- Gas Turbines
- Steam Turbines
- HRSGs
- Generators
- Controls
- Auxiliaries

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AERO O&M FOCUS

WTUI
LM2500
LM5000
LM6000
LMS100
Long Beach, CA
March 30 – April 2

FT8 USERS GROUP
www.FT8users.com
Charlotte, NC
March 18-20

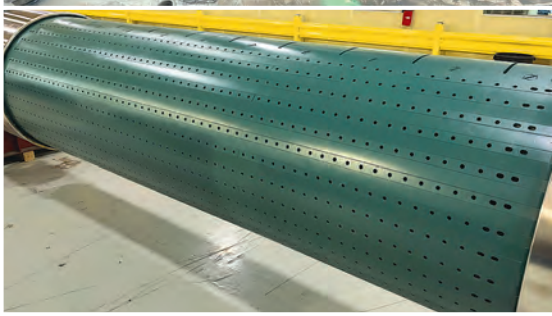
Features

7HA CCGTs claim Best of the Best

HRSGs

Everything else

Generator Isomode Pad Replacement



Read this case study at www.MDAturbines.com/Pad

MD&A experts performed a generator life extension project. The complete 7A6 generator isomode pad replacement included a stator rewind, field exchange, and removing and reinstalling the totally enclosed water-to-air cooled (TEWAC) assembly.

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Gas Turbine Users' Conference Calendar

March 18-20
FT8 Users Group

Second Annual Meeting, EPRI Campus, Charlotte, NC.
Details/registration at www.FT8users.com as they become available.
Contact: Ashley Potts, ft8@ft8users.com

March 30-April 2
Western Turbine Users Inc

35th Anniversary Conference and Expo, Long Beach, Calif, Long Beach Convention Center. Details/registration at www.wtui.com.
President: Ed Jackson, Missouri River Energy Services.
Contact: Charlene Raaker, conference registration coordinator, craaker@wtui.com

May 13-15
European HRSG Forum (EHF)

11th International Conference, Monash University, Prato, Italy. Details/registration at https://europeanHRSGforum.com.
Chairman: Barry Dooley, Structural Integrity Associates (UK).
Contact: Rachel Washington, rachel@meccaconcepts.com.au

May 19-23
7F Users Group

2025 Conference and Vendor Fair, Sheraton Birmingham Hotel and BJCC, Birmingham, Ala. Details/registration at https://www.powerusers.org as they become available.
Contact: SV Events, planning.team@sv-events.net

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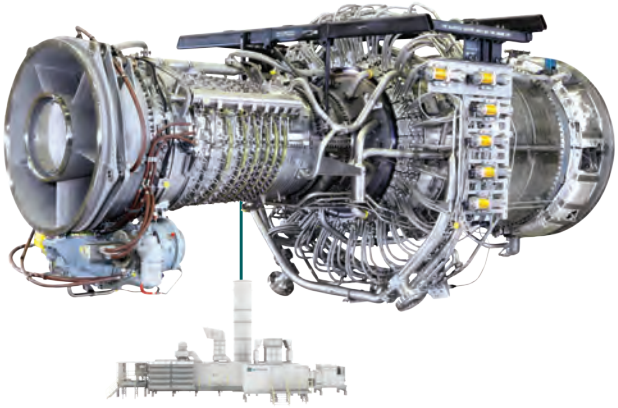

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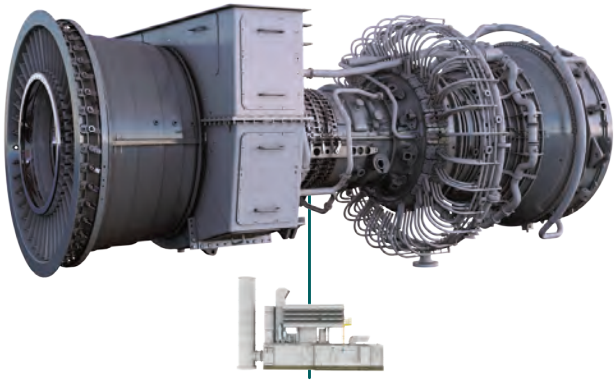

