skid

**Results.** The site completed the full-load liquid-fuel operation audit without any water-injection-system or gas-turbine trips caused by forwarding-system air entrainment or pressure transients. Success of the system changes was verified in the winter as the site operated on oil over a dozen times with no events related to air entrainment. This change has reduced manual operator intervention during fuel-oil transfers and has greatly improved liquid-fuel-system reliability. Reduced venting and the eliminating of continuous manual venting also has reduced demin-water consumption.

**Project participants:**

Tom Fallon, plant manager
Eric Pigman, engineering manager
Hank Kadel, project engineer (Cogentrix Field Services)

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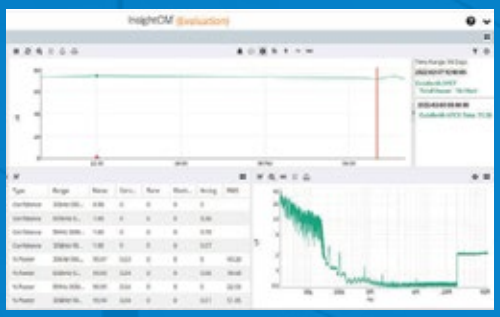

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**Rumford Power LLC**

*Operated by Cogentrix Energy Power Management*

265-MW, gas-fired, 1 × 1 7FA-powered combined cycle located in Rumford, Me

**Plant manager:** Justin Castagna

# Reduce time of response to address common plant issues

**Challenge.** Changing markets and location have reduced run opportunities for Rumford Power. Response of the maintenance staff to the plant's rural Maine location usually is half an hour or more. Given Rumford's low capacity factor, response time is critical to resolving issues and returning the plant to operation: There's little opportunity to make up for the unavailability by extending week-long runs as was done in the early 2000s.

Through the plant's RCA process, which is implemented for every forced-outage event, staff was able to identify common areas of improvement that with a little training would enable others (for example, onsite operations personnel) to troubleshoot and repair once they better understood the affected system. This effort could help reduce the plant's equivalent forced-outage rate (eFOR).

**Solution**. The plant already was using GP Strategies for web-based OSHA training. Previously, that program had been expanded to include some process safety management training. Based on the successes gained, staff decided to grow the training library further.

Looking back over the past five years of common themes or problems for call-ins at the site, the three areas that routinely came up in troubleshooting events during off-hours, or when the plant was in a forced outage, were the following:

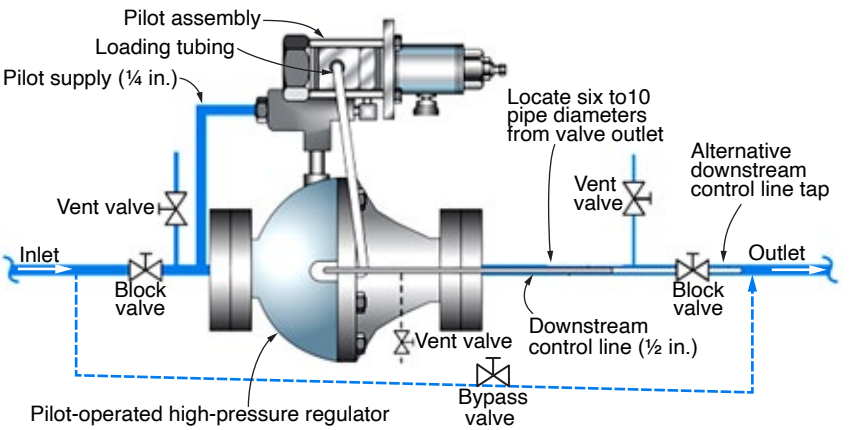
- Fuel-gas letdown adjustment.
- CEMS calibration-gas bottle replacement.
- Breaker racking.

*The fuel-gas letdown adjustment* was simply a response to a common issue the plant had in 2017-2018. Repeat failures of the gas letdown system caused starting-reliability issues, including a short period of forced-outage time. Maintenance technicians knew the process of checking and setting the Emerson (Fisher) 310A-32A pressure regulator (Figs 1 and 2), but the operators had little involvement in the process.

The training module created gave the background of the theory behind the "wide-open monitor" method of control and use of a second downstream pressure regulator as the controlling valve. Support documentation included cutaway images of the valve with descriptions, the four basic steps in setting the letdowns, etc.

*CEMS-gas bottle replacement* is a common task that the plant completes, but primarily by I&C technicians. Operators assist and swap bottles, but there was no formal training or instructions for the task—just on-the-job training. While it could be months, or years, between the need to swap a calibration-gas bottle on a Sunday afternoon, the training module eliminates to the need to call someone in on a day off.

The training goes through the steps required to confirm proper gas identification, swapping bottles, accessing the operator interface terminal, and navigation of the touch screen on the OIT (Fig 3).




**1, 2. Pilot-operated, high-pressure regulator,** Type 310A, is used where high capacity and accurate control are essential. Pilot assembly (Type 32A) is for pressure-reducing or wide-open monitoring applications

AFC

ADVANCED FILTRATION CONCEPTS

# GAS TURBINE Filtration Products & Services

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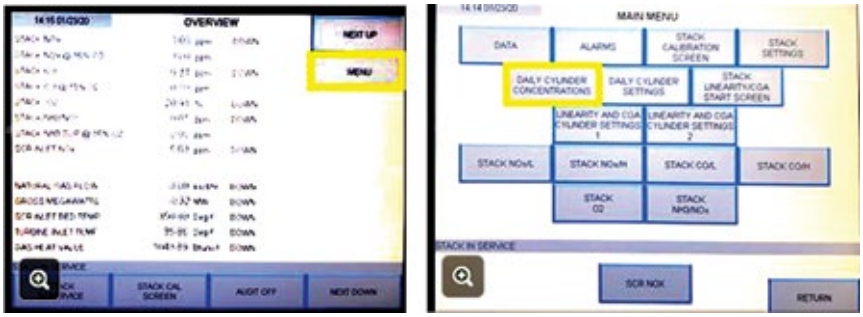



**3. CEMS panel on the operator interface terminal.** On the overview screen at left, tapping "main menu" button brings up the screen at the right. Tapping its "daily cylinder concentration" provides guidance on when cylinder replacement is necessary

*Breaker racking* was a training module motivated by an earlier arc-flash study. Modifications were made with new relays installed on the 480-V switchgear to reduce incident energy levels, and recommendations were made to purchase remote racking devices as a extra precaution to remove personnel from the potential "line of fire." Often during troubleshooting efforts in support of a forced outage, breakers must be racked off the buss and LOTOed.

The training module developed shares the PPE requirements for the task, the equipment and tools necessary, and the preparations needed for determining which method is best for racking (manual or remote) and how to perform each method. While this had no direct impact result in forced-outage reduction, it was identified as a best practice by the site to share all information about the breakers themselves, the racking devices, PPE, and process on confirming zero energy to maintain the plant equipment.

**Results.** The three examples of knowledge-sharing presented above, along with site-specific, web-based training help provide both process theory and real-world experience—the latter showing specific plant photos and equipment for staff to train on.

With an eFOR of 0.28% in 2019 and 0.47% in 2020, the training has paid dividends. With new staff replacing a retiring workforce, the training helps present real-world examples and expectations to new hires. When new personnel come aboard, they are given a database of information that the plant has gained over the last 20 years, enabling them to grow their skill sets and be better prepared for events as they arise.

**Project participants:**
Justin Castagna, plant manager
B J Dunlap
Jim l'Italien
Bill Calden
Cale Knox
Bob Richardson

# Training for emergency response during the pandemic

**Challenge.** Rumford Power is a process safety management site; it uses anhydrous ammonia for gas-turbine inlet cooling. The plant is a participating member in the local emergency planning committee (LEPC).

Not having a facility-based hazmat team, Rumford would rely on its relationship with the local fire department and hazardous response unit in the event of an uncontrolled ammonia release. Staff annually participates in a table-top exercise (TTX), gathering members of the plant, fire, police, hazmat, paramedics, local regional dispatch, and the hospital to talk through potential scenarios and go over the process of what a response to those situations would look like.

The event creates a camaraderie between the plant and first responders, and is a knowledge-share, usually creating follow-up actions or plant tours to show first responders the site and where they would be responding to in the event of an emergency. A unique learning situation was created in 2020 by the Covid-19 pandemic, when in-person TTX was not realistic.

**Solution.** Zoom to the rescue! As most of the world learned, Zoom and Microsoft Teams became the go-to options for remote meetings. Rather than taking a "pass" on the year, with all participating personnel available to participate remotely, Zoom was the platform chosen, because of its breakout rooms for side discussions.

The scenario (italics below) for the TTX developed in collaboration between the plant and the LEPC deputy director was split into the following two modules:

*Module 1*

*The two Rumford Power employees on duty begin the startup process at the facility. One employee is in the control room, one outside. The employee in the control room notices a vehicle approach the gate, where it sits for several minutes. The employee calls 9-1-1 to report the suspicious vehicle.*

*While on the phone with 9-1-1, the vehicle drives through the gate and into the plant. The employee reports seeing on camera, the driver's arm outside the window of the vehicle holding what looks like a handgun.*

*Module 2*

*The vehicle makes multiple laps around the facility, and then leaves the property. Upon reviewing the camera footage, the employee notices a vapor cloud near the anhydrous ammonia lines outside the facility. Soon after, the south ammonia ceiling detector begins to alarm (150 ppm) indicating a leak.*

The scenario presented several items for discussion: from suspicious activity, to security breach, to anhydrous ammonia release; plus, it tested communication and coordination between the plant and multiple first responders. Once the meeting commenced, the "scenario" was presented to plant employees onsite that day, a 9-1-1 call was simulated with the regional communications center, and the event played out testing reactions and emergency response procedures in place both onsite, and with the first responders.

Breakout rooms were created so plant personnel and first responders could congregate (1) to develop initial action items and then get back together, (2) simulate developing an incident command structure, and (3) gather plant information and share it with first responders so action plans could be developed.

The two modules were played out back-to-back, with initial communication made from the plant to the regional communications center. Following the initial trigger of site "Emergency Response Plan for Suspicious Activity" and generating a response from police, the site personnel answered questions to provide information to the first responders.

Once completed with the initial module, a new discovery was made of a potential anhydrous ammonia vapor cloud being picked up on plant security footage that was being reviewed by staff to gather more information on the gate breach, which expanded the interagency response and brought in fire and hazmat response and planning in the situation.

**Results.** The after-action report and improvement plan revolved around two

main core capabilities: operational coordination and operational communication.

Coordination strengths included the following:

- Quick notifications to mutual aid resources and supporting organizations while mobilizing needed resources.
- Hospital quick notification allowed setup of mass decontamination capability if needed at the hospital for patient surge or chemical exposure treatment.

Areas of improvement included these:

- Increased visibility and familiarity for first responders. Facility tours were provided for all first responders. Rumford Fire had many traiing experiences at the plant, but the Rumford Police Dept had not. Thus, familiarization training was provided to all PD staff. Large signs were made, at the suggestion of first responders, to label the sides of the building (A, B, C, D) and to number doors. These action items were completed by Rumford employees.
- Harden the plant for safe place of refuge in event of a facility breach.

Rumford follows CIP-003 protocols for physical security with fence, gates, and locked doors. As an added measure, deadbolts were strategically located so plant staff could create a safe room if a breach around the outer security level at the site were to occur.

Communication strengths from the TTX were the results from the simulated 9-1-1 call with dispatchers. Walking through all questions from the playbook showed plant staff what would be asked if the scenario were to arise. The Zoom break-out rooms were also deemed to be a benefit to the exercise to create an "isolation" like a real event would be, not having everyone at the same table as had been performed in years past. The plant had previously purchased a two-way radio to communicate directly with first responders if the need were to arise. A test was conducted with first responders to confirm proper operation and programming of the radio.

As a result of these activities and outcomes, the plant was named the Oxford County LEPC 2020 Facility of the Year. The deputy director of the Oxford County EMA presented this exercise to national peers in early 2021 as a demonstration of evolving with the 2020 pandemic and still achieving success in keeping up-to-date with training and preparation for potential serious events.

**Project participants:**
Justin Castagna, plant manager
B J Dunlap
Jon Hambrick
Justin Henry


**Empire Generating Co**

*Owned by Empire Acquisitions LLC*

*Operated by NAES Corp*

635-MW, gas-fired 2 × 1 7FA.03-powered combined cycle located in Rensselaer, NY

**Plant manager:** Chet Szymanski

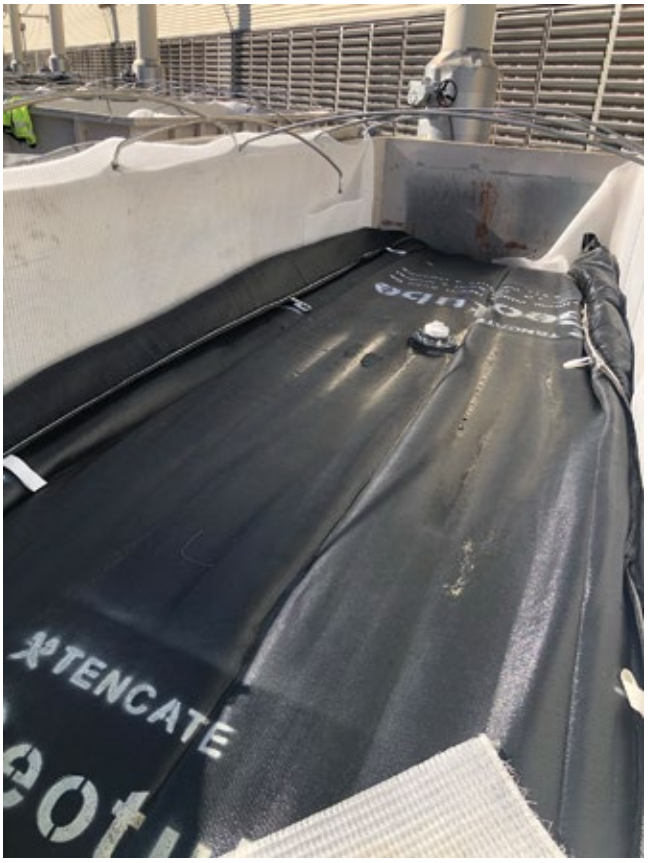
# Removing suspended solids from a chlorine contact chamber

**Challenge.** Empire Generating uses gray-water effluent from a local municipality's sewage treatment plant as incoming process water for both the steam-generating and cooling-water systems. Water quality, specifically total dissolved solids (measured as conductivity), varies greatly depending on the time of year and the quantity of water received. During high-conductivity events, even with the primary filtering mechanism, a Parkson Corp Dynasand® filter operating at optimum efficiency, the plant experiences carryover of impurities to its other systems.

To minimize the carryover effects and to ensure that the water is properly disinfected prior to being used as a cooling medium, a 600,000-gal chlorine contact chamber is located upstream of the cooling tower.

The chamber is designed as a series of five tanks placed within each other and partitioned such that a minimum of 486,000 gal of incoming makeup water will travel a minimum helical path of approximately 542 lineal ft at 4500 gpm to ensure a 90-min model contact time with the injected sodium hypochlorite prior to entering the cooling tower. Following construction, the operational travel length was calculated at 695 lineal ft, verifying the required model contact time would be met.

Over more than 10 years of system operation, the tank-in-a-tank and its helical-flow-path design have proved extremely effective at removing the carryover material from the makeup water. However, system design made no provision for its removal. An ever-increasing amount of waste material reduced tank volume and increased the travel length needed to ensure




**1, 2. Semi-solid waste material** is pumped from the chlorine contact chamber (left) to geotubes (right) by an engine-driven pump

**3. Sump pumps** transfer water, recovered as geotubes drain to the frack tank above, to the cooling tower

the 90-min model contact time. To ensure the system continued to operate as designed, an effective method to remove this semi-solid waste material had to be developed.

**Solution**. The goal was to both clean out the sludge and recapture as much of the water as possible. Note that a previous attempt to remove semi-solids by vacuum truck proved unsuccessful because of poor performance and high cost.

Plant personnel and water-treatment vendor Suez identified geotubes (a permeable system of engineered textiles specifically designed for dewatering high-moisture-content sludge and sediment), in conjunction with an approved flocculant, would be the most effective solution.

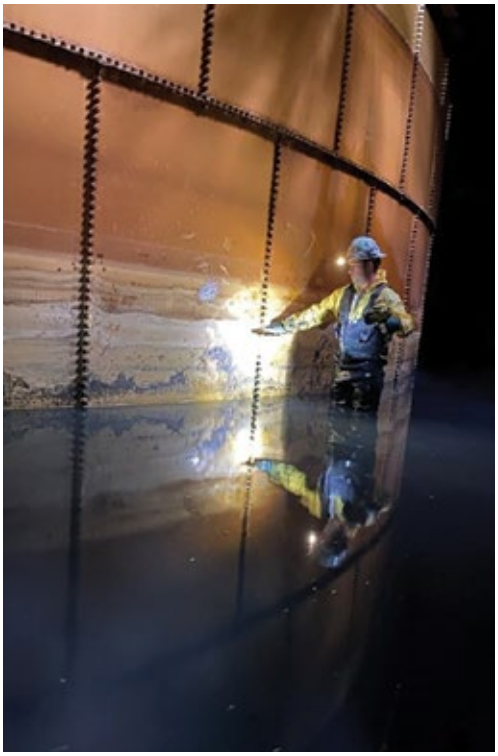
To allow for water recapture and to prevent discharges to stormwater, the geotubes were placed inside watertight rental dumpsters. The semi-liquid waste material was pumped out of the chlorine contact chamber using a high-capacity, engine-driven pump and transferred via a PVC distribution manifold into the geotubes (Figs 1 and 2).

Automatic sump pumps transfer water, recovered as the geotubes drain to the frack tank (Fig 3), to the plant's cooling tower. The semi-solid material remaining, characterized as non-hazardous for waste disposal, is sent to a local landfill.

**Results.** Using this process, the plant was able to remove, in an environmentally safe manner, approximately 48 in. of semi-solid waste material (Figs 4 and 5) from the chlorine contact chamber, recovering approximately 60% of the water for reuse, and ensuring the chlorine 90-min model contact time requirement continues to be met.

**Project participants:**

Craig Terry, operations manager
Jason Glassbrenner, water-treatment technician
Anne Benson, Paul Mayovich, and Pete Wrede, Suez Water Technologies & Solutions




**4, 5. About 4 ft of semi-solid** waste material was removed from the chlorine contact chamber to maintain proper system performance (left). Flocculant testing of the semi-liquid waste material is at right


**Hunterstown Generating Station**

*Owned by Platinum Equity LLC*

*Asset managed by CPV Competitive Power Ventures*

*Operated by NAES Corp*

810-MW, 3 × 1 7FA.04-powered combined cycle located in Gettysburg, Pa

**Plant manager:** Thomas Hart

# Ensure outage LOTO accuracy, completeness by mapping procedures on drawings

**Challenge.** Clearly identify the LOTO scope and how it assures safe access to equipment for a specific outage workscope. Provide the means to present and communicate the LOTO scope to all outage employees, including outside contractors.

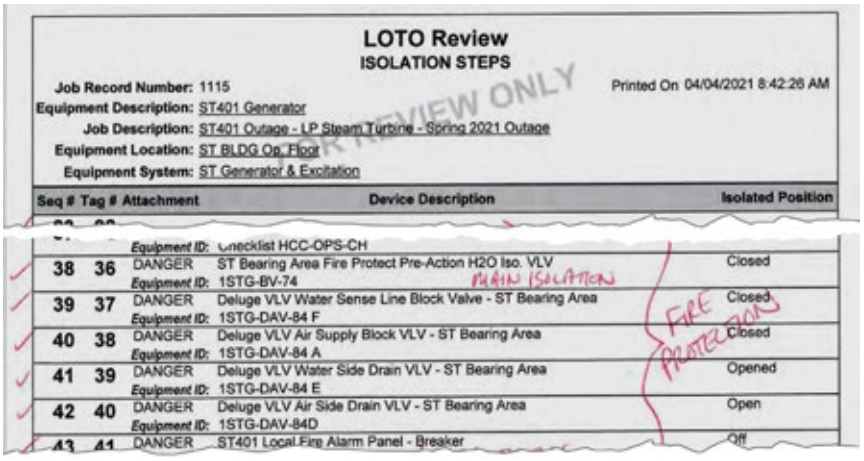
**Solution.** Hunterstown requires that all outage LOTOs be mapped out on electrical and mechanical drawings. Locations of work must be delineated in the drawing package and isolation points highlighted, demonstrating the relationship between workscope and LOTO boundary.