LM6000VELOX*
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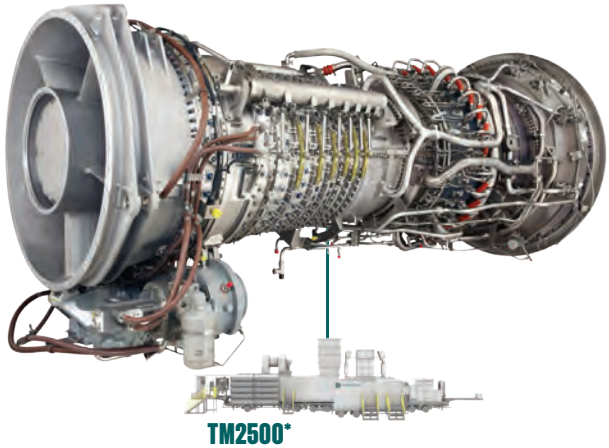

TM2500*
Power plant on wheels

LMS100*

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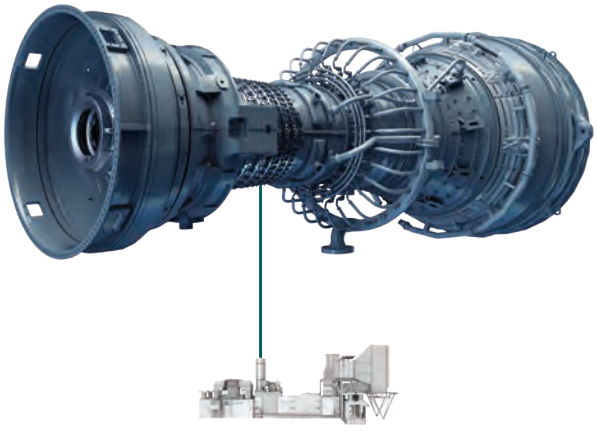

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34th Annual Conference and Expo

March 30-April 2, 2025
Long Beach Convention Center

President's welcome

On behalf of the board of directors, officers, breakout-session chairs, and support staff, welcome to the 34th annual conference of the Western Turbine Users.

In the late 1980s, a handful of brave investors purchased some early model LM2500 and LM5000 gas turbines for service in California. Their O&M personnel quickly realized the common issues and advantages of the LM engine, gathering in small groups to compare experiences and provide solutions to present to the OEM.

Western Turbine Users was born. Incorporating in 1990, the small group of plant representatives grew to 50, doubled to 100, then 500, and now is over 1000 members strong. Be proud to associate with our organization's legacy, rich history, and worldwide influence as you collaborate with other industry professionals. Little did our predecessors imagine their forethought would result in something as meaningful, relevant, and influential as WTUI.

Join me in celebrating 35 years of the evolving aeroderivative gas-turbine industry. Users like you have challenged equipment suppliers to improve their products, as we demand new uses and extend the lives of our gas turbines and all support equipment. As a WTUI member, your conference contribution is the root to our success. You are a vital element of the volunteer organization as we move forward.

Ed Jackson
President, WTUI

Western Turbine Users Inc, the world's largest independent organization of aeroderivative gas-turbine owner/operators, celebrates 35 years of service to the industry at its annual conference and expo, March 30-April 2, 2025, in the Long Beach Convention Center.

What follows is an overview of the upcoming 34th WTUI meeting, plus technical highlights from last year's conference. Presentations from the 2024 meeting, as well as those from earlier conferences, are available at https://wtui.com/forums for WTUI members wanting to dig into the details. For access, email Wayne Feragen, treasurer and webmaster, at wferagen@wtui.com.

WTUI 34 (2025)

The Long Beach conference offers the opportunity to reconnect with colleagues, some of whom you may not have seen recently because of all the industry changes. WTUI organizers provide plenty of time to fulfill this objective.

Prime examples include a golf tournament Sunday morning at the Skylinks at Long Beach golf course (7:00 a.m. to 1 p.m.) and bowling tournament at CalBowl in nearby Lakewood (10 a.m. to 1 p.m.). Plus, the vendor-sponsored Sunday evening welcome reception, from 5:30 to 8:30 in the exhibit hall, which is your first opportunity to thank the more than 100 exhibitors (p 10) and sponsors (p 22) for their participation. The Monday night reception is in the Pacific Ballroom (adjacent to the convention center), from 6:30 to 9:30, and will feature local foods, live music, and interactive exhibits with a racing theme.

For WTUI first-timers, it's not necessarily about connecting with colleagues, but rather meeting new people with professional needs and concerns that align with theirs. The best place to begin this process is at the Sunday afternoon session (3:30-5:00), "Welcome to WTUI/Conference Familiarization," in Promenade 102A.

The Sunday session is chaired by Andrew Gundershaug, plant general manager, Calpine Corp, who has years of experience in the design, operation, and maintenance of GE aeros, gained both on his day job and as the organizer and discussion leader of Western Turbine's LM5000 and LM6000 breakout sessions.

Gundershaug is a patient instructor who will help newcomers maximize the benefits of participating proactively in the engine-specific technical sessions on Monday, Tuesday, and Wednesday. Plus, he will provide valuable guidance on how to assure units under their purview operate safely and at high reliability.

In his opening remarks on Sunday, Gundershaug will explain the conference arrangement, how to organize your participation, and how to navigate the 2025 sessions for maximum effectiveness. Then he will review the progression of the LM product line from the 2500 to the 5000, to the 6000, and finally to the LMS100. The philosophy of each turbine variant will be discussed and how the turbine/generators are arranged—for example, gear or direct drive.

The slide deck for Gunderhaug's 2024 presentation, which will be updated for 2025, contains many very instructive drawings and photographs useful in plant-breakroom training sessions. Review it on the WTUI website to better prepare for this session.

A quick read through the technical program (p 8) will remind you of WTUI's value to your professional growth and development. Highlights

(Continues on p 14)

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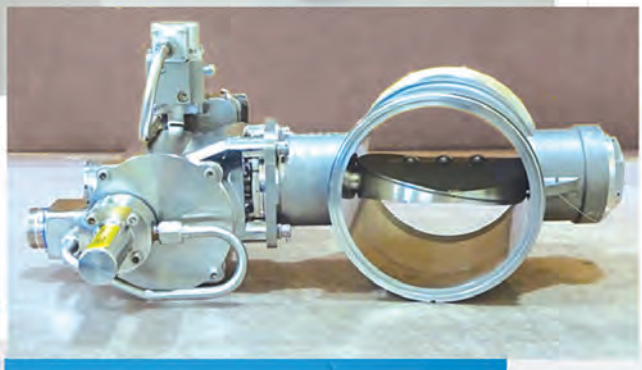

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Technical Program

As of Feb 10, 2025

Conference Mobile App

Where to go

Registration: Convention Center Promenade Lobby
Exhibits: Convention Center Exhibit Hall C
Breakfasts **Monday and Tuesday:** Convention Center Exhibit Hall B
Wednesday: Convention Center Promenade Ballroom 104 (foyer)
Luncheons: Convention Center Exhibit Hall B
LM2500 Breakout Meetings: Promenade 101
Chair: Joshua Svejcar, Veolia
LM5000 Breakout Meetings: Promenade 102A
Chair: Perry Leslie, Yuba City Cogeneration
LM6000 Breakout Meetings: Promenade 103
Chair: Dave Fink, Allied Power
LMS100 Breakout Meetings: Promenade 102B/C
Chair: Jason King, Onward Energy

Sunday, March 30

AFTERNOON

2:00 to 7:30 Conference registration
3:30 to 5:00 Welcome to WTUI/Conference Familiarization, *Promenade 102A*
Chair: Andrew Gundershaug, Calpine Corp
All new registered conference attendees

EVENING

5:30 to 8:30 Exhibitor-Sponsored Welcome Reception, *Convention Center Exhibit Hall*
All registered attendees and spouses/guests

Monday, March 31

MORNING

7:00 to 4:00 Conference registration
7:00 to 8:00 Breakfast
All registered conference attendees
7:00 to 5:30 Exhibit Hall open
Must have name badge to enter
8:00 to 9:30 General Session, *Promenade Ballroom 104*
All registered conference attendees
9:30 to 9:45 Break, *Exhibit Hall B*
9:45 to 11:00 GE Services/New Products Update, *Promenade Ballroom 104*
All registered conference attendees
11:00 to noon Worldwide GT Business Update, *Promenade Ballroom 104*
Mark Axford, Axford Turbine Consultants LLC
All registered conference attendees