*Editor's note: Extensive documentation—including 15 E-size P&IDs—was submitted to CCJ in support of Hunterstown's Best Practice, far more than was possible to publish. The ancillary material presented here—LOTO review (isolation steps), checklist for isolation and restoration of the bearing fire-protection pre-action valve serving the steam-turbine bearing area, and associated drawing—focus on one small segment of the entry to illustrate the plant's LOTO process.*

**Results.** This process provides the means to easily demonstrate through a drawing review and walk-down of equipment that the site's LOTO program is effective and the specific workscope to be performed by a contractor is compatible with the LOTO scope applied to the equipment and presented in the LOTO package (including drawings). This results in clarity for contractors and confidence in the site's safety programs. Because of this there are fewer requests from contractors to make changes that would expand LOTO scope to increase the LOTO boundary.

Feedback from contractors has been positive. One example: GE said, "Hunterstown's LOTO program is unmatched in providing clear understanding to the scope of the LOTO and how the work we will be performing is covered under the LOTO hung on the equipment in the field. With our GE procedures, we are required to walk-down every LOTO and Hunterstown's program provides assurance that we can clearly see on paper in the marked-up drawings how what we see in the equipment walk-down provides protection for our workforce."

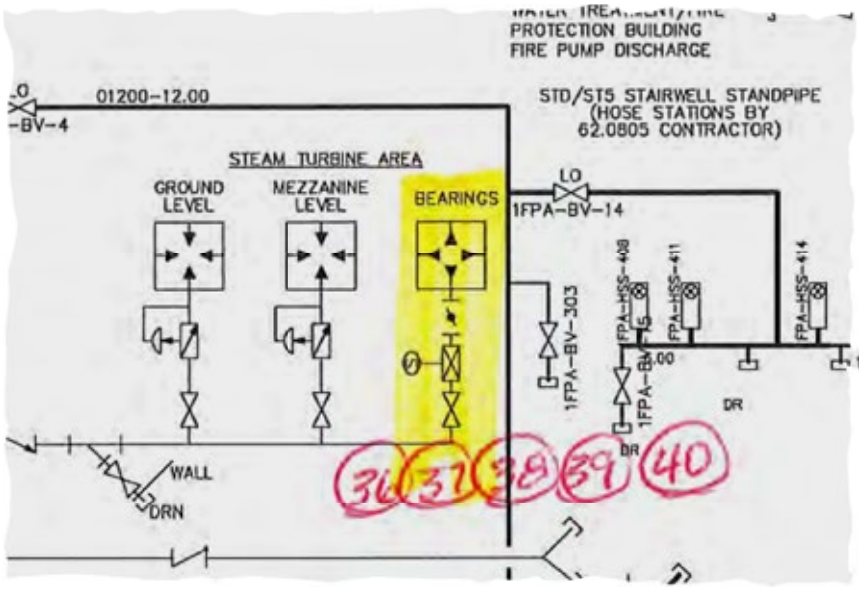
**Project participant:**
Thomas Hart, plant manager



LOTO Review
ISOLATION STEPS

Job Record Number: 1115
Printed On 04/04/2021 8:42:26 AM
Equipment Description: ST401 Generator
Job Description: ST401 Outage - LP Steam Turbine - Spring 2021 Outage
Equipment Location: ST BLDG Op. Floor
Equipment System: ST Generator & Excitation

| Seq # | Tag # | Attachment | Device Description | Isolated Position |
|---|---|---|---|---|
| | | Equipment ID: | Checklist HCC-OPS-CH | |
| 38 | 36 | DANGER | ST Bearing Area Fire Protect Pre-Action H2O Iso. VLV | Closed |
| | | Equipment ID: | 1STG-BV-74 | |
| 39 | 37 | DANGER | Deluge VLV Water Sense Line Block Valve - ST Bearing Area | Closed |
| | | Equipment ID: | 1STG-DAV-84 F | |
| 40 | 38 | DANGER | Deluge VLV Air Supply Block VLV - ST Bearing Area | Closed |
| | | Equipment ID: | 1STG-DAV-84 A | |
| 41 | 39 | DANGER | Deluge VLV Water Side Drain VLV - ST Bearing Area | Opened |
| | | Equipment ID: | 1STG-DAV-84 E | |
| 42 | 40 | DANGER | Deluge VLV Air Side Drain VLV - ST Bearing Area | Open |
| 43 | 41 | DANGER | ST401 Local Fire Alarm Panel - Breaker | Off |



| NAES | Steam Turbine Fire Protection 1STG-DAV-84 Bearing Pre-Action Valve Isolate & Restore | |
|---|---|---|
| | Hunterstown Combined Cycle Generating Station | HCC-OPS-CHK-18<br>Page 1 of 2<br>Rev 0 4/20/19 |

| Step | Initials | Description |
|---|---|---|
| Note: | N/A | This Checklist is to be used to Isolate and Restore Steam Turbine Bearing Fire Protection Pre-Action Valve **1STG-DAV-84.** |
| Note: | N/A | The following steps Shall be completed in sequence to isolate and remove from service the Steam Turbine Bearing Area Pre-Action Valve |
| 1 | | ENABLE "Walk Test" on the Local Fire Control Panel. (This will disable system alarms.) |
| 2 | | CLOSE 1STG-BV-74 Steam Turbine Bearing Area Pre-Action Main Water Isolation Wall Indicator Valve. |
| 3 | | CLOSE 1STG-DAV-84 F Steam Turbine Bearing Area Pre-Action Water Pressure Sense Line Block Valve. |
| 4 | | CLOSE 1STG-DAV-84 A Steam Turbine Bearing Area Pre-Action Air Supply Block Valve. |
| 5 | | OPEN 1STG-DAV-84 E Steam Turbine Bearing Area Pre-Action Water Side Drain Valve. |
| 6 | | OPEN 1STG-DAV-84 D Steam Turbine Bearing Area Pre-Action Air Side Drain Valve |
| 7 | | DETERMINE if "Walk Test" is to be DISABLED to normal stand-by operation enabling all system wide alarms. This will be based on the length of time the Steam Turbine Ground Lvl Fire Protection Deluge Dry Valve **1STG-DAV-84** will be out of service. OBTAIN Management Direction. |
| Note: | N/A | The following steps Shall be completed in sequence to valve-in and place into service the Steam Turbine Bearing Area Pre-Action Valve |
| 8 | | Disable the Electric Fire Pump and Diesel Fire Pump to prevent a start while valving in the Pre-Action Valve |
| 9 | | ENABLE "Walk Test" on the Local Fire Control Panel. (This will enable system alarms.) |
| 10 | | CLOSE 1STG-DAV-84 D Steam Turbine Bearing Area Pre-Action Air Side Drain Valve |
| 11 | | OPEN 1STG-DAV-84 A Steam Turbine Bearing Area Pre-Action Air Supply Block Valve. PRESSURIZE to 40 psi air pressure prior to proceeding to the next step. |
| 12 | | OPEN 1STG-DAV-84 F Steam Turbine Bearing Area Pre-Action Water Pressure Sense Line Block Valve. |
| 13 | | SLOWLY CRACK-OFF-SEAT 1STG-BV-74 Steam Turbine Bearing Area Pre-Action Main Water Isolation Wall Indicator Valve. This will allow water to flow into the Pre-Action Valve and down the Water Side Drain. |
| 14 | | SLOWLY CLOSE 1STG-DAV-84 E Steam Turbine Bearing Area Pre-Action Water Side Drain Valve. |
| 15 | | SLOWLY OPEN 1STG-BV-74 to FULL OPEN Steam Turbine Bearing Area Pre-Action Main Water Isolation Wall Indicator Valve. |
| 16 | | ENABLE the Electric Fire Pump and Diesel Fire Pump to restore the Fire Protection System to normal stand-by operation. |
| 17 | | DISABLE "Walk Test" on the Local Fire Control Panel. (This will enable system alarms.) |

**RECORD the reason for Isolation:**_____

**Management Notified (to Determine if Fire System Impairment must be submitted)**

**Initials:** _____

**Isolation Completed by:** _____

**Date:** _____ **Time:** _____

**Submit this checklist to the Operations Manager after system isolation.**



## Index to advertisers

# Marcus Hook

## Successful troubleshooting cuts generator hydrogen consumption in half

**Challenge.** Marcus Hook Energy Center has four hydrogen-cooled generators: three GE 7FH2 machines, one Toshiba TAKS. Hydrogen is supplied by a local firm in 16-cylinder cradles; delivery is by truck (Fig 1). Consumption of the 7FH2 generators is 500 ft³/day by design; the TAKS unit uses 1236 ft³/day. The 16-packs are moved to each generator by forklift. Challenge was to reduce $H_2$ consumption, thereby reducing cylinder handling and improving system safety.

**Solution**. Operations personnel used a spreadsheet to track 16-pack movements and hydrogen use. All generators, save one on the gas-turbine units, were consuming well above design. The operations team worked systematically to locate the leaks, which were found to be the following:

- GT2 generator. A ½-in. poppet check valve in the hydrogen supply line was found leaking and replaced.
- GT1 generator. A bad gage caused $H_2$ supply pressure to run high and a small relief valve unseated as a result. The gage was replaced.
- ST generator. The scavenging valve for the hydrogen purity meter was allowing excessive flow and that was corrected.

**Results.** There has been a 50% reduction in 16-pack changes and hydrogen use. All four generators now are consuming hydrogen at a rate *below* design, reducing cylinder handling and onsite traffic, and the plant's risk profile. Expectation is the combined improvements will save about $50k annually. Also under consideration: Reducing onsite storage of the 16-cylinder packs, thereby increasing saving.

**1. Hydrogen for Marcus Hook's** generators is delivered in 16-cylinder cradles

### Marcus Hook Energy Center

*Owned by Marcus Hook Energy LP*

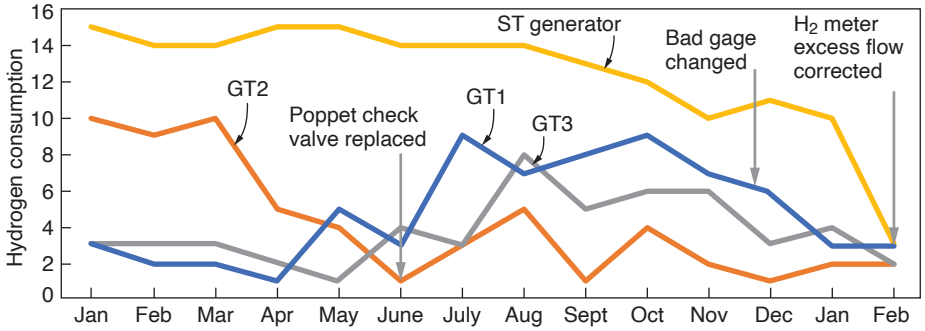
*Operated by GE*

813-MW, 3 × 1 7FA-powered combined cycle located in Marcus Hook, Pa

**Plant manager:** Frank Meade (former); Mike Kelly (current)

**Project participants:**

Mike Kelly, plant manager (current)
Frank Meade, plant manager (former)
Dennis Shannon, operations specialist
Ken Bubar, production team leader (FieldCore)
Bryan Kyler, production team leader (FieldCore)
Tim DiVincenzo, production tech (FieldCore)




**2. Gas consumption was reduced** by locating and fixing leaks in the hydrogen systems of three generators

HRSG FORUM

# Discussion centers on creep damage, elemental zinc in weld HAZ areas

As usual, a tremendous amount of technical content was offered in two presentations during the HRSG Forum, Jan 28, 2022—No. 7 in a series organized by Chairman Bob Anderson. But the underlying message was more about the state of our industry.

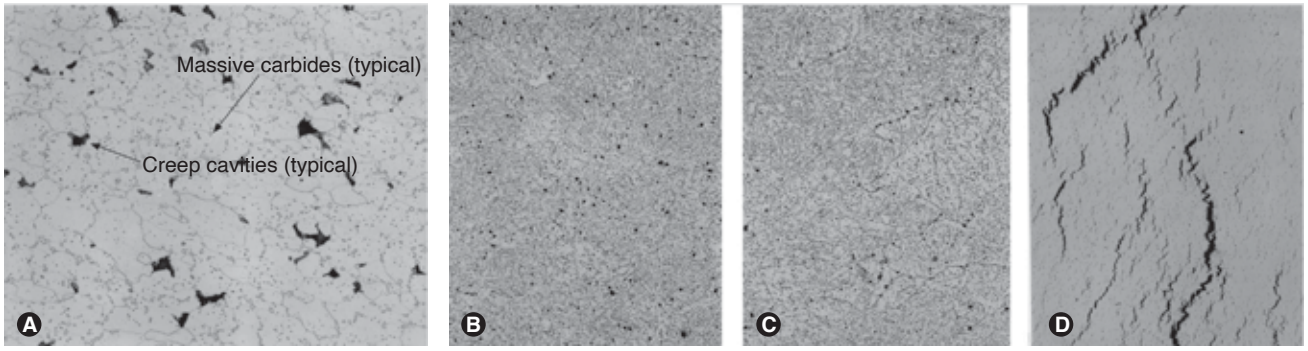
A few participants, discussing aging of high-energy piping (HEP), said they were "astonished at the lack of knowledge in major NDE [non-destructive evaluation] firms" and that boiler OEMs "are different" these days and there are new people in the industry. You can interpret "new" as suppliers who are inexperienced, or low-balling bidders, or doing shoddy work, but also buyers who accept low bids or don't establish the proper design specs or QA processes and protocols.

Later in the Q&A, one Forum organizer, discussing zinc issues with boiler pressure parts, said HRSG OEMs are "not giving answers [about zinc] with high confidence levels" and that it is "buyer beware" when it comes to at least one OEM.

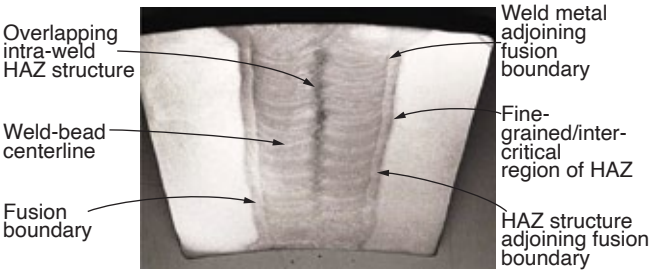
The first presentation, "NDE, Welding, and Metallurgy: Tools Supporting the Safe, Efficient Operation of Aging HEP," was delivered by industry veteran Jeff Henry, now with the Combustion Engineering Solutions (CES) division of Advanced Thermal Coatings (ATC).

There are many reasons why you should care about aging HEP, but if you've recently upgraded your gas turbine for higher output and efficiency, you are likely going to be expending the creep life of your superheater and reheater piping faster than you might have expected. This situation makes HEP components more susceptible to catastrophic failures at the weld areas.

Creep is "time-dependent strain, or changes in dimensions of the material, that accumulates in response to stress such as load and pressure." Over time, cavities form in the metallurgical grain structure, then begin to align into cracks which represent an "advanced stage of damage" (Fig 1). While creep can manifest as swelling of the pipe diameter, by far the most failures occur at welds, which are omnipresent in HEP systems.




**1. Stages in the evolution of tertiary creep,** following the onset of detectable damage (A), begin with non-aligned cavities (B) which start to align (C) and then form micro-cracks (D), and finally macro-cracking and failure




**2. Characteristics of welds** in high-temperature service are categorized based on these six areas of a typical weld

Onset of creep damage of course depends on the type of material and alloy. For Grade 22 material, the values for elevated temperature, according to Section 2, Part D of the ASME Boiler & Pressure Vessel Code, start at 952F. Code fabricated materials should last 250,000 operating hours, Henry said, *as long as piping supports*

*are properly maintained, the components are operated within design limits, and the original fabrication was conducted to within specifications.* For an aging facility, that's a lot of caveats.

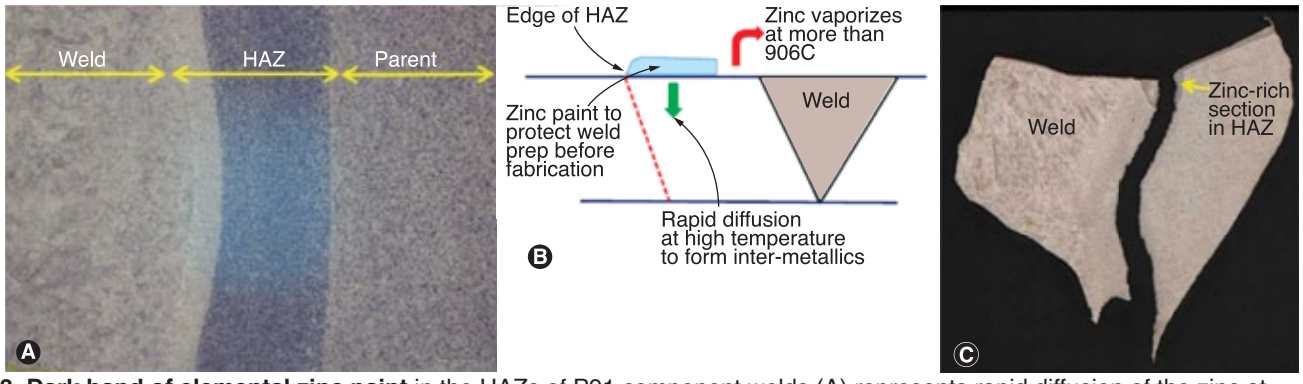
Inspection is critical to identify piping condition, but indications have to be properly characterized and the root cause understood before an effective repair is executed. In response to an audience question, Henry stated that 50,000 ops hours is a reasonable inspection interval if there are no operating or structural issues. When asked if there are protocols or industry standards, he recommended EPRI's qualification and certification program for NDE detection in high-energy piping.

Many of Henry's slides depict damage in six defined areas of HEP welds (Fig 2), and are not to be missed if you are responsible for an aging HRSG.

The second presentation, "Casting the Die: Implications of Zinc for Pressure Part Integrity," was given by Paul James, Uniper Technologies Ltd. Main takeaway: Presence of elemental zinc (not zinc oxides) in paint used to protect weld prep areas before fabrication makes pressure parts more susceptible to creep damage, especially in the weld heat-affected zone (HAZ). Fortunately, according to James, elemental zinc bands, beige-yellow which darkens with exposure to high temperatures, can be readily distinguished from the red lead oxide coating/primer traditionally used (Fig 3).

James emphasized that component integrity concerns are confined to weld HAZs where depth of zinc penetration is significantly greater than the depth of penetration remote from the weld. Where elemental zinc is suspected of being present, or there's uncertainty, a scraping of material from the area should be analyzed. Remedial work will require grinding back to bright metal more than 50 cm from the weld prep area.

During the Q&A, an informal poll of HRSG OEM representatives was cited, with several saying they'd never heard of the issue. Owner/operators need to put QA protocols in place, James cautioned, even if procurement specs explicitly prohibit the use of elemental zinc paints. CCJ




**3. Dark band of elemental zinc paint** in the HAZs of P91 component welds (A) represents rapid diffusion of the zinc at high temperature to form inter-metallics at the edge of the HAZ (B), a "metallurgical notch" which can possibly prompt crack initiation and failure, as shown in the cross section of a failed weld (C)

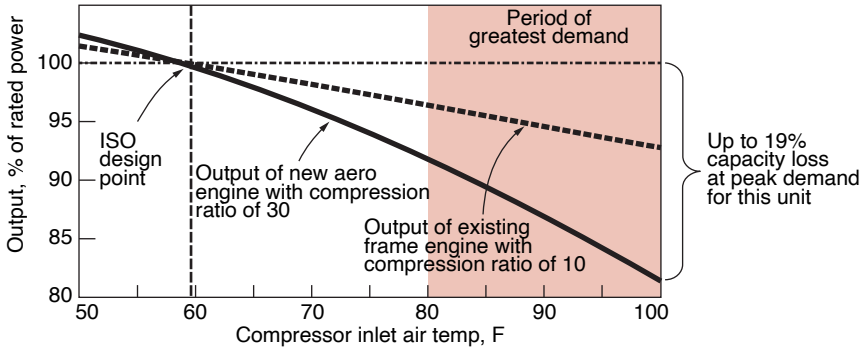
# Turbine inlet cooling: First step on the pathway to net zero emissions

## Adding TIC to a combined cycle will eliminate the need to boost output with an aero peaker and its less-friendly emissions profile to meet grid demand

**By Dharam Punwani,** Turbine Inlet Cooling Association

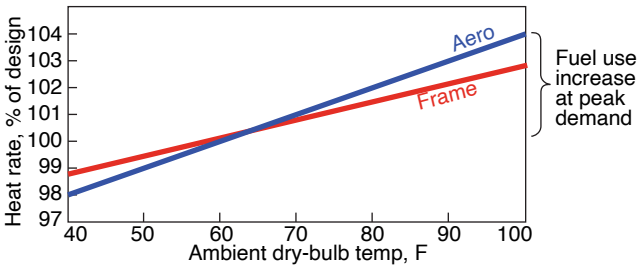
Gas turbine systems produce over one-third of US electric energy requirements. They provide reliable baseload power, in addition to that required to support the intermittent production of electricity from renewable sources. According to a *Washington Post* article, "Turns Out Wind and Solar have a Secret Friend: Natural Gas," every 0.88% of capacity from renewables needs 1% capacity back-up from a fast-reacting fossil-fuel system.

Thus, gas turbines, a cornerstone energy conversion technology for the efficient production of electricity and heat today, are destined to play an important role in the emerging global quest for zero carbon emissions.

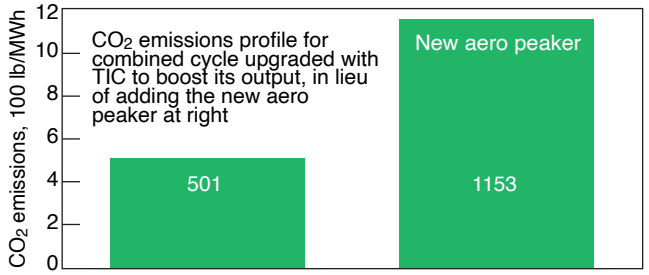



**1. Power production decreases** as compressor inlet air temperature increases

The operating capacity and energy efficiency of gas turbines is impacted by ambient temperature and humidity. These machines are rated at a standard set of ambient conditions, defined by the International Standards Organization (ISO) as 59F and 60% relative humidity. Increases in




**2. Fuel consumption increases** as air temperature increases. Heat rate is directly proportional to fuel consumption per kilowatt-hour and inversely proportional to energy efficiency




**3. $CO_2$ emissions** from the capacity gained by adding turbine inlet cooling to a nominal 500-MW combined cycle (left) are less than half those from the 50-MW simple-cycle peaker eliminated by it (right). The peaker in this example is an LM6000PC Sprint with hot SCR and TIC

**Scan the QR codes to quickly access TICA webinars on these important topics:**

| | | |
|---|---|---|
| Adiabatic wetted-media evaporative cooling (TICA 1) | Wet compression (TICA 3) | Thermal energy storage for chilled-water indirect heat exchange (TICA 5) |
| Fogging for evaporative cooling (TICA 2) | Indirect heat exchange with chilled water (TICA 4) | Hybrid cooling (TICA 6) |

ambient temperature and humidity adversely affect output and energy efficiency of all gas turbines. Figs 1 and 2 present examples for the two major types of gas turbines: aeroderivative and industrial frame.

Since high ambient temperature reduces the performance of gas turbines, the logical solution for preventing this adverse effect is to cool the inlet air before it enters the compressor. Several technologies have been used successfully for this purpose.

The Turbine Inlet Cooling Assn's (TICA) website at https://turbineinletcooling.org is an excellent source of information on these solutions. The table lists them and includes QR codes that link directly to information of value in decision-making. The website also includes an inlet-cooling performance calculator, database of installations, and library of publications and presentations on all technologies.

Bear in mind that each technology has its pros and cons. No one technology is best suited for all applications. Selection of the optimum technology for your plant depends on many factors—including gas-turbine design, weather data for the plant location, value of additional electrical energy produced, and the value of unitized fuel saving.

The following summarizes the benefits attributed to cooling of gas-turbine inlet air:

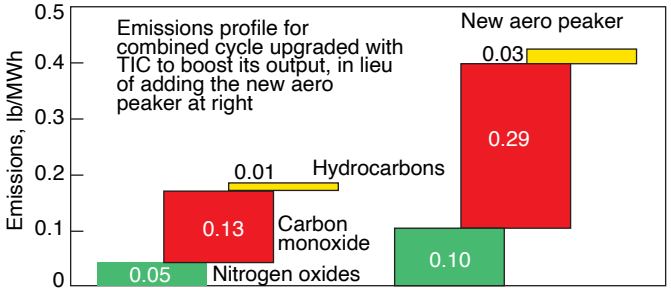
- Increased power output.
- Increased energy efficiency.
- Reduced emissions per unit of electric energy produced (higher efficiency).
- Reduced grid-wide emissions (reduced need to operate less-efficient systems for meeting grid demand).
- Increased thermal energy in exhaust gases, which benefits combined-cycle and cogeneration systems.
- Lower capital cost compared to the addition of a peaking unit to increase capacity.

Because combined cycles are the most efficient fuel-fired option for producing electricity, upgrading with inlet cooling eliminates the need to operate a less-desirable alternative—such as running a simple-cycle peaking turbine with a rated capacity equal to the combined-cycle output gained by adding inlet cooling.

Examples of the quantitative benefits of using TIC on a 500-MW combined-cycle system for reducing emissions of carbon dioxide and regulated pollutants, are compared in Figs 3 and 4 to the emissions from a simple-cycle peaking turbine whose need was eliminated.

Similarly, installing inlet cooling on simple-cycle turbines eliminates the need to operate less-efficient systems.

According to an estimate by TICA, the use of inlet cooling on all combined-cycle systems in the top 20 states can reduce carbon emissions by more than 22 million tons annually. CCJ




**4. Regulated emissions** from the capacity gained by adding turbine inlet cooling to a nominal 500-MW combined cycle (left) are significantly less than those from the 50-MW simple-cycle peaker eliminated by it (right). The peaker in this example is an LM6000PC Sprint with hot SCR and TIC

# HA Users to meet in Atlanta, August 9-10

Prepared by the HA steering committee and GE

The 2022 HA Users Conference is designed to foster a transparent dialogue between HA customers and GE Gas Power about the technology throughout its lifecycle, candidly discuss technical issues and solutions, and share best practices and lessons learned among users.

While there are quarterly webinars between the users and GE, the in-person conference has been very effective in driving strong engagement between the user community and technical experts from GE. Conferences also provide an opportunity to visit other HA-related facilities. While Covid prompted a virtual conference in 2020, the in-person meetings in Fort Worth (2018) and Detroit (2021) provided an opportunity to tour an HA powerplant site, and the session in Greenville (2019) included the opportunity to visit GE's gas-turbine manufacturing facilities.

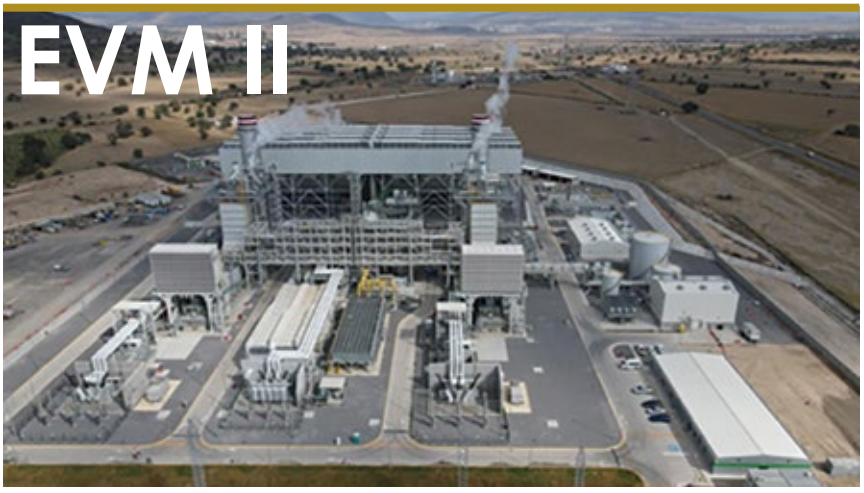
The Fifth Annual HA Users Group Conference will be held as a two-day event in Atlanta (Ga), August 9 and 10. Day One will be exclusively for HA owner/operators, allowing members to share information and experiences from their sites either in operation or in commissioning. Selected vendors will also be onsite, providing an opportunity to meet in-person.

On Day Two, technical experts from GE will review latest updates, learnings, and improvements for the HA fleet and provide the users an opportunity to interact in an open, candid manner. Participants can also tour GE's Monitoring and Diagnostic Center.

Steering committees from the HA Users Group and GE are working on finalizing the agenda. A registration link for the conference will be sent out in the next few weeks. We look forward to the event to continue the strong partnership and collaboration between HA Users and GE. CCJ

## HA steering committee

Mike Banks, *DTE Energy*
Chris Bates, *NAES (Long Ridge Energy)*
Mike Cashon, *TVA*
Jason Gatewood, *Florida Power & Light*
Meg Guillaumin, *DTE Energy*
Jeff Klier, *Exelon Generation*
Rama Krishna, *Sharjah Hamriyah O&M Co*
Meredith Neal, *TVA*
Adam Sensenig, *NAES (Birdsboro Power)*




# Mechanical vaporizer enables plant to convert to ZLD facility during construction

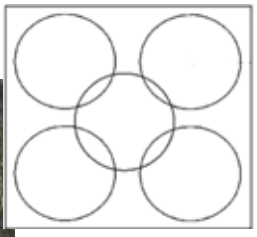
**Challenge.** EVM II, the recently commissioned (COD Jan 1, 2021) H-class, 2 × 1 combined cycle in Mexico State, was designed to send treated wastewater to underground infiltration wells. But the plant's discharge permit was revoked during construction because of changes to environmental laws, forcing plant staff to scramble to find an acceptable way to dispose of about 115,000 to 160,000 gal/day—the volume of wastewater expected when the plant is operating baseload year-round.

**Solution.** The plant owner's technical team analyzed several options and settled on evaporation as the most cost-effective solution. However, the pond required to evaporate 160,000 gal/day naturally would cover about 50 acres, which was not practical. This calculation was based on the semi-arid weather conditions at the plant location which suggested 10 ft² of pond surface was required to evaporate a gallon of water. An engineering factor of 125% was added on top of that.

To assist the evaporation process and reduce pond size, so-called mechanical evaporators were designed into the system. They create a mist that hangs in the air long enough for natural evaporation to occur above the pond surface. Engineers factored historical weather data from the Mexican National Meteorological Service (temperature, humidity, wind speed, etc) into their design to assure that water would not be sprayed outside the pond area. For example, pump speed can be regulated when wind gusts are experienced.

Another design condition was that the pond be designed to hold all the rainwater from a 100-year storm event. The plant's Best Practices entry included the data and analyses conducted in support of this goal. The outcome: Retention-pond capacity required was about 5.5-million gallons. Given that a nominal 2-million-gal pond was included in the original plant design, a pond of about 3.5-million gallons had to be installed onsite.

Fig 1 (left) shows the new pond during construction; the drawing at the right, the arrangement of its five mechanical evaporators (plus one in the original pond) required to achieve



**1. New pond** under construction is at left. One mechanical evaporator was installed in each of the 200-ft-diam pond sections outlined above

## Energía del Valle de México II (EVM II)

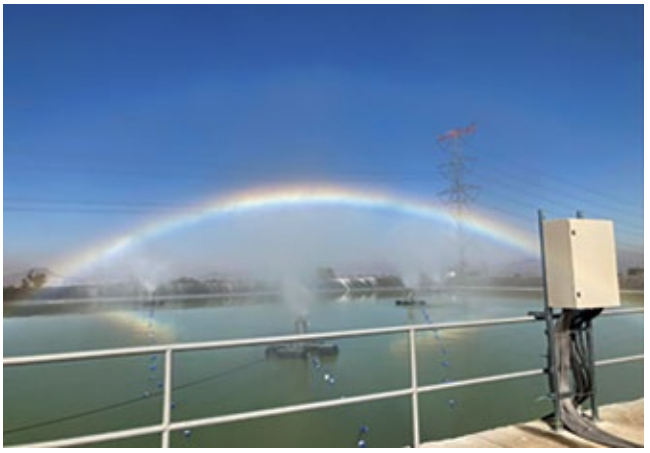
*Owned by EVM Energía del Valle de México Generador SAPI de CV*

*Operated by NAES Corp*

850-MW, 2 × 1 combined cycle powered by 7HA.02 gas turbines, located in Axapusco, state of México, México

**Plant manager:** Javier Badillo

**2. Mechanical evaporator** is set in final position



**3. Rainbow** puts a finishing touch on the wastewater evaporation project

the desired evaporation rate. The mechanical evaporators each serve a 200-ft-diam section of the pond. Fig 2 shows the installation of a mechanical evaporator, Fig 3 the resulting rainbow during its operation.

**Results.** Cost of construction and equipment for the new pond was $375,000. Installation was done by plant personnel, who also did the controls work to allow automatic operation and commissioning. Factoring in operating expenses and infiltration fees, payback for the entire ZLD (zero liquid discharge) effort was achieved in two years.

In the first four months of operation, an average of 165,000 gal/day of wastewater was processed, more than expected because the gas turbines' evaporative cooling systems were forced to operate on relatively poor-quality raw water, increasing blowdown.

More recently, staff has been focusing on ways to improve the quality of water going to the GT evap coolers to both reduce the consumption of raw water and the amount of wastewater flowing to the evap ponds.

**Project participants:**
Alonso Saldivar, maintenance mgr
Armando Farias, plant engineer

BOOK REVIEW

# Electric co-ops: Aspire to better

Many rural Americans each year are invited to breakfast or lunch for pancakes or roast beef, next given an LED lightbulb, then are given a raffle ticket for a variety of appliances attached to an electric cord. These rituals, called an annual meeting, are held by electric cooperatives in 48 states. At these events, customers, called "members," also vote for the co-op Board of Directors. What many members won't see are directors, or candidates for the office, who reflect the cultural, socio-economic, or ethnic characteristics of the membership.

Author Mark Glaess

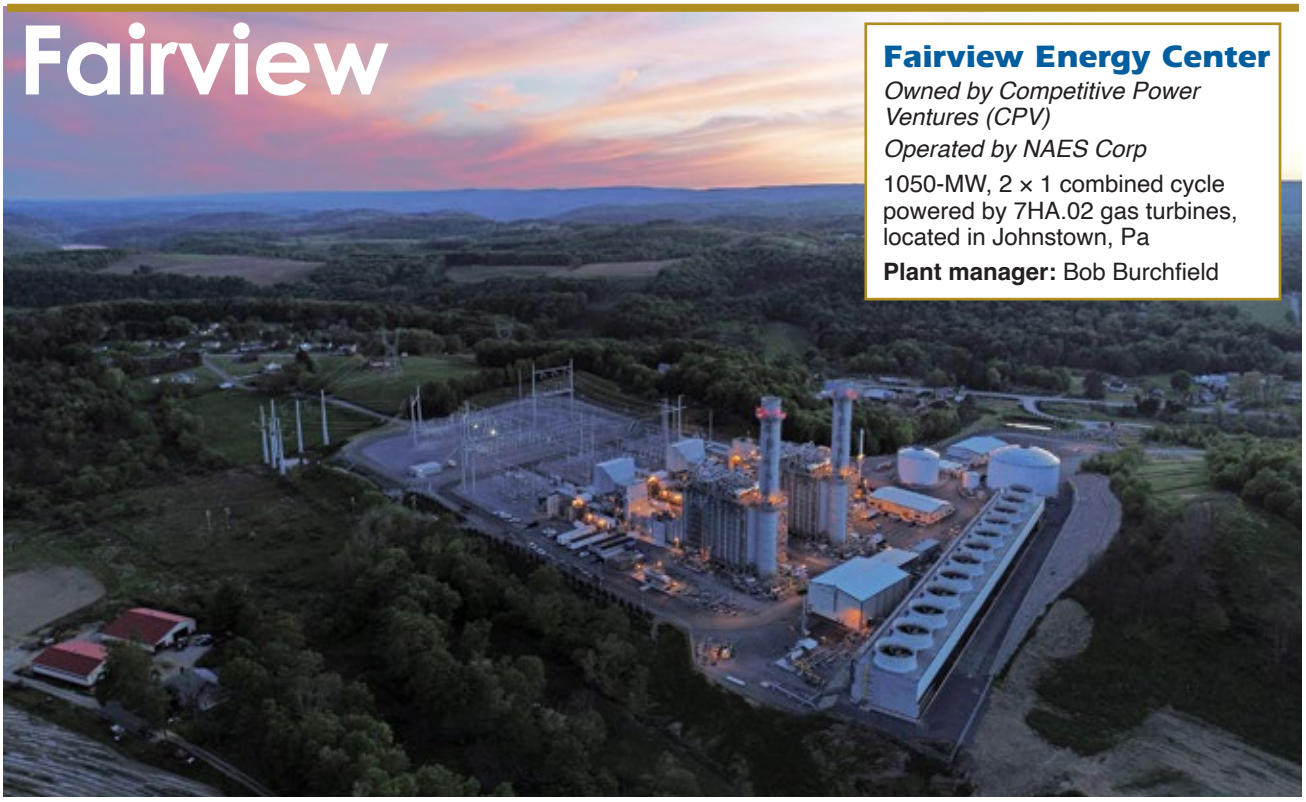
You may be one of them. Forty-two million member-ratepayers, perhaps more, belong to an electric cooperative presided by an elected board of directors, who, as well, receive a per diem exceeding the average income of most of the members. The Board also decides who gets what—internet service, clean water, energy conservation, jobs, electric vehicle financing, et al, and perhaps as well, what goes into member and employee retirement accounts.

Another thing members don't see is the amount of carbon dioxide associated with their electricity use. Members should ask their co-ops: Why not? At the same time, ask directors about the millions of dollars of members' money they hold in their "deferred" capital credit account.

Capital Credits? Members' heirs will learn about them when members pass on. Why not find out about the money owed you now? While you're at it, ask the Board why there's hardly any women on the Board or why the largely black or Hispanic membership doesn't have a say in how the co-op spends their money?

All great questions and even more answers in this book: "Aspire to Better: The 21st Century Electric Cooperative," which has been described as a book brimming with wit and passion. Others called "Aspire" a compelling narrative, while still others called it a "must read." The sad fact is 42 million "members" juiced from their electric cooperative probably won't. But you should.

Learn more at www.aspirebetterbook21.com.




**Fairview Energy Center**

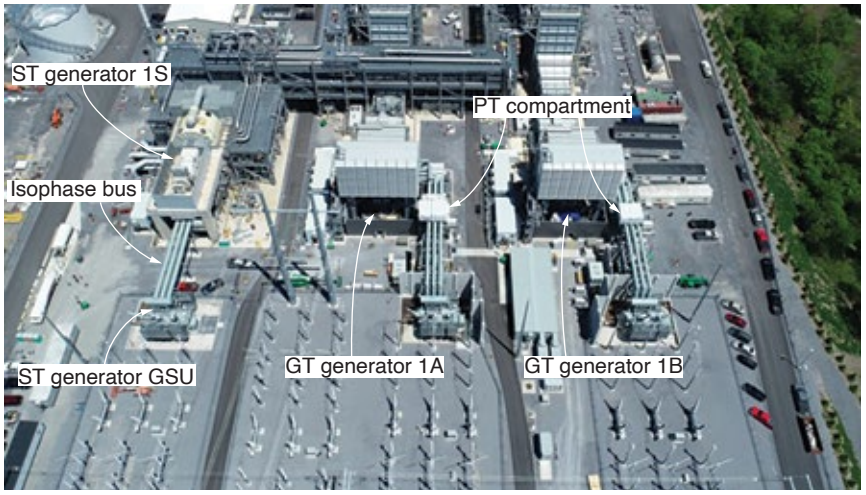
*Owned by Competitive Power Ventures (CPV)*

*Operated by NAES Corp*

1050-MW, 2 × 1 combined cycle powered by 7HA.02 gas turbines, located in Johnstown, Pa

**Plant manager:** Bob Burchfield

# Use EMI to assess the condition of generators, transformers, HV electrical gear




**1. EMI test locations** are indicated on site plan view (above)

**2. Arcing on 23.5-kV PT cables** was attributed to compromised insulation and water (right)

**Challenge.** Soon after commissioning, one of Fairview's gas turbine/generators experienced stator-ground-fault trips attributed to isophase-bus (IPB) water ingression into potential transformer (PT) cabinets, followed by persistent lower-than-expected resistance readings. Doble Engineering was engaged to perform electromagnetic interference (EMI) testing on several components of the plant's three power trains to assess their condition. Generators, step-up transformers (GSUs), unit auxiliary transformers (UATs), and IPB were suspect in each train (Fig 1).

Following the first trip on stator-ground-fault 64 relay, damaged cables and condensation were found in a PT cabinet (Figs 2 and 3). To learn more on the importance of addressing grounding issues in a timely manner, read "IEEE standards may not sufficiently address grounding issues in rotor, stator windings," by Clyde V Maughan, CCJ, 2Q/2013, p 7.

**Solution.** Given the extensive amount of IPB and connections, the CPV and NAES engineering teams advised the plant to perform EMI testing to identify other potential sources of arcing and abnormalities. An EMI diagnostic was conducted to determine the possible origin of the problems.

Recall that EMI testing is per-

**3. Condensation** is in evidence in PT cabinets

**4. Radio-frequency** current transformer is placed around the PT cabinet's ground bar

formed online and can detect several mechanical and electrical defects on generators, IPB, transformers, and motors. Defects in the bus connections or insulators generate radio-frequency signals that can be measured.