AFTERNOON

Noon to 1:00 Lunch and activity awards
Must have name badge to enter
Noon to 2:30 Lunch/Exhibits
Must have name badge to enter
1:30 to 2:30 Women in Energy, *Promenade 102A*
2:30 to 5:30 Breakout Meetings: LM2500, LM5000, LM6000, LMS100
Users and GE only (blue and yellow badges)

EVENING

6:30 to 9:30 Monday Night Reception, *Convention Center Pacific Ballroom* (adjacent to the Convention Center)
All conference attendees and registered spouses/guests. Must have name badge or wristband and be 21 years old for entry.

Tuesday, April 1

MORNING

7:00 to 4:00 Conference registration
7:00 to 8:00 Breakfast
All registered conference attendees
7:00 to 2:30 Exhibit Hall open
Must have name badge to enter
8:00 to 9:15 Breakout Meetings: LM2500, LM5000, LM6000, LMS100
Users and GE only (blue and yellow badges)
9:15 to 9:30 Break, *Exhibit Hall*
9:30 to noon Breakout Meetings: LM2500, LM5000, LM6000, LMS100
Users only (blue badges)

AFTERNOON

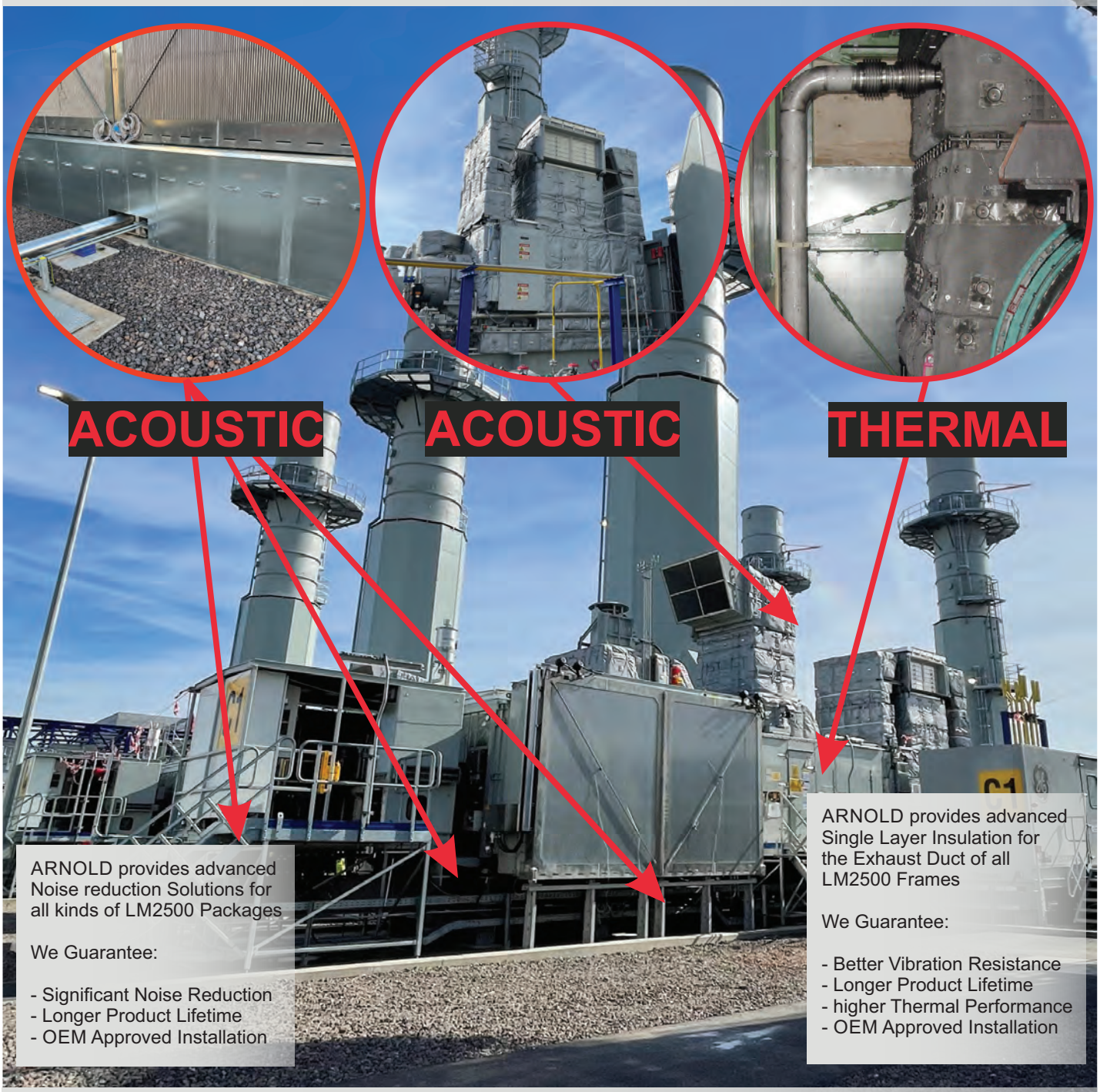
Noon to 1:00 Lunch and recognition awards
Must have name badge to enter
Noon to 2:30 Lunch/Exhibits
Must have name badge to enter
2:30 to 5:30 Special Technical Presentations
All registered conference attendees
2:30 to 3:30 Aero best practices (CCJ), *Promenade 101*
Flow modeling for aero powerplant performance optimization (Airflow Sciences), *Promenade 102B/C*
Improving HRSG efficiency with operational and design mods (HRST), *Promenade 103*
3:30 to 4:30 So, what's going on in my turbine control any way? (Woodward), *Promenade 101*
Aero airfoil repair options and best practices (Liburdi), *Promenade 102B/C*
How to prevent (inlet air) catastrophic failure during extreme conditions (Donaldson), *Promenade 103*
4:30 to 5:30 Aero generator challenges (NEC), *Promenade 101*
Maintain, modernize switchgear (ABB), *Promenade 102B/C*
Predictive analytics: Applying AI processes in ORAP® with national labs (SPS), *Promenade 103*