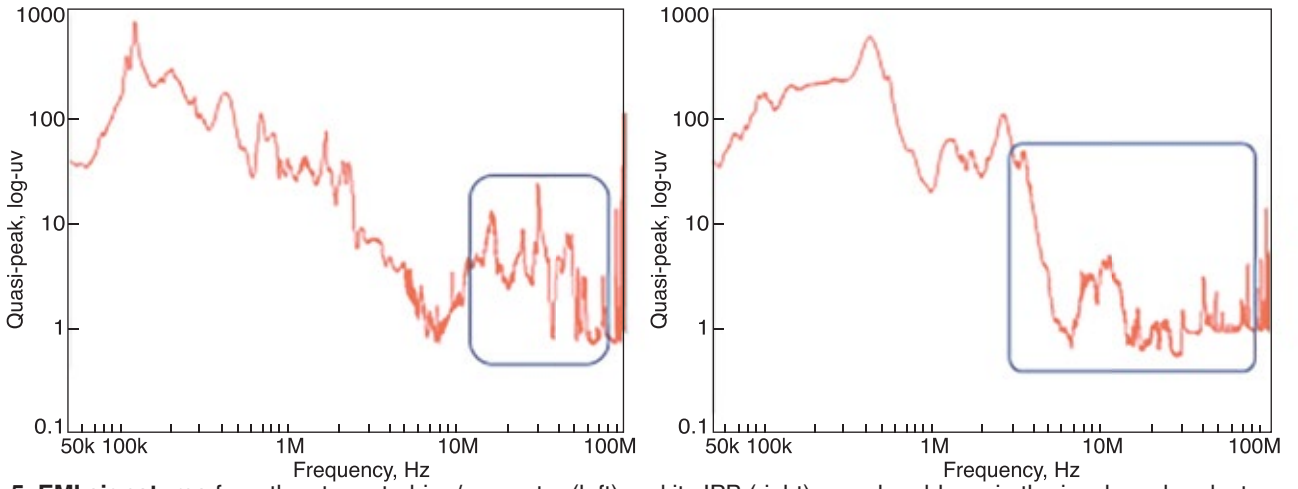
| Component | Signal detected | Suspected location |
|---|---|---|
| ST generator 1S | High PD, sparking | Generator/IPB interface |
| GT generator 1A | High PD | Generator/IPB interface |
| Isophase bus 1S | PD, sparking | Generator/IPB interface<br>Transformer/IPB interface |
| Isophase bus 1A | PD | Generator/IPB interface<br>PT cabinet |

To perform an EMI diagnostic, a radio-frequency current transformer is placed around the neutral, a safety ground, or power conduit of the asset (Fig 4) to measure and identify the signals generated from the component or system defects. The EMI diagnostic method measures a broad spectrum of radio frequencies to evaluate signal patterns—including, but not limited to, corona, partial discharge (PD), and arcing.

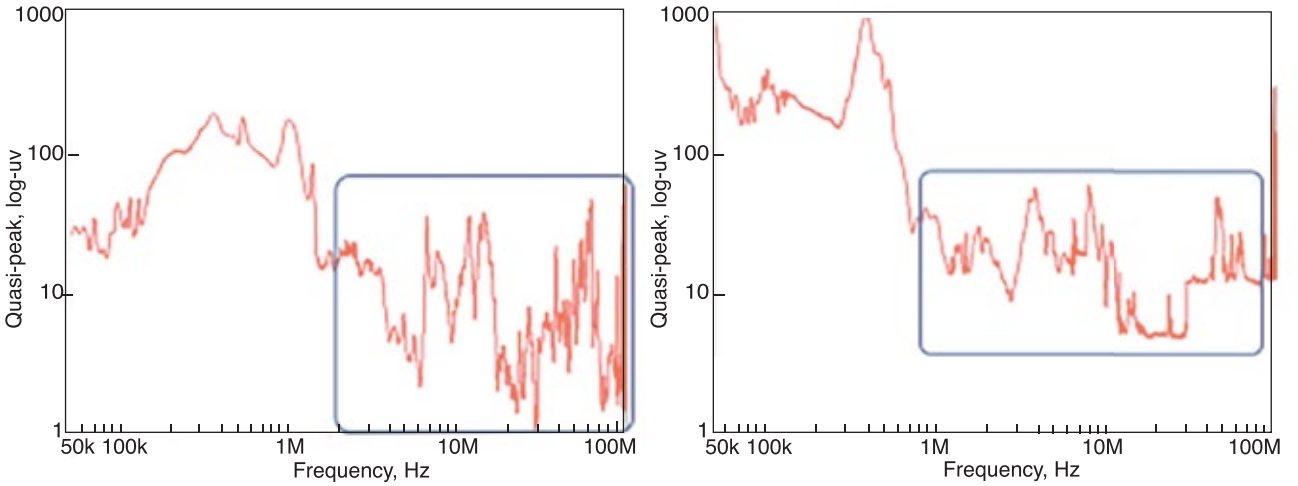
Additionally, a handheld device is used in conjunction with the EMI signature to further identify the defect location. This device detects the EMI signals radiated from each component or system defect, allowing the technician to measure the intensity of the activity.

EMI testing is performed while the asset is in service and is a nonintrusive technique that will not cause the equipment to trip offline. A baseline measurement is helpful but not required for the analysis; therefore, maintenance recommendations are provided starting with the very first test, and the analysis helps to prioritize maintenance based on asset condition.

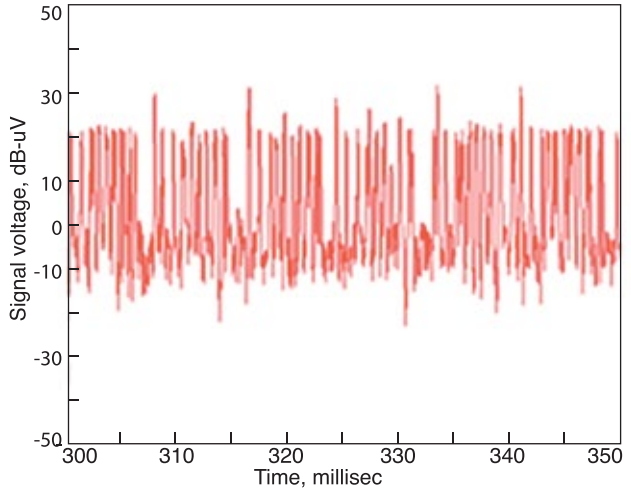
The generator, IPB, UAT, and GSU for each of the three units were tested and inspected. The table sum-



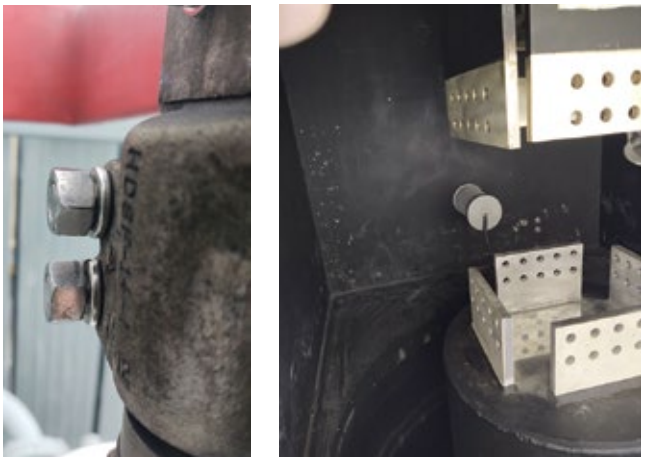

**5. EMI signatures** from the steam turbine/generator (left) and its IPB (right) reveal problems in the isophase busduct




**6. EMI signatures** from gas-turbine/generator 1A (left) and its IPB (right) reveal problems in the isophase busduct




**7. Sparking activity** is in evidence in the waveform for the HF band (12 MHz)



**8. Loose neutral bushing** in the GSU for the STG (left)

**9. Loose wire** was found by EMI in the PT (right)

**10. Insulator tracking** was found in Phase A of the steam turbine/generator

marizes the most relevant findings. The EMI signatures in Figs 5 and 6 were acquired at different grounds on each component. The frequency ranges indicated on the EMI signatures, upon further and detailed analysis of the waveforms, revealed abnormal PD and sparking activities. Fig 7 is an example of a sparking waveform.

The activities detected typically are associated with insulation deterioration, defective connections, and loose hardware inside the IPB. To pinpoint the locations of the defects, a scan was performed with a handheld device to identify areas with high radiated EMI. After a thorough analysis, an internal inspection of different sections of the bus system was recommended.

Referring to the detailed EMI report provided by Doble, the locations identified in the table were highlighted on electrical one-line and 3-phase drawings. These marked-up prints were used to plan lockouts, scaffold erection, and inspections at the next planned outage. Figs 8-10 show examples of the findings in locations identified by EMI testing.

**Results**. Deficiencies were identified and corrected at each suspect location identified by EMI testing.

EMI testing enabled non-outage inspections of the electrical distribution system, thereby reducing the length of outage inspections and facilitating advance planning prior to the outage start date.

Given the success of the one-time EMI survey, CPV Fairview is installing a permanent EMI detection system. The team has initially selected the ST generator, IPB, and GSU for permanent monitoring.

A permanent installation may not fit everyone's business model. As a minimum, we recommend conducting an annual survey or as-need surveys following repairs or the installation of new equipment.

### Project participants:

*CPV:* Joe Michienzi, Preston Patterson, Tom Favinger, Ali Bibonge

*NAES:* Bill Lovejoy, chief engineer; Rick Marshall, maintenance manager; Jason Havash and Aaron Roberts, I&E technicians

*Doble Engineering:* Roberto Martinez and Oscar Montano

# Online resources enable plant personnel to better prepare for upcoming outages

## MD&A focuses on inspection, repair, upgrade of retaining rings, turbine valve actuators

Summaries of MD&A's spring 2022 webinars on topics of interest to all involved in the operation and maintenance of generating plants powered by gas turbines follow. Both experienced personnel and those new to the industry might benefit from a quick read to identify topics of immediate value and then follow up by listening to recordings of the webinars of interest. All run less than an hour.

To access MD&A's library of webinars, go to www.mdaturbines.com, scroll down to, and click on, the link for the spring webinar series, then click the webinar of interest.

### Take a deep dive into failures, repairs of generator retaining rings, main leads

Retaining rings (RR) and main leads are two of the most stressed components in large combined-cycle generators and thus prone to failures. James Joyce, generator repairs ops manager for MD&A, during a Feb 24, 2022 webinar, covered the basic design and purposes of these two components, along with what can only be called gruesome slides (Figs 1 and 2) of what they look like when in disrepair or fail from mechanical and/or electrical issues.

MD&A has developed repairs and upgraded components, which should be considered as replacements when maintenance intervals allow. The slides depict the design, manufacturing, and installation process for these upgraded parts.

Joyce also reminded attendees that GE has issued a Technical Information Letter (TIL) for users to replace 18/5 (18% manganese, 5% chromium) RRs with 18/18 (18% manganese, 18% chromium) material on all GE generators that currently do not have 18/18 RRs. It is observed that most OEMs have issued similar information documents recommending changing currently installed retaining rings to that of the 18/18 composition.

The many audience questions elicited additional valuable contributions to the presentation, including:

- There is no such thing as "severe" retaining ring cracks. If there are *any* cracks, the component should be replaced, and preferably upgraded at the same time. Plus, cracks on the outer diameter end means there are cracks on the inner diameter end and it's time to replace.
- High-speed balancing is strongly recommended after retaining-ring replacement.
- Follow OEM maintenance schedules for when inspections are due, but generally every two to three years and during a major overhaul.
- Standard NDE for RRs is a dye

**1. Main lead rotational and radial failure** manifests as compressed and twisted leaf copper (left) and broken leaf copper (right)

**2. Three examples of main-lead J-strap** overheating and arcing, an electrical failure

penetrant test; radiographic tests are not normally performed.
- A complete RR replacement takes five to seven days, depending on whether the size in question is in stock.
- Damage to the RR from a motoring event will depend on the amp load and length of time; one type of damage mechanism could be arcing on the dovetail slots.
- MD&A can identify the RR material using NDE, and without knowing the OEM.
- Continuous cycling will greatly impact the main leads.
- MD&A is not aware of cracking issues with 18/18 RRs but cracks could show up in five to 10 years as operating hours are gained.
- "Top tooth" cracking is rare, but does exist; perhaps 2% to 3% of units are susceptible.

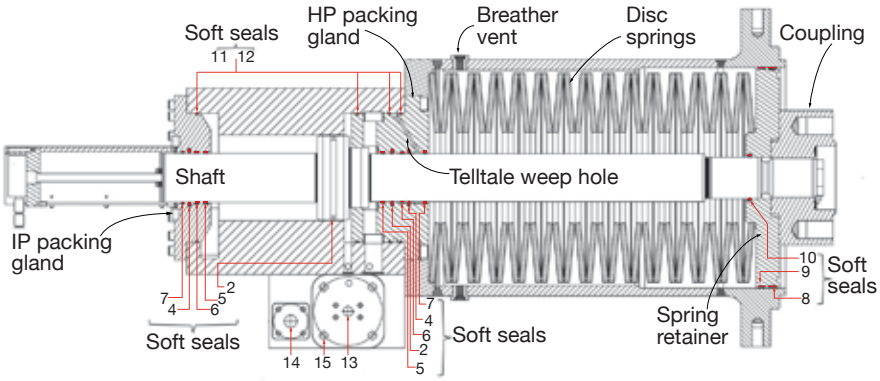
## Sweat the small stuff when it comes to steam-turbine valve actuators

If you think your combined-cycle steam-turbine valve actuators are one of those "set and forget" components, think again. As Anthony Catanese explains during the Feb 15, 2022 webinar hosted by MD&A, "Turbine Valve Actuator Operational Issues and Upgrades," even the most robust actuators, such as GE's "legacy EHC," running in a baseload plant may last up to 30 years, but "when they fail, they fail spectacularly."

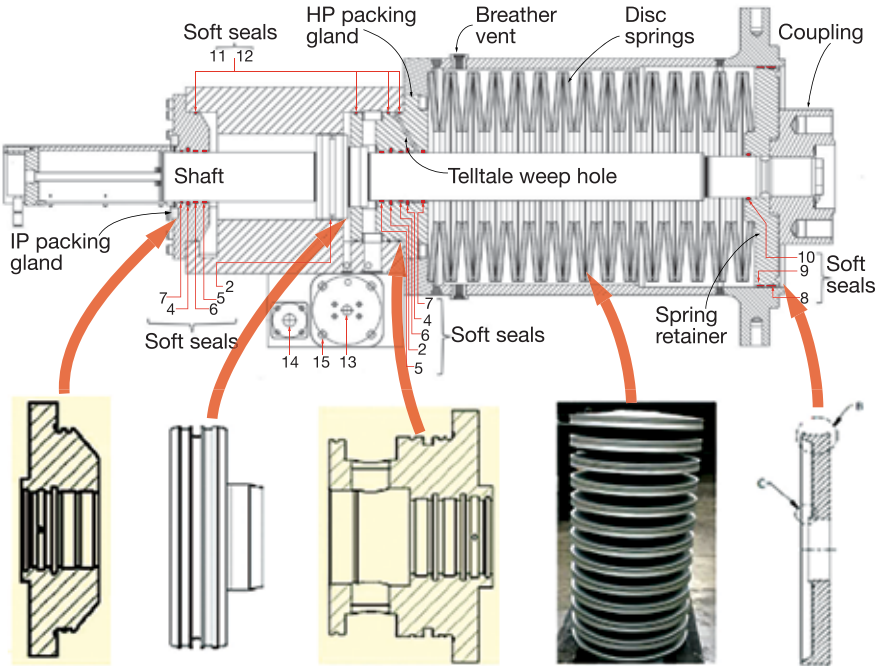
Actuators all function pretty much the same from a fundamental mechanical point of view (Fig 3), says Catanese—hydraulic force to open, spring force to close. But some designs are more complicated than others by virtue of their many bells and whistles (Rexroth) and/or more components (legacy Westinghouse). Check out the video if you're looking for a refresher on fundamentals about the various popular designs.

Catanese's recommendations for spares (Fig 4) and maintenance intervals were the heart of the material. Generally, he says, plants should keep half a set of servos and solenoids in stores, although a full set is preferred, and filters, of course, should be changed regularly and oil kept clean. People tend to think less about the LVDTs and switches. Catanese suggests keeping one or two of these handy at all times.

As for preventive maintenance, legacy GE units should be sent to the shop every 10 to 15 years, legacy Westinghouse every five to eight years, and Rexroth and combined-cycle LP actuators every four to eight years. The rest of Catanese's slides explain, through photographs of typical long-term damage to internal components, why disassembly, repair, and inspection during regular maintenance intervals is so vital: You want to identify issues before the actuator fails.




**3. Steam-turbine valve actuators** employ same basic mechanical movement, but older-style legacy GE and Westinghouse models are more robust (although the GE has fewer parts), while the more modern Rexroth designs offer more bells and whistles but require shorter in-shop maintenance intervals




**4. MD&A stocks Rexroth spares** and upgraded parts in sufficient quantities to respond to customers' emergent situations

Insights gleaned from the Q&A:
- If your actuator is experiencing stickiness or sluggishness, nine times out of 10 the problem will be with the servo.
- Be sure to test disc springs if/after they've been coated—most sites neglect to do this.
- If one disc spring in the stack cracks, replace them all; otherwise, the forces will not be uniformly distributed during closing.
- MD&A is the only "sanctioned" non-OEM service firm for Rexroth actuators.

## Don't fear the Mark VI Trender in your toolbox: It's your friend!

If you are leery of using the Toolbox Trend Recorder/Trender function in the Mark VI and VIe control systems when your gas turbine is running, Joe Clappis, senior engineer, MD&A Control System Div, has a message for you: Don't be! You don't need a password and you can't alter the turbine's control logic. Clappis encouraged his audience during the webinar, "Troubleshooting Alarms and Trips with High-Speed Data Capture," Feb 22, 2022, to get familiar with Trender, which he calls the "the best tool in the Toolbox."

Unlike data historians, which typically capture data at rates of once per second or slower, Clappis noted, Trend

Recorder takes data as fast as once per 40 milliseconds. Low-speed data capture is best for slow-moving long-term trends—such as bearing metal temperatures and vibration. High-speed data capture allows you to analyze control valves, combustors, inlet guide vanes, exhaust temperature spreads, and other variables which can change far more quickly.

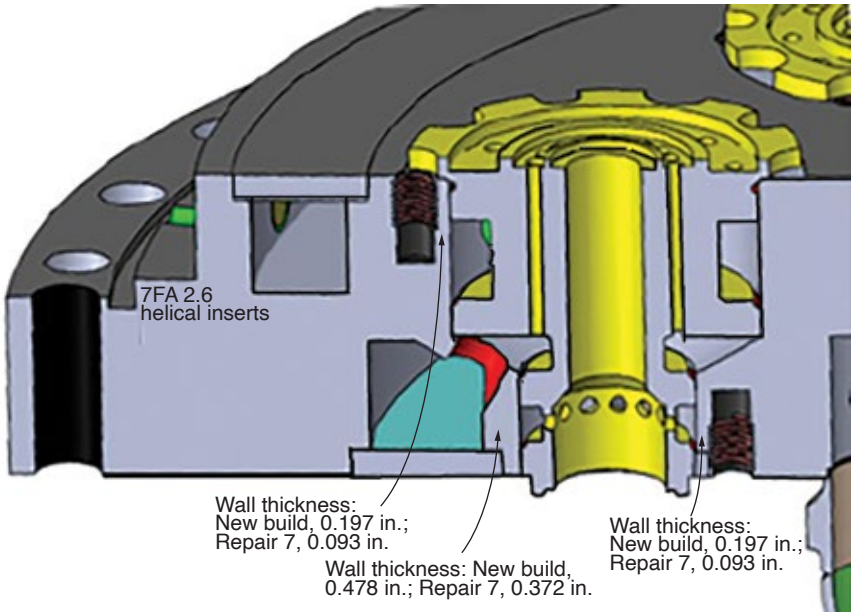
Trend Recorder also captures alarms and events in addition to raw data and all the data can be viewed in graphical form.

"Users often send us screen shots, or smart-phone camera photos of HMI views, and ask us to troubleshoot a particular problem or event, but these are often not helpful," Clappis lamented. However, data summarized and presented in Trender can be extremely useful. You can study starts and shutdowns, compare "good starts to bad starts," study DLN combustor mode transfers, and identify intermittent issues. Or Clappis and company can give you a higher-level diagnosis if you send them Trender files.

Many of Clappis' slides showed the audience how to find Trend Recorder/Trender from the Mark VI home page, create and save a Trend Recorder file in Toolbox or ToolboxST, analyze data, simplify screen views and graphics, and drill down to actionable data. Clappis distinguished between actionable data and anecdotal data, like "I saw this happen and it never happened before!"

For those unfamiliar with data analysis, monitoring, and/or control systems, it's best to follow along with the recording of Clappis' webinar with your Mark VI screens in view. He gives explicit instructions for how to navigate within the Toolbox and Trender.

Finally, OEMs typically configure data historians and high-speed data recorders poorly, usually trying to capture too much data too fast, but also often not capturing the right




**5. Nondestructive testing** and modeling of end-cover insert pieces identified substantial wall thickness available for repairs and led to an improved brazing process

values for certain types of trouble-shooting. Factory configurations are not tailored to the site, or require much special training to extract the value from the data. "You have to be dedicated to learning the system," Clappis stated.

As a caution, Clappis reminded participants that Trend Recorder is not a substitute for long-term data archival and retrieval. In response to an audience question, Clappis noted that the Mark IV does not include a trending program, the Mark V, "sort of." A feature called View Tools can collect data on a limited number of data points.

## More attention to fuel-nozzle upgrades, repairs pays huge dividends

Blind faith in your OEM's DLN fuel-nozzle component repair and replace recommendations could kill your outage budget, and that's not all. That was the underlying message during the Feb 17, 2022 MD&A webinar, "Gas Turbine Fuel-Nozzle Flow Issues," led by the tag team of Joe Palmer, general manager, and Pat Murphy, director of the company's Fuel Nozzle Services Group, formerly ICS.

Fuel-nozzle overhaul is often the lowest cost area of a scheduled outage, and therefore not at the forefront. That's a shame, stressed Palmer and Murphy, because many combustor issues originate with the fuel nozzles. Thus, there are other important benefits of upgraded fuel nozzles—easier tuning at startup, reduced temperature spreads, and less risk of lean blowout. Improperly maintained fuel nozzles also adversely impact the life of major hot-gas-path (HGP) components.

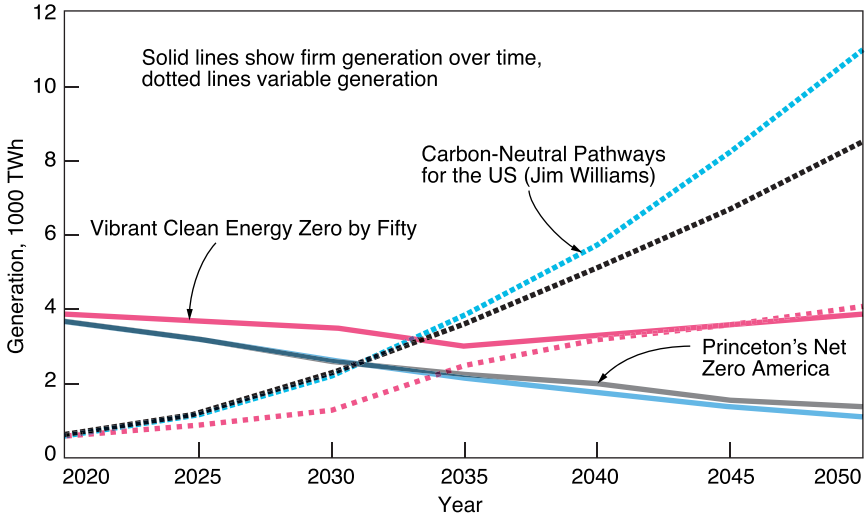
MD&A has developed, and fully warrants, upgraded fuel nozzle components for 7FA DLN 2.0- and 2.6-equipped engines (and combustors of other models), especially the subassembly wear parts. Remanufactured nozzles from MD&A are warranted as "like new" and can operate nearly "indefinitely." For example, upgraded outer/center nozzles, using several part calculation strategies, could operate for nearly 148 factored years! Meanwhile, the OEM claims a 48,000-hr lifecycle for its component. The as-new quality parts are a fraction of the cost of OEM replacement components, claims MD&A.

The third-party solutions provider's new end-cover insert can operate over seven repair cycles. MD&A's improved brazing process and choice of braze material have greatly improved cover life (Fig 5). Plus, the amount of cyclic insert braze cracking has been reduced. Several of the slides are dedicated to explaining and illustrating the detail of this component "case study."

The company offers an exclusive "in-situ flow testing" method, which helps pinpoint nozzle issues and solutions. "Component balancing and set balancing of fuel nozzles also can avoid a separate combustor inspection (CI) and extend run time to the next HGP outage." The exclusive testing is an alternative to a complete nozzle system teardown for pinpointing flow variances and accurately and expediently addressing them.

# Thermal performance audit key to extracting more dollars from older plants

The road to net zero carbon by, well, pick your date, 2030, 2035, 2050, is paved with pledges, promises, mandates, and political rhetoric, but the




**1. Melding of three net-zero studies** forecasts coal generation essentially gone by 2035 and variable renewable resources outstripping firm generation in less than two decades

**Self-imposed duct-firing temperature constraints by operators**

- Up to 20 MW per unit could be recovered
- Even a 10% recovery per unit could mean over $1.6 million annually

**Industry cooling-tower issue causing condenser to underperform**

- Cooling water 3-4 deg F high, resulting in loss of 1.3 MW and 9 Btu/kWh per unit
- Potential annual loss is greater than $600k

**Hidden problem with inlet fogging in two units was reducing plant output**

- Additional 2 deg F of inlet cooling recovers 3.5 MW and 72 Btu/kWh per unit
- Potential annual loss is greater than $600k

**Slow degradation in turbine performance during peak generating season**

- Generating loss of 2 MW and 200 Btu/kWh attributed to infrequent water washing
- Left unchecked, this would have amounted to an annual loss greater than $300k

**2. $3.1-million of potential value** was identified through the TPA of a 4 × 2 highly flexible plant, over half extracted immediately (duct firing) or pretty quickly (fogging)

landscape will most surely be dotted with gas-fired combined cycles making megawatt-hours when the variable renewable resources are not, according to Jeff Schleis, gas-turbine product manager, EthosEnergy.

In a webinar conducted Jan 25, 2022, Schleis, reviewed net-zero-carbon trends at the national level, offered some insight gleaned from Black & Veatch's Annual Strategic Directions Report (a survey of industry leaders on top-of-mind issues and investment scenarios), and summarized three recent net-zero forecasts on one graph (Fig 1).

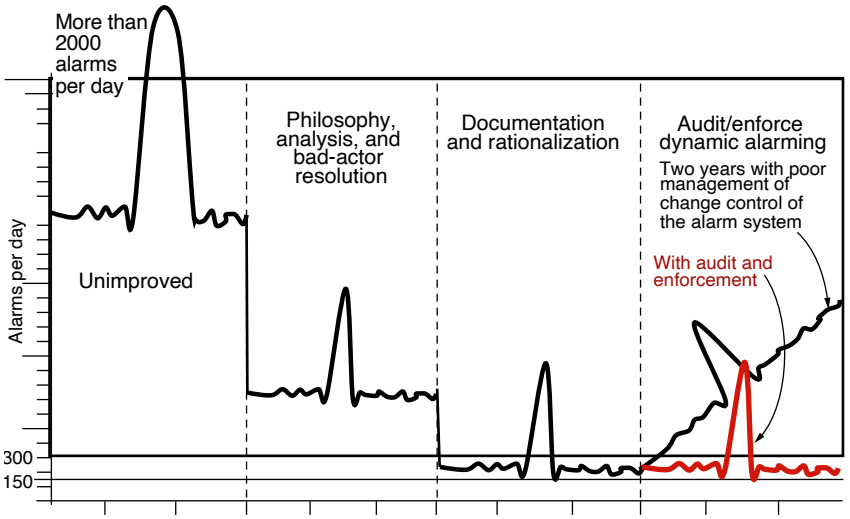
Upshot of the last is that variable generation could exceed firm in less than 20 years. That represents opportunity for gas-fired combined cycles, but you have to be intentional about it. Schleis advocates conducting a thermal performance audit (TPA) to identify the gaps in performance, or where an older plant can extract additional value.

Equipment degrades over time, he said; the goal of the TPA is to analyze historical operating data and glean info from the operators to build a plant model that captures current equipment condition. Then you compare existing performance to original design, and individual turbines to each other, to determine where the gaps are, and what investment is required to close those gaps and extract the dollars.

The balance of Schleis' slides (access via the QR code) is a deep dive into a case study on a 4 × 2 plant "designed to be very flexible." The high-level results are shown in Fig 2. The one audience question directly relevant to the presentation queried the time it takes to conduct the example TPA and the "timeframe for improvements." Schleis answered that the study takes six to eight weeks depending on plant complexity and that the fogging issues (see figure) were "pretty quickly corrected," while the duct-firing issue was resolved immediately.

# Follow these steps to reclaim your control-system alarms

Many combined-cycle plant operators suffer from poor control-system alarm management. Like the rest of the plant, the alarm system probably was designed with a specific operating mode in mind and brand-new equipment. Digital control system designers also tend to over-indulge in the convenience of alarming way too many




**Alarm management in one slide,** as Holyfield put it, shows what you can achieve by following the seven-step program described in the webinar. Chart graphs the dramatic reduction in the number of important alarms likely missed by implementing the first three of the seven steps

parameters.

The really good news, according to Bill Holyfield, principal alarm management consultant, Hexagon/PAS, during a webinar on alarm management Feb 4, 2022, is that 60-80% of alarm issues can be addressed by following just the first three of a seven-step program (figure): preparing an alarm philosophy document, analyzing historical alarms and establishing benchmarks, and resolving bad actors, like "chattering" alarms, which can be up to 90% of bad actors. These three steps can often be accomplished in a few weeks at very low cost.

Holyfield set the foundation by reviewing work PAS had done with EPRI in analyzing and improving the alarm situation at 15 powerplants, including several combined cycles; defining elements of an alarm philosophy, especially setting alarm priorities based on need, and time to operator response, and the process consequences of not properly responding to the alarm; and establishing benchmarks, such as alarms per day and frequency of alarm floods, to gage progress.

Plants can even get under 300 alarms/day by going the extra miles of documentation and rationalization, audit and enforcement, and state-based, or dynamic alarming. To put that number in perspective, powerplants typically experience from 2000 to 10,000 alarms per day. Another "alarming" stat: Powerplant operators spend an average of 7% of their time facing alarm "flood" conditions, defined as 10 or more alarms coming at them every 10 minutes!

Dynamic alarming, the holy grail, simply refers to automatically altering alarm setpoints, priorities, and suppression based on the *plant's current process state*. For example, the alarming system for a plant that runs fairly steadily five days a week then ramps down to lower load, or shuts down, over the weekend will be different from a plant that experiences two starts and four-hour run periods daily.

The webinar slides (access via the QR code) not only include the "flesh on the bones" of what's summarized here, but great references for digging deeper, such as Hexagon/PAS white papers on the latest alarm statistical performance parameters, the ISA 18.2 Alarm Management Standard (produced with heavy Hexagon/PAS involvement), and the EPRI Alarm Management Guidelines, co-authored by PAS. CCJ

BOOK REVIEW

# Sound knowledge management processes are critical to business success

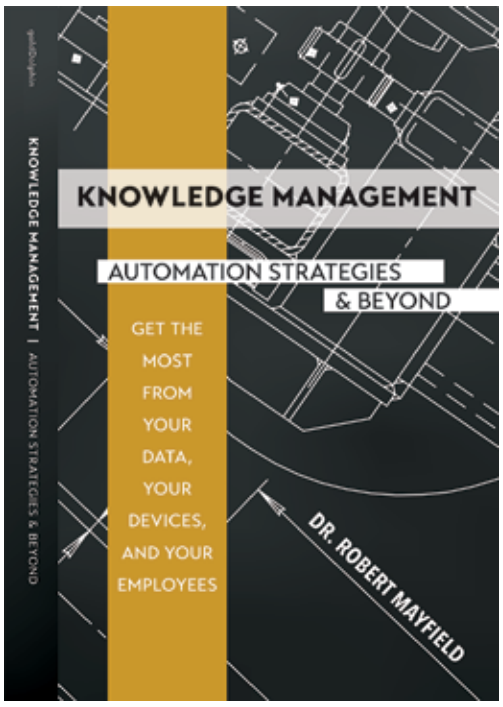
Knowledge management is viewed by many organizations as synonymous with information management. This is no longer true. Taking such a perspective may lead to the mistaken belief that the installation of highly sophisticated information-technology infrastructure is the end-all and be-all of knowledge management and transformation.

Knowledge management is not like the movie *Field of Dreams,* where if you build it, they will come. Effective knowledge management relies less on technology as a support tool and more on how people operate within the organization, based on the deep experience of author Dr Robert Mayfield, a well-respected plant manager and the author of "Knowledge Management—Automation Strategies and Beyond."

It's time that energy organizations acknowledge, address, and measure the risks associated with the loss of mission-critical knowledge through employee retention, recruitment, productivity, training, and benchmarking. We must trust one another and share knowledge across the entire energy industry. To stay competitive, equipment manufacturers, vendors, contractors, and energy organizations need to share their ideas, best practices, and lessons learned. All knowledge to be shared with our competitors is not proprietary.

Dr Robert Mayfield

While actionable intelligence certainly plays a central role in knowledge management, it is not knowledge management. However, actionable intelligence is the only way to connect geographically dispersed people in an efficient manner. An organization's ability to leverage technology effectively determines its sustainable competitive advantage.




In the end, that depends on the people—the executives, senior management, supervisors, and workers—within an organization.

The industry must recognize that people are the key to competitiveness. It must transform hierarchical cultures into team knowledge-based cultures. Unless knowledge management processes are implemented in this manner, companies will not be able to avoid a looming staffing crisis.

To be competitive, a company must establish processes and conditions that enable employees to grow from an assignment-based mentality to a proactive attitude. An effective knowledge management program includes business acumen training to facilitate greater cross-departmental fertilization through a new rotation program that cracks open the departmental silos. In addition, an assessment process must be applied to identify those individuals who are stepping out, stretching their capabilities, and delivering hard results.

With knowledge management processes in place, the competitive organization will experience expanding opportunities with each new knowledge-enabled employee. Employees who are uniquely positioned and empowered to apply their explicit and tacit knowledge toward innovation and creativity will be able to meet unforeseeable challenges. CCJ

# Legacy Turbine Users Group

The Legacy Turbine Users Group, formed by Power Users to facilitate the transfer of knowledge among members of the Frame 7EA, 6B, and 5 Users Groups, greatly benefits owner/operators of these engines. With the number of experienced O&M personnel in decline because of retirements, and the high cost of meetings to share experiences increasing dramatically in a time of reduced plant budgets, it makes good sense to aggregate the talent on both the user and supplier sides for all to share.

A select group of independent consultants and shop owners, most with a half century or more of direct experience with these engines, is expected to participate in the First Annual LTUG Conference at the end of August (see ad, pages 92 and 93 for details). The list includes Dave Lucier of PAL Turbine Services, Paul Tucker and Ken Knecht of FIRST/TBS, Bob Johnston, Keck Group International (formerly GE Gas Turbine Upgrades), and Mike Hoogsteden of Advanced Turbine Support, as well as several others. They will offer guidance on how to extend the lives of your units and extract maximum value from them. CCJ

## Acronyms for GE gas-turbine technology

Participants in the Legacy Turbine Users Group may find that many speakers talk in "shorthand," using acronyms freely. If you're not up to snuff on your GE legacy-engine lingo you can get lost in a hurry and possibly miss key points. The "cheat sheet" that follows, prepared by Dave Lucier of PAL Turbine Services LLC, can help you remain focused. If you have acronyms to add to this list, a work in progress, please email them to bob@ccj-online.com.

AG—Accessory gearbox
AVR—Automatic voltage regulator
BLFN—Breech-load fuel nozzle
BPV—Bypass valve
CBV—Compressor bleed valve
CCO—Constant control-oil pressure (fuel regulator era)
CDP (or PCD)—Compressor discharge pressure
CI—Combustion inspection
CRV—Compressor recirculation valve
DSP—Digital speed setpoint (Speedtronic™ Mark I and II)
FD—Flame detector or flow divider
FPI—Fluorescent penetrant inspection
FSNL—Full speed, no load
FSR—Fuel stroke reference (Speedtronic™ Mark IV, V, and VI)
GCV—Gas control valve
GEN—Generator
GOV—Governor control
GT—Gas turbine
HCF—High-cycle fatigue
HGP—Hot gas path
HP—High-pressure turbine shaft (MS3002 and MS5002)
HPC—High-pressure compressor (MS3002 and MS5002)
HPCR—High-pressure compressor rotor
IGV—Inlet guide vane
LCF—Low-cycle fatigue
LG—Load gear
LO—Lube oil
LP—Low-pressure turbine
LPC—Low-pressure compressor (MS3002 and MS5002)
LPCR—Low-pressure compressor rotor
LS—Low-pressure turbine shaft (MS3002 and MS5002)
LVTD—Linear variable differential transformer
MI—Major inspection
NHP (or TNH)—Turbine speed
OEM—Original equipment manufacturer
OST—Overspeed trip
OTT—Over-temperature trip
PCD (or CDP)—Compressor discharge pressure
PM—Project manager
PN—Part number
PPP—Package power plant
PT—Pressure transmitter
RCA—Root cause analysis
RFQ—Request for quote
RVDT—Rotary variable differential transformer
SP—Spark plug or igniter
SRG—Speed reduction gear
SRV—Gas stop/speed ratio valve
STIG—Steam-injected gas turbine
TA—Technical advisor
TBC—Thermal barrier coating
TD—Technical director
TFT—Turbine firing temperature
TNH (or NHP)—Turbine speed
TTX—Turbine exhaust temperature
VASN—Variable-area second-stage nozzles (MS3002 and MS5002)
VCE—Variable control voltage (EMF) for Speedtronic™ Mark I and II
VCO—Variable control-oil pressure (fuel regulator era)
VI—Visual inspection
VIGV—Variable inlet guide vanes

## Steering committees, 2022

7EA Users Group

Dale Anderson, *East Kentucky Power Co-op*
Joshua Coots, *Duke Energy*
Tracy Dreymala, *EthosEnergy Group, San Jacinto Peakers*
Jeff Hansen, *Old Dominion Electric Co-op*
Guy LeBlanc, *IHI Power Services Corp*
Tony Ostlund, *Puget Sound Energy*
Mike Vonallmen, *Clarksdale Public Utilities*
Lane Watson, *FM Global Chemical Operations*

6 Frame 6B Users Group™

Michael Adix, *Motiva Enterprises*
Kevin Campbell, *Chevron*
Robert Chapman, *Chevron*
Jonathan LaGrone, *Formosa Plastics Corp USA*
Doug Leonard, *ExxonMobil Technology and Engineering*
Mike Wenschlag, *Chevron, El Segundo Refinery*
Zahi Youwakim, *Indorama Ventures, Port Neches Operations*

**Steering committee advisers:**
Jeff Gillis, *ExxonMobil retired*
John F D Peterson, *BASF retired*

FRAME 5 Users Group

Josh Edlinger, *Eastern Generation*
Shannon Lau, *Suncor Energy*
Logan Quave, *Indorama Ventures*

If you're an owner/operator of a GE 7EA (a/k/a MS70001EA and 7E.03), or one of its predecessor engine models A, B, C, or E, the technical meeting offering the "most bang for the buck" is the first annual Legacy Turbine Users Conference (LTUG), August 29 to September 1, at the San Antonio Marriott Rivercenter.

User groups for the other legacy GE frames—5 and 6B—will be sharing the venue, with the three organizations meeting concurrently, each in its own room. Meals and vendor fair will bring all attendees together.

As the ad on pages 92 and 93 shows, four other user groups in the Power Users family (p 95) also will be meeting at the same time: Combined Cycle (CCUG), Generator (GUG), Steam Turbine (STUG), and Power Plant Controls (PPCUG). A 7EA registration allows your participation in any group's meeting at any time. You can't beat that benefit.

In sum, more than 300 users and well over 100 exhibitors are expected to participate in the late-summer conference.

The steering committees for the organizations served by LTUG (p 77) currently are evaluating technical content for their meetings and developing agendas. The 7EA group may be furthest along in this regard, already having invited Mike Hoogsteden as its opening speaker to share what Advanced Turbine Support's technicians are finding during their inspections of this frame. The company is believed to conduct more inspections of legacy engines than any other firm.

Hoogsteden told the editors that his 7EA presentation will include the following:

- Rotor blade/stator vane clashing.
- Rotor-blade radial tip cracks and liberations.
- Advancements in the in-situ blending of compressor and turbine airfoils—including an overview of blending equipment.
- Internal and alliance-partner engineering support.
- New Technical Information Letters (TILs) released by the OEM.
- Update on generator robotic inspections.