Wednesday, April 2

MORNING

7:00 to 8:00 Breakfast
8:00 to 11:45 Open Forums: LM2500, LM5000, LM6000, LMS100
All registered conference attendees
11:45 to noon Wrap-up/Adjourn, *Promenade Ballroom 104*
All registered conference attendees

LM2500 INSULATION SOLUTIONS AT IST FINEST



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Exhibitors

As of Feb 10, 2025

Conference Mobile App

Company	Booth
ABB	450
Advanced Express	353
Advanced Filtration Concepts	534
Advanced Turbine Support	525
Aeroderivative Gas Turbine Support	219
Aerotest Ltd	606
AGT Services	125
Air Hygiene International	339
Airflow Sciences Corp	249
Airgas Specialty Products	637
Alta Solutions	454
AP4 Group	637
Baker Hughes	333
Baseload Power Generation Parts & Services	111
BASF Corp	535
Braden Group	529
Bradley Griffin	121
Brownell Aeroderivative Consulting	337
Bvessel Filtration	537
Camfil Power Systems	623
Catalytic Combustion	438
CC Jensen	601
CCC - Continental Controls Corp	132
CECO Environmental	245
CEM Service Group	348
CEMTEK KVB-Enertec	224
changeOVR	220
Chromalloy	239
CleanAir Engineering	521
Conax Technologies	432
CORMETECH	609
Denox Environmental Group	347
Detector Electronics	234
Donaldson Hy-Pro	624
Durr Universal	636
EagleBurgmann Industries	447
ECT Inc	551
eLogger	325
EnergyLink International	129
ENTRUST Solutions Group/TG Advisers	137
Environex	538
ESC Spectrum Corp	445
EthosEnergy	638
Evident	627
FIB Industries BV	245
Fossil Energy Research Corp (FERCo)	139
Freudenberg Filtration Technologies	346
GasTops	108
GE Vernova	103
Global Energy Services Alliance	240
Groome Industrial Service Group	118
Ground Power Parts	507
GTSMRO	116
Heiberger Solutions	128
Hill Brothers Chemical	136
HPI Energy Services	434
HRST	236
IHI	403
Industrial Air Flow Dynamics	134
Industrial Info Resources	152
Interlock Energy	355
Kinectrics	444
Liburdi Turbine Services	634
Lone Star Controls	451
Marioff North America	436
Maximum Turbine Support	100
MC Tech Group	450
Mee Industries	603
MFS (Mechanical Field Support)	545
Mjorud	154
Montrose Environmental Group	135
MTU Maintenance	319
Munters Corp	141
National Electric Coil	539
National Mechanical Services	254
Nationwide Boiler	155
Nederman Pneumafil	724
Northern Blower	446
NYCO Lubricants	238
OEM Parts Network	411
Pacific Standard Environmental	344
Parker Hannifin	145
Petrotech	639
Power Engineering Services and Solutions	550
Precision Iceblast Corp	252
Process Metrology	738
PROENERGY	225
Quality Generator Services	453
Regal Rexnord	620
Relevant Industrial (Switch Filtration)	439
Relevant Power Solutions	645
Rochem Fyrewash	130
Rust Automation & Controls	536
Score Group	253
SCR Solutions	148
SISO Engineering	112
Sisu-EE	138
SJ Turbine	429
SSS Clutch Company	151
Starfish PPS	111
STI CEMS	542
Strategic Power Systems	114
Sulzer Turbo Services Houston	442
SVI BREMCO	435
Sweeney	153
Swift Filters	425
Synergy Catalyst	532
T2E3	437
TE Wire & Cable	247
Teledyne Air Quality	546
The BG Service Company	544
Thomas Pump	541
Toshiba America Energy Systems	625
TTS Energy Services	605
Umicore	433
US Cleanblast (Premium Plant Services)	607
Xinergias	119
VBR Turbine Partners	631
Vector Systems	726
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(Continued from p 6)