**1. Rotor-blade tip distress** is most commonly caused by contact with the case during operation

**2. Eddy-current inspection** detect radial tip cracking shown prior to tip liberation

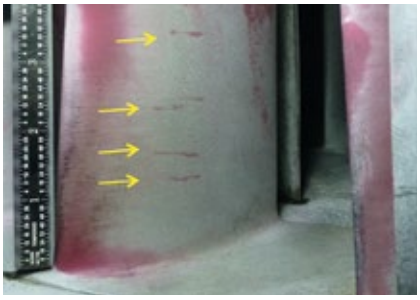
Hoogsteden touched on some of these same topics in his presentation to the group last year. Owner/operators registered by Power Users can access the complete PowerPoint in the 7EA conference file at https://www.powerusers.org. Highlights of that slide deck follow:

**TIL 1854,** "Compressor Rotor Stages 2 and 3 Tip Loss," suggests blending and tipping to mitigate the impact on availability and reliability of Row 2 and/or R3 tip loss (Figs 1 and 2).

Importantly, note that this TIL does not address R1 rotor-blade tips. Nor does it recommend in-situ inspections, and it suggests that tip losses are low risk. Advanced Turbine Support's resume notes that the company has conducted over 1000 in-situ visible dye-penetrant inspections, identifying more than 70 cracked rotor blades and 50 blade-tip liberations in the process.

**TIL 1884,** "7EA R1/S1 Inspection Recommendations," addresses the need to inspect R1 and S1 airfoils for possible damage caused by clashing—the unwanted contact between the leading edges of S1 stator-vane tips and the trailing edges of rotor blades in the platform area.

The TIL recommends a visible inspection, followed by visible or fluorescent dye inspection, in the so-called "area of interest" on the suction side if clashing is identified (Fig 3). Using discoveries as a basis for effective inspection techniques, Advanced Turbine Support recommends eddy current for these inspections.



**3. Vane cracking** was identified with penetrant and eddy current

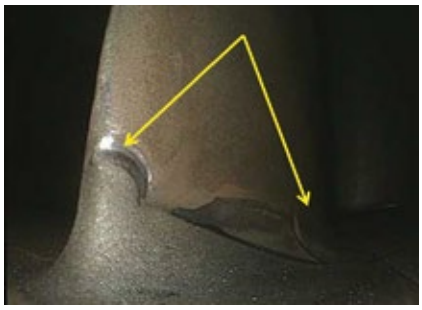
**TIL 1980,** "7EA S1 Suction Side Inspection Recommendations," advises users to inspect for crack indications on S1 vanes made of Type-403 stainless steel, regardless of whether clashing damage is in evidence on S1 and R1 airfoils or not.

While the TIL recommends visible or fluorescent dye, Advanced Turbine Support favors eddy current for these inspections using previous discoveries to support its opinion. The company says that if the stator vanes are coated, visible or fluorescent dye penetrant inspections may not be dependable, nor will they have an acceptable probability of detection.

UT results also could be compromised if coating degradation, such as debonding, occurs.

Hoogsteden explained that if the stator vanes are coated, the company's eddy-current technique—featuring ultra-high sensitivity and very high resolution—has the ability to maintain sizing capabilities through coatings of up to 0.125 in. thick. He added that eddy current also is preferred when looking for crack initiation because it can detect problems sooner than ultrasonics.

**4. Failure of retention hook** allows shim to protrude from the compressor



**5. Stator was damaged** by liberated shim

**TIL 1562-R1,** "Heavy-Duty Gas Turbine Shim Migration and Loss," informs users on the need to monitor the condition of compressor shims and corrective actions available to mitigate the risks of migrating shims (Figs 4-5).

**Other presentations.** In addition to reviewing Hoogsteden's PowerPoint, you might want to look over the other vendor presentations made at the 2021 meeting of the 7EA Users Group and available on the Power Users website—this to come up to speed before heading for San Antonio. Generally speaking, the more you put into preparing for a meeting, the more you'll take away.

The first morning's program (August 24) had a compressor focus and featured the following 30-min presentations:

- *Compressor Vane Looseness: What to Look for and What to Do,* CTTS (a/k/a Core Tech).
- *Emergency Rotor Support Services Case Study,* Sulzer.
- *Analysis of Inspection Protocols for S-1 Clashing,* Veracity Technology Solutions.
- *Getting Your 7EA Ready for Increased Run Time,* Emerson.

The afternoon session started immediately after lunch. The lineup:

- *Bus Maintenance in Action,* RMS Energy.
- *The GTC Quick Solutions Package,* GTC Control Solutions.
- *PGO Servo Valve Product Release,* Moog Industrial Group.
- *Gas-Turbine Operability Challenges in an Unstable Grid Environment,* EthosEnergy.

**August 25.** Half-hour vendor presentations continued throughout the third day of the conference. These were made in the morning:

- *7EA Turndown Solutions: How Low Can We Go?* PSM.
- *Remote Operations for Simple-Cycle GT Sites,* Emerson.
- *Using Flow Net Modeling to Optimize Fuel-Nozzle Calibration and Flow Testing,* Trinity Turbine Technology.
- *Emergency Material and Design Support,* Schock Manufacturing.
- *Generator Testing: What the Tests Mean and How They are Resolved,* AGT Services.

An open discussion forum launched the afternoon session as it did the previous day. These vendor presentations followed and closed out the day's technical program:

- *Considerations for the Fleet Management of Gas Turbine Lubricants,* EPT Clean Oil.
- *Predictive Analytics to Improve Gas Turbine Power Forecasting and Maintenance Practices,* Camfil Power Systems.
- *Breaking Down the Run-to-Failure Strategy: Why Proactive Bus Duct Maintenance is Critical,* Electrical Builders. CCJ


# Safety, reliability foremost when purchasing a mobile fall-protection system

**Challenge.** Several locations at Lincoln Generating Facility and Crete Energy Venture require fall protection, and there are no adequate tie-off points available.

One of the most notable: Generator circuit-breaker platforms at Lincoln. When performing generator breaker work from the platform, personnel have adequate fall protection. However, most often the work requires climbing up to a higher level, which exposes workers to a fall risk and therefore requires fall-protection harnesses.

A problem arises when the technician is standing on the highest point in the area and is only able to tie off to the equipment that he/she is standing on. If the person were to fall to the platform below, the fall protection would not work, because the drop is less than the distance required to fully engage the fall-arrest lanyard, but it's still high enough to cause serious injury.

If the technician fell off the structure entirely, the fall-arrest equipment would come into play; however, there is a possibility of injury by the fall-arrest system because of the distance the worker would drop before activation.

**Solution.** Staff has explored numerous options over the years to eliminate the fall risk described—including temporary scaffolding during planned maintenance, which was not practical when required for unexpected issues forcing the unit into an outage. Permanently installed tie-off points proved costly because of their installation and periodic testing requirements.

Personnel observed a demonstration of an OSHA-approved mobile tie-off system, which could be used in many different locations through the site and shared between the Lincoln

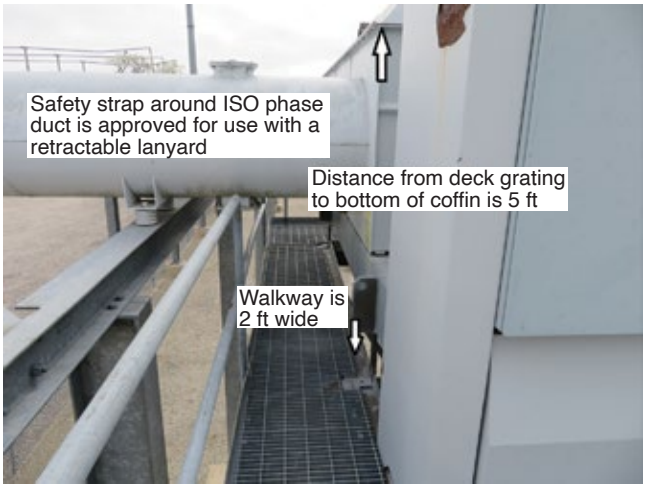
## Lincoln Generating Facility

*Owned by Lincoln Generating Facility LLC*

*Operated by Consolidated Asset Management Services LLC*

600-MW, eight-unit simple-cycle peaking facility powered by 7EA (DLN-1) gas turbines, located in Manhattan, Ill

**Plant manager:** Brad Keaton


**1, 2. Personnel have adequate** fall protection when generator breaker work can be performed from platforms designed into the plant

**3, 4. Mobile tie-off system** in travel mode at left, ready for work at right.

and Crete sites as required. Cost of the system was half that for the permanently installed systems considered for just the breaker platforms. The mobile system demonstrated has tie-off points for three workers, which is adequate for the workscopes site personnel perform.

The mobile tie-off project received owner approval and an OSHA-approved system was purchased.

**Results.** The mobile tie-off system has been used successfully in many locations throughout the facility. Its proven benefits include the following:

- Cost was half that for permanently installed systems considered for just the generator circuit breaker platforms.
- The mobile system has tie-off points for three workers, which is adequate for the workscopes plant personnel perform.
- Scheduling and coordination of temporary scaffolding during outages is no longer required.
- Staff now is capable of safely performing emergency repairs.

**Project participant:**
Jeremy Escolar, O&M technician IV


**Crete Energy Venture**

*Owned by Crete Energy Venture LLC*

*Operated by Consolidated Asset Management Services LLC*

330-MW, four-unit, 7EA-powered, simple-cycle peaking facility located in Crete, Ill

**Plant manager:** Brad Keaton

# Mark V lifecycle, reliability improvements produce dramatic results

**Challenge.** Crete, commissioned 20 years ago during the gas-turbine boom, has experienced challenges with obsolescence, parts availability, and OEM support. This is especially true for the Mark V gas-turbine control system. OEM declarations ceasing production support of system components in 2014, outdated HMI interfaces and hardware, limited OEM training offerings, plus the wear and tear of daily operation, led staff to investigate methods for the continued reliable operation of the control system.

**Solution.** After performing their due diligence, it became clear to plant management that a full control-system upgrade was not necessary, as multiple third-party vendors provide solutions for parts repair/replacement and field service support, and the functionality of the TMR (triple modular redundant) Mark V controls remained robust.

Staff determined that multiple methods of improvement were available for a comprehensive control-system reliability program and implemented the following solutions:

*Mark V health checks.* Since 2016, Crete has hired a third-party vendor on a biennial interval to perform reliability assessments of the Mark V control panels and associated equipment. It identified numerous issues lingering below the surface which eventually could have caused forced outages if not addressed.

Mark V cards, ribbon cables, and instruments have been replaced proactively during the assessments, and bad wiring terminations in remote junction boxes have been corrected. The permanent clearing of what could be considered nuisance Mark V diagnostic process alarms and dc-equipment grounding issues also was a site priority during the process. Result: The plant now experiences significantly fewer unplanned equipment failures than previously.

*Inventory management.* After the initial increase in site inventory and the addition of firmware revision-specific spares—such as EEPROMs (electrically erasable programmable read-only memory)—plant personnel continued to discuss optimized plant inventory levels for each Mark V card and component during every reliability assessment.

Increased inventory levels of high-use/high-failure-rate boards, like the TCEA and TCPS, have proved beneficial on multiple occasions, reducing downtime during controls-related upsets. Crete also replaced the GE TCPS power-supply boards with an upgraded aftermarket version from GTC Control Solutions after experiencing a failure or alarm condition that predicted future issues. Any used card, or one of unknown condition, that may have been replaced during troubleshooting also is sent to an outside vendor for a condition assessment and in-panel test to ensure that all site inventory is functional upon installation.

*BOP PLC upgrade.* The original installation used an obsolete pairing of GE Fanuc 90-70 and 90-30 PLCs—each with limited parts availability, single CPUs, and the need for a no-longer-supported Genius Bus Module communications device (Fig 1 left). Personnel determined that because of

**1. Original BOP PLC** (left) was obsolete and replaced with GE's fully redundant RX3i PLC at right


**2. A large portion** of the existing ARCnet network was replaced with a fiber-optic/ethernet communications ring for reliability purposes

PIC
PRECISION ICEBLAST CORP

# WHEN IS 10 TONS OF DEBRIS A GOOD THING?

**Recently Precision Iceblast Corporation** was contracted to clean a standard HRSG located in the United States after explosion cleaning methods were utilized. The client initially experienced somewhat positive results from the explosion cleaning efforts. However, within a short time frame the client's back pressure increased near gas turbine tripping points.

**Precision Iceblast Corporation** removed an additional 10 tons of debris after explosion cleaning efforts. Client experienced an additional 3.5" reduction in back pressure. Client has been able to maintain the reduced back pressure after the PIC HRSG Deep CleaningTM process.

It was determined that explosion cleaning efforts were only able to clean to the fourth/fifth row of tubes leaving a large amount of the heating surface untouched.

**AFTER EXPLOSION CLEANING**
(4TH & 5TH ROWS OF TUBES)

**AFTER PIC HRSG DEEP CLEANING**
(4TH & 5TH ROWS OF TUBES)

## PIC HRSG Deep Cleaning

- ✓ No federal permitting required
- ✓ Dramatic reduction in heat rates
- ✓ Dramatic increase in Gas Turbine output
- ✓ Closest return to design back pressure possible
- ✓ No requirement to remove other contractors from the HRSG unit
- ✓ Scaffold required ensuring complete cleanliness allowing for borescope inspection of each level of the HRSG

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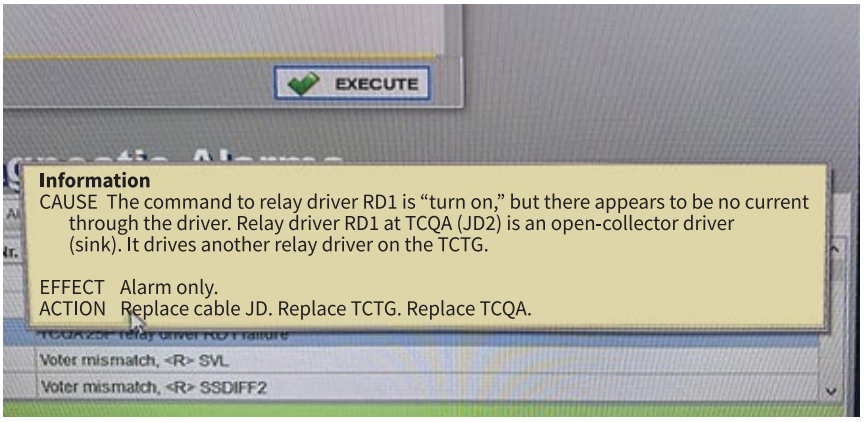


**3. Operators efficiently troubleshoot** Mark V alarms using advanced tools and user-friendly interfaces with files, such as Help.QD

obsolescence, single-point-failure risk, and limited forward compatibility, this PLC should be replaced. The latest product offering from GE was selected and a fully redundant RX3i PLC was installed by Innovative Werks in fall 2019 (Fig 1 right).

*HMI upgrade*. The site's OEM Cimplicity HMI servers were a major point of concern when assessing overall reliability, cybersecurity, and functionality of the turbine control system. Continued hardware issues required extensive man-hours for monthly server backups and re-boots to prevent server and ARCnet lockups. Plus, the Windows XP platform had long been obsolete, increasing cybersecurity vulnerability.

Additionally, the existing system had only one Mark V server in the control room and one in Unit 2's packaged electrical and electronics control center (PEECC), limiting access to logic forcing, signal name, and TC2K reports, as well as to more advanced Mark V engineering and diagnostic tools.

Crete contracted TTS Energy Services to install a redundant server TMOS HMI system in May 2020. The Traffic Management Operating System eliminated a large portion of the existing ARCnet network and replaced it with a fiberoptic/ethernet communications ring, removing a costly and long-lead-time failure point from the control network (Fig 2). Recall that Cimplicity HMI ARCnet cards are proprietary and difficult to source.

This system also did not require any modification or head-end upgrades to the Mark V control panels, making it a very cost-effective solution. The new network topology includes a client HMI workstation in each of the plant's four PEECCs and the control room, giving technicians full access to the Mark V control screens and engineering tools in all locations.

Easier access to dynamic point logic, trends, and signal names/values directly from the control screen provides a more intuitive operator interface, allowing for reduced troubleshooting time during abnormal plant operating events and a more simplistic training process. It also provided the site with state-of-the-art Windows Server 2019 and Windows 10 operating systems. Continued patching and Windows support for these machines allow Crete to maintain a high cybersecurity standard on the controls network.

**Results**. While each of the aforementioned projects individually would have had a positive impact on the lifecycle of the existing Mark V control system, Crete has seen marked improvements in hardware reliability and system functionality after implementing the full program. Mark V card replacements, when required, typically are done proactively, rather than reactively.

Operators are able to efficiently troubleshoot Mark V alarms using advanced tools and user-friendly interfaces with files such as Help.QD (Fig 3) and direct click access to dynamic logic rungs. Technicians learning Mark V can be trained on specific tasks with ease, removing the tedious and time-intensive process of learning and perfecting the exact syntax and terminology used in command prompt.

Additionally, the TMOS came equipped with a historian, giving personnel access to higher-resolution operating data without requiring a View 2 file to be running to capture operating events.

With the process improvements described, and with resources in place, site personnel are confident they can continue reliable and sustainable operations with the Mark V control system for many years to come.

**Project participants:**
Brad Keaton, plant manager
Joe Albers
Mike Viater
Ryan Lowther

# LED lighting upgrades make for safer maintenance, operation

**Challenge.** With a staff of three, the Crete site continuously explores methods for optimizing maintenance activities and eliminating high-man-hour tasks that don't directly contribute to the site's high standard for safety, reliability, and availability. While evaluating the facility's equipment condition and the man-hour contribution of different systems, staff determined that a significant amount of time was being spent on changing MCC indicator lights and fluorescent building lights. Plus, a man-lift rental was required annually for street-lamp replacement.

Constant lighting failures also presented a safety concern, because failed indicator-lamp sockets can cause confusion on equipment operating status. Plus, plus, ergonomic constraints for replacing other fixtures increased hazard exposure. Considering these issues, as well as the potential to improve energy cost efficiency and reduce hazardous waste generation, plant personnel pursued an alternative, and simple, solution.

**Solution.** Advances in LED lighting technology afford industrial facilities the opportunity to upgrade lighting cost-effectively. Plant personnel researched product offerings and found solutions for the majority of the site's lighting fixtures. Outdoor high-intensity-discharge (HID) lamps were replaced with LED equivalents expected to reach more than 94,500 hours of useful life with vastly improved light dispersion and output (Fig 4).

MCC indicator lights and sockets in the PEECCs were replaced with relampable LED fixtures that have a much brighter display and required no modifications to wiring or bucket mounting (Fig 5). The control building, switchgear building, PEECCs, generator breaker cabinets, and accessory gears all were retrofitted with LED lighting solutions over the last three years (Fig 6).

Today, the only remaining non-LED lights onsite are the turbine-compartment and fuel-gas-module lamps because there are relatively few product offerings that can withstand the operating conditions and/or

**4. Street lighting improved dramatically** with the switch to LED (right)

**5. MCC indicator lights** and sockets in the PEECCs were replaced with much brighter, relampable LED fixtures. No mods to wiring or bucket mounting were required

**6. Control building** looks like a new facility following the switch to LED lighting technology

regulatory requirements for hazardous atmospheres.

**Results.** After the lighting upgrades, the man-hours required to replace failed lighting has been reduced from about 200 hours annually to fewer than 20. Hazardous waste generation related to lighting (as well as universal waste from ballasts) has virtually been eliminated because all remaining non-LED fixtures are incandescent bulbs. The improvements to site safety also are notable, as better work-area lighting and reduced hazard exposure are in line with Crete's commitment to employee safety and continuous process improvement.

**Project participants:**
Joe Albers, Mike Viater,
Ryan Lowther, Kevin Bray
Neil Schultz, Mike Yankovich

# Frame 6B Users Group™

Welcome back to in-person conferencing.

You probably remember that the Frame 6B Users Group conducted a virtual meeting last year on the first three Tuesdays of May, from 10 a.m. to about 2 p.m. Owner/operators unable to participate in that event on one or more days can catch up by listening to the recorded sessions available at www.powerusers.org. These include the compressor, I&C, combustion, and turbine roundtables; GE Day sessions; and technical presentations by AGT Services, GTC Control Solutions, National Electric Coil, and PSM.

Even if you attended the 2021 conference, a video review of selected sessions is a good way to prepare for this year's meeting at the San Antonio Marriott Rivercenter, August 29 through September 1. User groups for the other legacy GE frames—7EA and 5—will be sharing the venue, with the three organizations meeting concurrently, each in its own room. Meals and vendor fair will bring all attendees together.

As the ad on pages 92 and 93 shows, four other user groups in the Power Users family (p 95) also will be meeting at the same time: Combined Cycle (CCUG), Generator (GUG), Steam Turbine (STUG), and Power Plant Controls (PPCUG). A Frame 6B registration allows your participation in any group's meeting at any time. You can't beat that benefit.

**The 2021 conference** began with a compressor roundtable, chaired by J C Rawls, BASF's Utilities Dept technology engineer at the company's Geismar (La) facility, home to two gas-fired 1 × 1 Frame-6B-powered cogeneration units. You won't find Rawls name on the steering-committee lineup on p 77 for the first time in a decade because the 33-year industry veteran is retiring just prior to the 2022 meeting.

His loss will be significant, especially given Rawls' boiler and related controls expertise, which he has generously shared over the years with fellow users at 6B meetings and in the pages of CCJ (p 88).

The recorded compressor roundtable has value beyond keeping you informed. The well-organized program can do double duty as a training aid for new hires given its coverage of filter selection, safety, options for conditioning inlet air to boost output, value of inlet bleed heat, calibration and maintenance of inlet guide vanes, details on rotor components and extractions, etc. Here are some specific take-aways to support that thought:

- Hydrophobic HEPA filters are recommended for top engine performance. The session leader reminded that a Frame 6B operating baseload ingests well over 1-million lb/hr of air, so even a small amount of fine particulate matter entrained in inlet air adds up quickly.
- A compressor kept clean year-round without washing minimizes performance loss for the entire run cycle, virtually eliminating the cost of demineralized water and soap for washing, as well as any expense and permitting associated with wastewater disposal. But before stopping online water washes, be sure your compressor blades are not susceptible to pitting from corrosive deposits.
- Fogging likely is the fastest way to boost output, provided atmospheric conditions are right. When considering a retrofit be sure to conduct a rigorous system evaluation: The added water could loosen years of dirt from silencers, sidewalls, etc, which would foul the compressor quickly and *reduce* output.

Be sure to seek advice from experienced colleagues. Example: Special consideration must be given to must-run baseload units in process plants because you can't shut down to wash the compressor and an online wash is not as effective as offline cleaning.

**I&C.** The steering committee's Mike Wenschlag followed Rawls. The I&C roundtable that he chaired dug into key challenges of the several GE control systems associated with this frame—from the Mark IV through the latest version of the VIe. These included specific issues, support, and upgrades, plus a review of controls related Technical Information Letters from the OEM (TILs 2081, 2082, 2086, 2095, 2110, and 2134), LVTDs, servos, gas valves, and DLN tuning.

Wenschlag used Power Users' polling capability several times during his stay in the control center (the "podium" for virtual meetings) to share current information of value among the participants.

The chairman, who recently completed 32 years of service at Chevron's El Segundo (Calif) Refinery, told participants that company personnel do most of the controls support work required at his facility; however, OEM or third-party support may be called on periodically. A lesson learned that he shared: Upgrading from a Mark IV to Mark VIe control system is a big undertaking that requires careful planning and significantly more space than the original installation.

J C Rawls

Regarding servos, Wenschlag said that over the years his plant went from no spares on hand, to periodic replacement, to service on demand after replacement with a spare from the warehouse. He added that servos and LVTDs might be different for different systems and users should be mindful of that when ordering spares and when retrieving them from the warehouse.

An attendee reported that the changing composition of natural gas in the pipeline serving his plant can impact fuel valve operation because of sulfur deposits. Valves must be cleaned periodically. Another participant concurred, suggesting a baby-bottle cleaner with an appropriate spray is good for this purpose.

**The combustion-section** and turbine-section roundtables, chaired respectively by steering-committee members Robert Chapman, a senior repair optimization engineer for Chevron, and Zahi Youwakim, a principal engineer for Indorama Ventures, were conducted on the final day of the 2021 meeting. Both slide decks, like those prepared by Rawls and Wenschlag, are excellent training aids. CCJ

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# BASF Geismar

## Increasing the reliability of boiler drum-level controls

**BASF Geismar**

*BASF Chemical Co*

85 MW, gas fired, two 1 × 1 Frame 6-powered cogeneration units (one with an unfired HRSG, one fired) plus four conventional boilers and one small steam turbine/generator, located in Geismar, La

**Plant manager:** Graham White

**Challenge.** Most drum-level control systems employ 3-element logic, with feedback to the controller on drum level, steam outlet flow, and feedwater inlet flow. Data provided by pressure and temperature transmitters are used to enhance the accuracy of the steam-flow value. To illustrate: If the drum-level instrument is a dP-style level transmitter, a pressure transmitter is installed on the drum to provide the data necessary to make the density correction needed for accurate level calculations.

Thus, the term "3-element control" is somewhat misleading because it involves a minimum of six instruments—boiler feedwater (BFW) flow, steam flow, steam temperature, steam pressure, drum level, and drum pressure—for controlling the drum level.

And it is likely that more than one drum-level instrument is used. Many boilers have two drum-level instruments and control using the average value of the two. However, if one instrument goes bad the average value will be inaccurate. With two conflicting readings, how does one know which is the more accurate?

If any one of the instruments fails, particularly one of the main instruments (steam flow, BFW flow, drum level), the control system will not work. If any one of the supporting instruments fails (drum pressure, steam pressure, steam temperature), the control system may still work but it will be compromised.

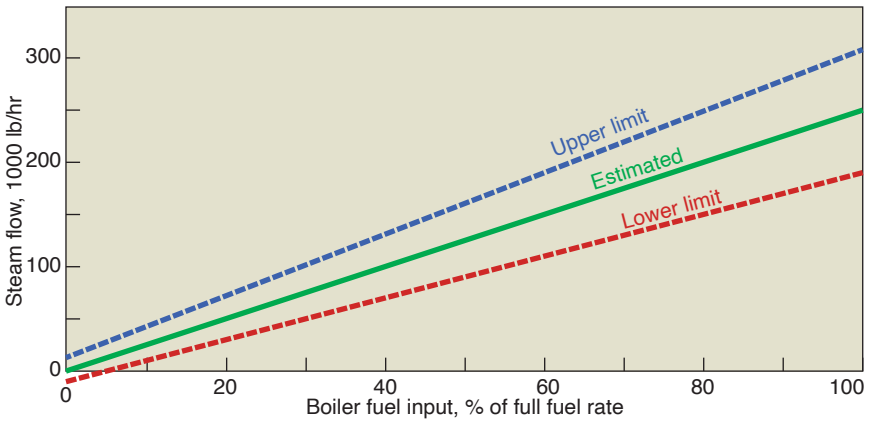
Occasionally, Geismar's steam flowmeter would fail. If it failed high, the signal sent to the drum-level controller would result in too much BFW flow, leading to carryover. If it failed low, there was a risk of BFW flow being reduced to the point of tripping the boiler on low drum level.

Similarly, if the BFW flow transmitter failed high or low, this inevitably would lead to high drum level and carryover or a low-drum-level trip.

Depending on your specific programming logic, some instrument failure scenarios will default the drum-level controller to manual. Geismar boilers had two level transmitters. If they disagreed by more than 4 in., the level controller would default to manual. This usually would occur when the level control valve already was open or closed too much, leading either to a carryover event or trip because of low drum level. The operator then would have to control the drum level manually and not have the option of returning the control to automatic.

During an unusually cold period one recent winter, the drum pressure transmitter froze and its milliamp signal went so high it caused an instrument input/output (I/O) error; the level control system defaulted to manual. Even if the drum pressure transmitter were wildly inaccurate, it generally would result in a drum-level measurement error of only a few inches, which is preferred over a default to manual. When the system defaulted to manual the drum level likely would get out of control and the unit would trip.

**Solution**. Given the drum-level measurement challenges, a third independent level instrument was installed—one using guided-wave radar technology. Having three level measurements available, control was changed from using the average of two level-instrument values to using the median value of all three instruments. If one went bad, the control system would continue without a hiccup; only if two instruments failed simultaneously would the level reading be impacted.




**Visual representation** of estimated steam production versus boiler fuel input

Regarding steam-flow measurement, Geismar uses a verification system to check reading accuracy. By modeling steam flow versus other operating parameters, staff can predict accurately what the steam flow should be. If measured steam flow varies from the predicted value by too much, the drum-level control system alarms and the predicted steam-flow value is used in place of the measured value.

For the plant's conventional fired boilers, steam flow can be predicted accurately using fuel flow (figure). For

the cogen unit with the unfired HRSG, steam flow is predicted based on gas-turbine output (megawatts), and for the cogen unit with the fired HRSG, on a combination of gas-turbine output and fuel flow to the duct burner.

All of these calculations are made by the DCS. So, it makes no difference if the steam-flow measurement is the result of a problem with the flow, pressure, or temperature transmitter because the predicted steam-flow value is close enough for the system to continue accurately controlling drum level.

Regarding the BFW flowmeter, this instrument is the most critical in the drum-level control scheme because the drum-level control is actually feedwater control used to regulate drum level indirectly. Geismar installed logic that monitors the difference between the measured feedwater flow and the feedwater flow setpoint. This difference normally is very small. A large difference indicates a problem (either measurement error or feedwater valve issue) and the control scheme would transition from a 3-element arrangement to single-element (drum level), thereby removing the faulty feedwater reading from the control scheme altogether.

For the drum pressure transmitter, staff removed the "default-to-manual" logic that occurred when an I/O error was received, defaulting the drum-pressure reading to a constant value typically seen during normal operations.

**Results.** The site lost all six of its steam producers (two cogen units and four conventional boilers) during a very hard freeze in January 2018. Reason: Low drum levels caused by a combination of the failure scenarios described above—inaccurate steam-flow measurement, inaccurate BFW flow measurement, and controller default to manual attributed to failed instruments.

Following the freeze event, the changes noted above were made and deficiencies in the heat-trace system were corrected. Since that time, the boilers have successfully weathered instrument failures on the steam-flow reading, drum-pressure measurement, and drum-level measurement.

A few instruments were affected during the hard-freeze event in February 2021, but the improvements made were sufficiently robust to keep all steam producers in service.

**Project participants:**

J C Rawls, Utilities Dept technology engineer

Troy Braud, Utilities Dept DCS programmer

# FRAME 5 Users Group

You may recall the enduring slogan for Timex wristwatches introduced in the 1950s: "It takes a licking and keeps on ticking." In the electric power industry, something similar could be said for the iconic Frame 5: "It takes a licking and keeps on running." The first engine in the seemingly ageless Frame 5 series of gas turbines shipped from GE's Schenectady shop 65 years ago (tables); some of the very early units still are operating.

To date, industry experts say, well over 3000 of these machines have been assembled by the OEM and its manufacturing partners and shipped in both single- and two-shaft versions for electric-generation (50 and 60 Hz) and mechanical-drive applications. Units in generation service are found in simple-cycle, cogeneration, and combined-cycle facilities. They are installed both onshore and offshore (on oil rigs and power barges, for example) and may be equipped for burning oil or gas only, or both fuels.

Owner/operators of this frame essentially have been underserved by the user community for years, the many forums organized in the last three decades typically focusing on a single late-model engine to share experiences, thereby helping the OEMs correct design deficiencies and improve their products.

But Power Users recognized the need to start a group dedicated to this engine because of its value in today's world for "chasing the wind" and other intermittent functions—especially given the rapidly declining number of O&M personnel with meaningful Frame 5 experience.

CCJ contacted several industry experts to provide a snapshot of this eclectic fleet to help you navigate the conversation at the group's first annual meeting in San Antonio at the end of August.

First, the naming convention: the Frame 5 is shorthand for the MS5001 (a/k/a Fr5, 5/1), the single-shaft version of the machine for electric generation; the MS5002 is the two-shaft version typically used to drive compressors and pumps.

Note the reference in Table 1 to the R-N/T and P-N/T models—still offered. These units typically are referred to as 51PA and 51RA engines, both of which can be upgraded with the company's performance enhancement kit (PEK) to produce about 4% more power or to extend the maintenance intervals. Major inspections are now possible on a 70,000-hr interval, liner and transition-piece inspections on a 35,000-hr interval.

Some facts that might help you better understand why there are so many different models in this fleet:

- GE stopped making gas turbines in Schenectady in 1987; however, several P-N/T and MS5002C units were made in Greenville until the mid-1990s. Note that the model designations for the 5/2 differed from those in Table 1 for the 5/1. The five models for this frame are A, B, C, D, and E.
- When GE purchased Nuovo Pignone in 1995, manufacturing of the 5/1 and 5/2 was transferred to Florence, Italy, where the focus has been on the two-shaft machine.
- Several GE business associates made MS5001P units until 2000. That year, GE bought John Brown Engineering and European Gas Turbines/AEG Essen and shut them down. GE also canceled its manufacturing agreement with Thomasson, leaving NP sole responsibility for the Frame 5.
- Of the 2500 5/1 units built, one expert believes GE uprated about 200 with N/T parts. Several dozen new engines also have been shipped with the N/T uprate.

## Table 1: Frame 5 data have changed significantly over the years

| Model MS5001 | Years shipped | Output, MW[1] | Firing temp, F | Exhaust temp, F | Heat rate, Btu/kWh[2] |
|---|---|---|---|---|---|
| A | 57-61 | 12 | 1500 | 840 | 15,810 |
| C | 61-64 | 12 | 1500 | 835 | 15,810 |
| D | 61-63 | 12 | 1500 | 834 | 15,810 |
| E | 63 | 12.9 | 1500 | 830 | 15,780 |
| G | 63-64 | 13.4 | 1500 | 830 | 15,120 |
| H, J | 64 | 14 | 1500 | 820 | 14,430 |
| K | 65 | 14 | 1500 | 820 | 14,430 |
| L | 66-67 | 15.7 | 1600 | 895 | 14,440 |
| LA | 68-70 | 17.1 | 1650 | 930 | 14,190 |
| M | 69-70 | 18 | 1700 | 965 | 14,050 |
| R | 70-87 | 19.4 | 1720 | 955 | 13,260 |
| R-N/T[3] | 87-?? | 20.5 | 1755 | 970 | 12,780 |
| N | 70-72 | 24.6 | 1730 | 898 | 12,190 |
| P | 72-78 | 24.6 | 1730 | 904 | 12,140 |
| P | 78-86 | 23.4 | 1730 | 901 | 12,020 |
| P-N/T[4] | 87-?? | 26.8 | 1765 | 905 | 11,860 |

[1]All ratings based on natural gas fuel [2]Based on fuel's lower heating value [3, 4]In 1987, the HGP of both the P and R turbines was updated and the models renamed PA and RA, respectively. Those models are called P-N/T and R-N/T when they are the result of an aftermarket uprate (N/T means new technology) Source: GER-4196

## Table 2: Physical characteristics of Frame 5 components

| Model MS5001_ | Compressor, No. of stages | Turbine, R1 wheel type | Turbine, R2 wheel type/diam | HGP technology | R2 buckets, type | Turbine speed, rpm |
|---|---|---|---|---|---|---|
| A-K | 16 | Old | Old/large | Pre-old tech | Tie-wire | 4860+ |
| L, LA, M | 16 | New | New/large | Old tech | Tie-wire | 5100 |
| M prime | 16 | New | New/large | Old tech | Tip shroud | 5100 |
| M, N/T | 16 | New | New/large | New tech | Tip shroud | 5100 |
| R | 16 | New | New/small | Old tech | Tip shroud | 5100 |
| RA (N/T) | 16 | New | New/small | New tech | Tip shroud | 5100 |
| N, P | 17 | New | New/small | Old tech | Tip shroud | 5100 |
| PA (N/T) | 17 | New | New/small | New tech | Tip shroud | 5100 |

Source: GER-4196

## Table 3: Frame 5 control system history

| System | Years |
|---|---|
| Fuel regulator | Before 1970 |
| Mark I | 1968-1975 |
| Mark II | 1974-1980 |
| Mark III | 1978-1985 |
| Mark IV | 1983-1993 |
| Mark V | 1992-2003 |
| Mark VI | 1999-2008 |
| Mark VIe | 2004-20?? |

## TURBINE TIPS, No. 17 in a series

# When referring to gas-turbine components, use their correct names to avoid confusion

**By Dave Lucier,** PAL Turbine Services LLC
www.pondlucier.com

*Turbine Tip No. 17 from the PAL solutions library applies to all models of legacy GE gas turbines.*

Components and auxiliary systems for GE gas turbines have specific names. It is important to use correct names when communicating with the manufacturer or service companies to be sure you're understood. For some, it may be like learning to speak a new language, which can be called "GE-ology."

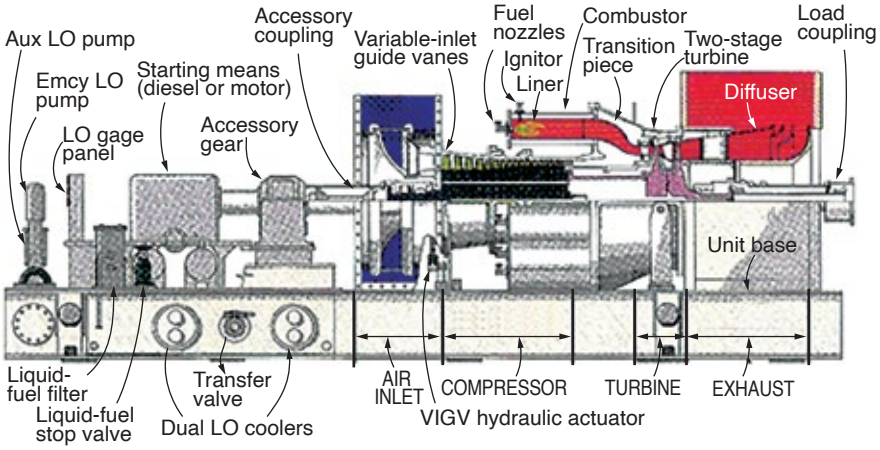
In 1961, GE introduced the gas-turbine Packaged Power Plant (PPP). According to industry records, the first such unit was installed at a facility owned and operated by South Carolina Electric & Gas. Other units soon followed for Central Vermont Public Service and Long Island Lighting. The first PPP from GE was the MS5001—a/k/a Frame 5.

The model series (MS) was named the 5001D, with the number "1" for single-shaft. It was sometimes referred to as a Frame 5D in the evolution. When introduced, the engine was designed to produce 12 MW, a rating that prevailed throughout the first half of the sixties. This peaking model preceded the Great Northeast Blackout of Nov 9, 1965, when the entire Northeast Seaboard went dark for approximately 12 hours.

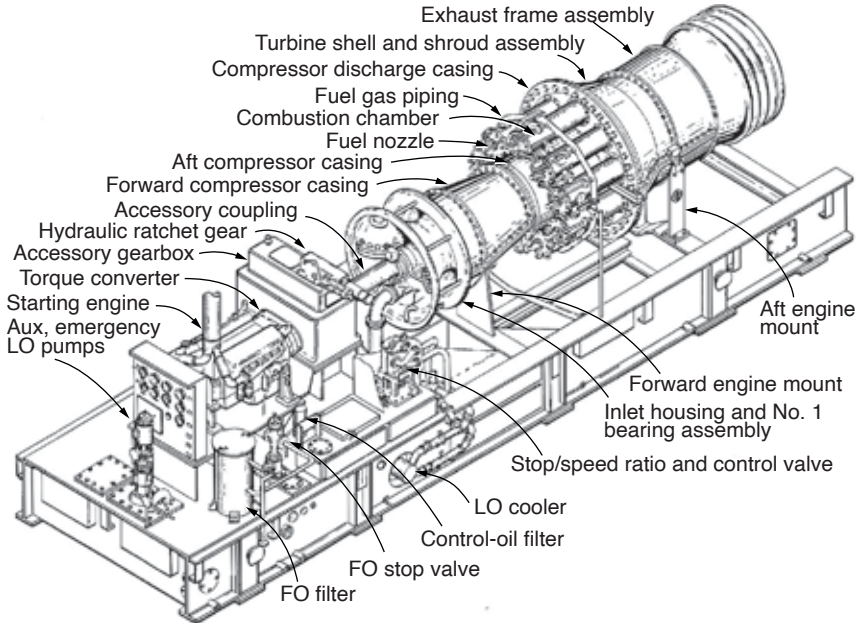
During the second half of the decade, demand for emergency power was unprecedented. Investor-owned electric utilities and municipalities—including such behemoths as Chicago's Commonwealth Edison, Washington's Potomac Electric, Detroit Edison, San Diego Gas & Electric, and Consolidated Edison Co of NY—placed orders for dozens of PPPs.

The PPP design had most of the auxiliary fluid systems located on the accessory base with the goal of minimizing installation and startup times. It included the following:

- Accessory gear with water, oil, and fuel pumps, and atomizing air compressor.
- Lube-oil (LO) tank integral to the I-beam base with oil pumps, coolers, filters, pressure regulators, etc, inside the base or above it.
- Hydraulic supply system using lube oil to provide high-pressure fluid for operating servo valves and the ratchet rotor-turning device, and for enabling clutch engagement. Earlier systems for clutch operation, diesel actuation, and ratchet engagement relied on high-pressure air.
- Fuel system components also atop the base included the following:
  - Liquid-fuel pump and flow divider.
  - Gas-fuel stop and flow-control valve.
  - Cooling water system installed in the roof with radiators and fin-fan drive.
  - Starting device (diesel engine or cranking motor) was on-base with jaw clutch.




**1. MS5001 gas turbine** (right-side view) identifies auxiliaries and their locations on the accessory base and turbine base




**2. Isometric view** of the engine in Fig 1 showing on-base auxiliaries

**Side notes:**

1. The liquid-fuel forwarding skid and fuel tank were installed off-base.

# 2022 Annual Conferences

COMBINED CYCLE USERS GROUP

GENERATOR USERS GROUP

POWER PLANT CONTROLS USERS GROUP

STEAM TURBINE USERS GROUP


## August 29 – September 1, 2022

### San Antonio Marriott Rivercenter
### San Antonio, TX

POWER USERS

powerusers.org

# First Legacy Turbine Users Annual Conference


**Seven Individual User Group Conferences…**
**Same Dates, Same Location…**
**Shared Meals and Vendor Fair**
**These conferences will be co-locating only for 2022.**

Check for updates on the Power Users website.

2. On-base auxiliaries facilitated operational testing at the GE factory in Schenectady, NY, where all Frame 5s were run up to 100% rated speed on liquid fuel using test-stand controls.
3. Once the test data at full speed/no load (FSNL) were recorded, compiled, and analyzed, results could be "extrapolated" to determine if the turbine was acceptable for shipment. The data were used to "predict" that the unit would achieve baseload operation when coupled to a generator or compressor at the installation site.

Fig 1 presents the right-side view of a gas turbine showing its auxiliaries and their locations on the accessory and turbine base. Fig 2 provides an isometric view. Most everything needed to operate the turbine is tagged. Some of the components not visible in Figs 1 and 2 include the fuel pump, 12-position fuel pressure selector valve and gage for each combustor, and liquid-fuel flow divider. Other devices that would be installed on the gas turbine include two compressor bleed valves, two igniters (a/k/a sparkplugs), and ultraviolet flame detectors.

Given the availability of a cured concrete foundation onsite, PPP installation typically took less than two months. Bear in mind that this was the first time the gas turbine was "introduced" to its generator, load gear, control cab, generator breaker, and protective devices—all manufactured at GE facilities in other cities.

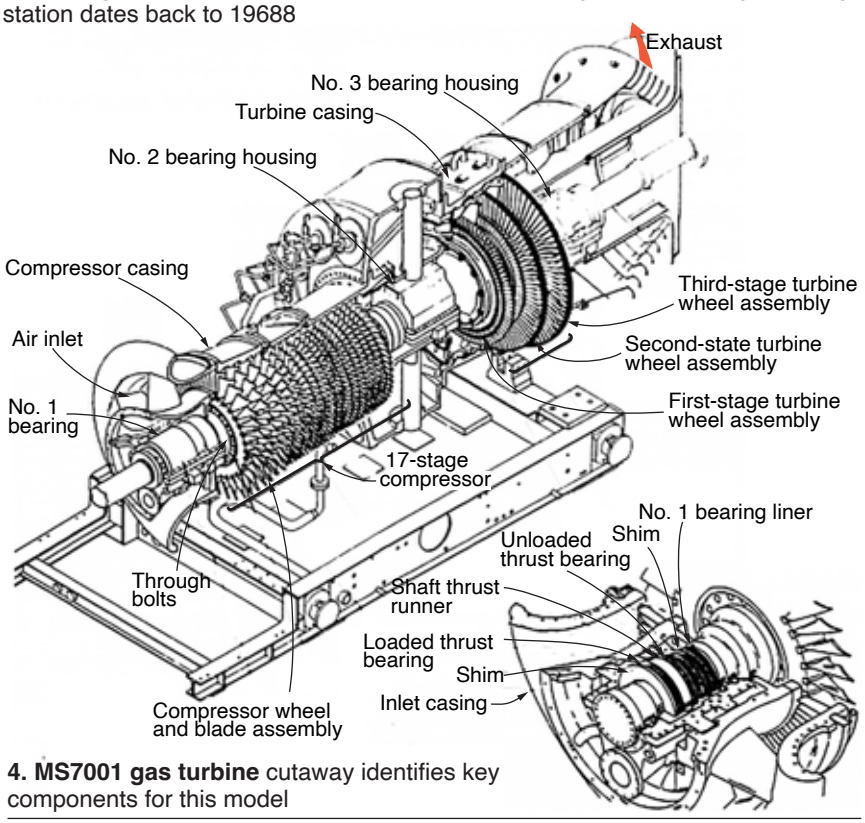
A typical PPP (Fig 3), installed at a Pennsylvania Power & Light site, shows the accessory base (left), gas turbine and exhaust (center), and generator (far right). This configuration of major components prevailed for over 50 years in the design of most GE Frame 5 and 6 gas turbines—even those installed inside buildings.

Owner/operators of early Frame 7 engines are referred to Fig 4.

In summary, it is recommended that readers who want to learn to communicate fluently in GE-ology should learn and use the given names. This backgrounder most certainly will benefit participants in the upcoming first annual meeting of the Legacy Turbine Users Group, at the San Antonio (Tex) Marriott Rivercenter, August 29-September 1. Avoid missing key points during presentations and discussions because you don't understand the lingo.

The latest details on this seminal event are available at www.powerusers.org. CCJ

**3. Package Power Plant** powered by an MS5001L engine at a utility generating station dates back to 19688




**4. MS7001 gas turbine** cutaway identifies key components for this model

## International Association for the Properties of Water and Steam

**IAWPS** is a global non-profit association involving 25 countries in all aspects of the formulations of water and steam and seawater, as well as in power-plant cycle chemistry. It provides internationally accepted cycle-chemistry guidance for power generation facilities in Technical Guidance Documents freely downloadable from the organization's website at www.IAPWS.org. Specific TGDs for combined-cycle/HRSG plants include the following:

- Procedures for the measurement of carryover of boiler water into steam.
- Instrumentation for monitoring and control of cycle chemistry.
- Volatile treatments for the steam-water circuits of power plants.
- Phosphate and NaOH treatments for the steam-water circuits of drum boilers.
- Steam purity for turbine operation.
- Corrosion-product sampling and analysis.
- HRSG high-pressure evaporator sampling for internal deposit identification and determining the need to chemical clean.
- Application of film-forming amines in power plants.

**Power Users is the umbrella organization for managing and coordinating the technical programs for the industry's leading User groups**


## Conferences

Visit https://www.powerusers.org/home/annual-conferences/ for the most updated conference dates for each group.

## Forums

Visit https://www.powerusers.org/forum/ for a full list of User Group discussion forums. Users must be logged in to have access to the forums.

Power Users Group is a non-profit company managed by Users for Users. It is designed to help Users share information and get solutions to power-production problems.

**www.PowerUsers.org**

# FFS of increasing importance to plant operators

Film forming substances can protect metal surfaces in powerplant steam/condensate and cooling-water systems against corrosion and other degradation mechanisms, making this relatively new branch of cycle chemistry of increasing importance to owner/operators. There have been some noteworthy success stories to date, but much more research is necessary before the use of these chemicals becomes commonplace.

The fifth annual FFS International Conference in March 2022, a virtual event co-chaired by Barry Dooley of Structural Integrity Associates (UK) and David Addison of Thermal Chemistry (New Zealand), brought engineers and scientists worldwide up to date on the accelerating progress in understanding and applying FFS.

The meeting, dedicated to advancing the knowledge of, and introducing the latest science about FFS, attracted a record 146 participants from more than 30 countries. Fifty plant operators/users and 11 chemical suppliers attended. FFS conferences are developed and supported by the International Association for the Properties of Water and Steam; please visit www.iapws.org.

Recall that FFS consist of two main categories of chemicals using the following internationally accepted nomenclature: Amine-based (FFA, film-forming amine, and FFAP, film-forming amine product) and non-amine-based (FFP, film-forming products). The latter group is comprised of proprietary compositions.

Some highlights of FFS2022 follow. Details of presentations and discussions of interest to owner/operators of plants powered by gas turbines will be published in the next issue of CCJ (No. 71).

- Daily introductions for the conference identified the wide range of FFS products and mixtures available from at least 11 vendors globally, making research, derivation of common guidance, and solutions difficult. The many products available also calls into focus the need to research the properties of absorbed films so operators know what must be done to change FFS products, if necessary.
- Several presentations provided key insights on using photoelectron spectroscopy (XPS) to prove the presence (but not the continuity) of films, with the potential to move away from today's standard hydrophobicity tests. Experts say this would benefit tube sampling and analysis significantly, provided it works in real operating environments.
- Film formation remains questionable in dry-steam areas. Plus, it is unlikely that an FFS film can form and exist at steam temperatures above 600C.
- Discussion initiated in previous meetings continued on the lack of understanding on the effect FFS have on the oxides that grow in steam circuits, and on the chromia oxide that forms in the phase transition zone (PTZ) of the steam turbine.
- Laboratory experiments provided positive results regarding the reduction of single- and two-phase flow-accelerated corrosion (FAC) using FFS containing ODA (octadecylamine) and OLDA under realistic plant feedwater conditions of between 150 and 165C at pH 9.2.
- The reduction of two-phase FAC in air-cooled condensers by FFS application has been validated by visual observation.
- There was special mention of the IAPWS Technical Guidance Document TGD8-16(2019), "Application of Film Forming Substances in Fossil, Combined Cycle, and Biomass Power Plants," in terms of the processes that should be adopted before application of an FFS to any plant. Attendees were referred to Sections 8 and 9 of this document, in particular.
- Attendees were told that problems still are occurring in a few plants following application of an FFS where there were no pre-application chemistry reviews of corrosion-product transport and deposition levels in fossil-fired boiler waterwalls and in HRSG HP evaporators.

  Examples of problems identified included the following: increased levels of internal deposits, boiler/HRSG tube failures (especially under-deposit corrosion), and formation of "gunk" (gel-like deposits) on heat-transfer and drum surfaces and in steam turbines. These problems are considered in need of further definition.
- Several presentations discussed the effect of FFS on online instrumentation, decomposition/breakdown products of FFA, thermolysis and distribution of FFA, adsorption kinetics of film formation, and ion-exchange resins.

Members of the FFS steering committee (https://filmformingsubstances.com) are Dooley, Addison, Matt Harris of AGL Energy (Australia), Christophe Wesoluch of EdF (France), Roy van Lier ofYara Nederland, Keith Fruzzetti of EPRI, Jörg Fandrich of Framatome (Germany), and Marion Roy of SECR CEA (France).

Mark your calendar: FFS2023 will be held next March in Florence, Italy. CCJ


**Pleasant Valley Generating Station**

*Great River Energy*

421-MW, dual-fuel, simple-cycle plant powered by two V84.3A2 and one 501D5A gas turbines, located in Dexter, Minn

**Plant manager:** Mike Herman

# Guided-wave radar improves accuracy of tank-level measurements

**Challenge.** Staff recently discovered that the 21-year-old nitrogen-bubbler tank-level gauging systems for Pleasant Valley's fuel-oil and demineralized-water tanks were obsolete. They were no longer supported by the manufacturer and parts were not available. There had been issues with these devices over the years, especially during extreme cold-weather events. During one polar vortex, for example, all indication of fuel-tank level was lost, temporarily disabling the plant from starting on the backup fuel.

**Solution.** A Rosemount rep came to the site and showed personnel the company's most accurate and robust tank-level gauging system; it uses guided-wave radar technology. Here's how it works: The device sends a low-energy microwave pulse down a probe. When the pulse hits the liquid in the tank, a significant proportion of the energy is reflected back up the probe to the device using the "time of flight" principle—similar to how dolphins use echolocation. System has an accuracy of ±0.12 in. and an operating temperature of from -320 to 752F.

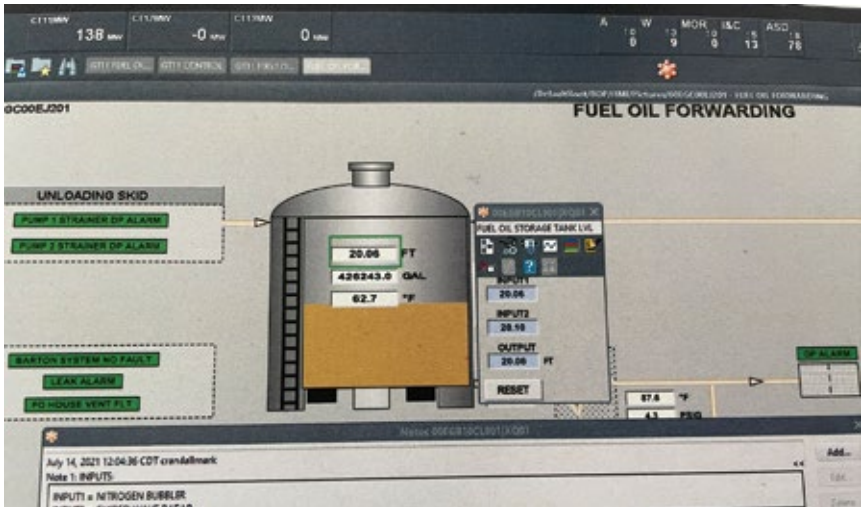
**1. Guided-wave radar** transmitters are located at the tops of the tanks

Guided-wave radar transmitters and control units were purchased for each tank. The latter provides a 4-20-mA analog signal to the plant control room. Staff mounted the transmitters at the tops of the tanks (Fig 1), installed conduit and cables to the control units, and then ran additional cables to spare analog input channels in the BOP control-system cabinet. Installation complete, personnel set up and calibrated the transmitters and worked with the gas-turbine OEM to add logic and graphics for displaying level data on the DCS (Fig 2).

Since the fuel-oil tank reading is especially important, the original level-measurement system was retained for the near term to provide redundancy. A new logic page was created with one-out-of-two selection on low input or a known satisfactory quality input. This way, if one value drops out or its quality is poor, system automatically reverts to the good-quality reading.

**Results.** Early experience with the new tank-level systems has been good.

**Project participants:**
Craig Birkett
Chuck Condon
Mike McVietty
Kevin Beske
Michelle Anderson




**2. Liquid level** is displayed on the DCS (left) and locally on the tank (right)

## Sensor technology for decarbonization

Riken Keiki Co announces that the OIML R140 Class A certified version of its OHC-800 calorimeter, which uses optical and sonic sensors to provide real-time monitoring with high accuracy, will soon be available for natural gas and natural gas plus hydrogen (up to 20% by volume).

Recall that competitor gas chromatographs can provide highly accurate analyses of fuel-gas composition but do not offer real-time monitoring. And while combustion-type calorimeters may offer real-time monitoring, they generally are not sufficiently accurate for process control.

With the OHC-800, measuring data can be updated every 0.25 seconds. Plus, response time to changes in calorific value is less than five seconds. The instrument is said to be virtually maintenance free with no sensor adjustment required and no need for regular replacement of parts and sensors.

However, if a part must be replaced, it's simple to do because the instrument has only four components: sonic sensor, optical sensor, main controller, and power supply. To learn more, use the QR code to access the 12-min recorded webinar produced by the manufacturer.

## TesTex offers inspection services for condensers as well as HRSGs

The TesTex name should be familiar to CCJ subscribers: The company advertises its HRSG tools and inspection services in every issue. For example, TesTex's "claw" is used to find tube-to-header weld cracking, its internal crawler to visually inspect tubes from the inside and measure wall thickness, and its scanning tool for measuring tube wall thickness from the outside.

But did you know that TesTex also provides systems and services for inspecting condenser tubes? The company offers two high-speed inspection systems, both designed for fully automated probe insertion in tubes up to 100 ft long using compressed air. Inspection using TesTex's TX-4400 eddy current system is conducted as the probe is extracted—by hand with the PD 6k™ system, automatically at the desired inspection speed with the PDP 22™ alternative.

The variable indexing capability of these intelligent products repositions the probe to inspect the next tube according to the sequence programmed into the TS-Map software provided. Up to eight tubes per minute can be inspected, based on a tube length of 30 ft. System accommodates tube ODs from 0.63 to 2 in. Please visit https://testex-ndt.com for more detail.

TesTex's inspectors, certified to ASNT SNT-TC-1A guidelines, analyze the incoming data in real time, allowing immediate retesting of suspect tubes to ensure an accurate analysis.

Finally, be aware that TesTex now operates an online store for easy ordering of inspection tools, eddy-current probes, etc. Orders typically are shipped on the day received.

**Technician uses TesTex's tools** to inspect powerplant condenser

## Cleaning, testing of condensers, heat exchangers

Conco's total performance platform is designed to increase the profitability, productivity, and reliability of power and process plants by using its cross-trained crews to both leak-test and clean condensers and heat exchangers. Access the short video (less than three minutes) to learn how Conco can help you improve efficiency, increase output, and reduce downtime.

## Going beyond monitoring with remote operation and support

This white paper from Mitsubishi Power, which can be accessed via the QR code, tracks the rapidly growing demand for remote technology—including early-warning diagnostics using advanced analytics, plus access to offsite technical expertise for troubleshooting and response. It walks readers through the company's considerable analytics experience, which began in 1999 with a remote monitoring center at Mitsubishi's extensive engineering and test facilities in Takasago, Japan.

Since that first step, digital solutions, like the company's growing Tomoni™ suite of offerings, allow O&M staffs to leverage the massive amounts of data from the thousands of sensors in a plant to provide valuable insights, solve complex problems, and maximize performance. Mitsubishi Power experts provide remote support to America's power and energy systems from the company's Tomoni Hub Analytics and Performance Center in Orlando.

Advancement through digitalization is a core focus of the paper, which includes experience gained when a scheduled plant outage was shifted because of the pandemic and condition-based maintenance intervals provided a pathway to success. Another sidebar presents the case history on how a Tomoni digital solution improved efficiency by enabling a process to actively optimize the flow of gas-turbine cooling air.

## Stop varnish from interfering with plant operations

Chevron explained to the editors that its VARTECH™ solution incorporates new technology capable of delivering a simple two-step approach to varnish control.

Step One is to clean your lube-oil system with VARTECH Industrial System Cleaner (ISC), which is compatible with most mineral-oil-based turbine lubricants.

Step Two is to refill the system with GST Advantage® turbine oils, formulated with VARTECH technology to control the early precursors of varnish.

Scan the QR code with your smartphone or tablet to get the details.

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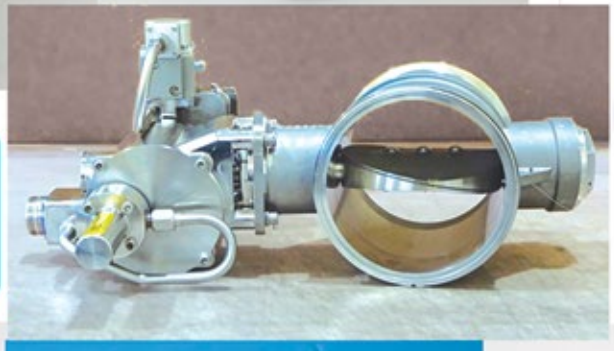


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# KinetiClean

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to clean a HRSG

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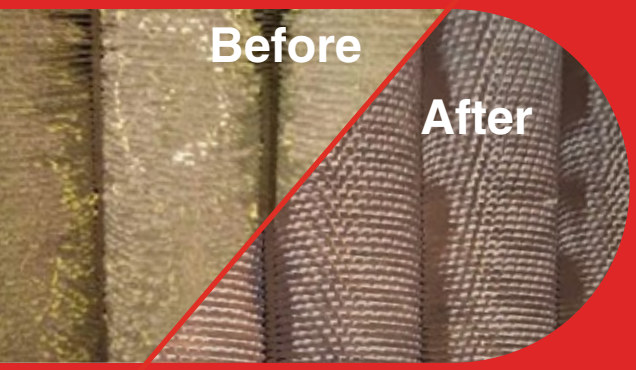
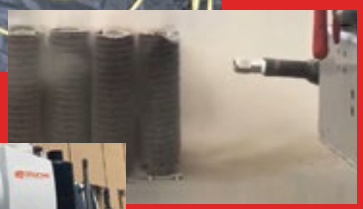
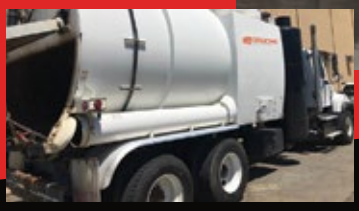
of any method currently used to clean HRSG fin tubes.





**Groome's patented technology uses a proven Kinetic Shockwave cleaning method to remove unwanted foulant. An innovative and automated air system then distributes high-pressure, high-volume air to liberate remaining debris.**

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- **Minimal-to-no scaffolding**
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- **No additional moisture**
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