include the following:

- Access to the industry's top technical talent Sunday evening through Tuesday afternoon in the vendor fair to help you solve plant problems. Think of this as free consulting.
- Special technical presentations by consultants and third-party solutions providers invited by the organization's leadership team (p 6).
- Presentations by the OEM focusing on shop findings and solutions. Important to have CCJ's acronyms sidebar handy (p 24) while listening to these experts because they tend to speak in shorthand—HPCR for high-pressure compressor rotor, FPI for fluorescent penetrant inspection), RPL for replaced part, etc. You don't want to disengage from the speaker to figure out what an acronym means.
- Experience with upgrades to boost output, availability, and/or reliability, and to reduce emissions.
- Open discussions in user-only sessions that provide insights you'll find valuable for improving the performance of your engines.

Monday morning

The pace of the meeting quickens after breakfast Monday in Exhibit Hall B of the Convention Center as all registered attendees gather at 8:00 for the General Session in Promenade Ballroom 104 for opening remarks by WTUI President Ed Jackson, plant manager of Missouri River Energy Services' Exira Generating Station in Brayton, Iowa.

Jackson, who was elected WTUI's leader in 2022, is only the sixth president in the organization's more than three decades of service to the industry. His predecessors: John Hudson, 2020-2022; Chuck Casey, 2013-2020; Jon Kimble, 2008-2013; Jim Hinrichs, 1992-2008; and John Tunks, 1990-1992.

Following the introduction of officers, directors, breakout session chairs, and support staff, plus the treasurer's financial report, badge rules, and other business matters, the conference agenda will be reviewed and appropriate acknowledgements made. This year's meeting will differ from those in the recent past in that the three service providers (a/k/a ASPs) authorized by GE to work on LM2500 and LM6000 engines—IHI, MTU, and TCT—will not be participating.

Highlights of the first morning's presentations, after the refreshments break in Exhibit Hall B ends at 9:45, are the following:

- GE Services' offerings and the OEM's new products update in Promenade Ballroom 104 from 9:45 to 11:00.
- Worldwide gas-turbine business update by Tony Brough and Mark Axford, from 11:00 to lunch at noon, also in Promenade Ballroom 104. Brough, president, Dora Partners & Company, will update the group on the state of the global gas-turbine market using engine-specific and geographic stats considered by many among the industry's most reliable. Mark Axford, president, Axford Turbine Consultants, who has presented to this group on the state of the energy industry for two decades and a crowd favorite will use his crystal ball to help attendees prepare for the future.

Brough

Axford

Engine-specific sessions

Breakout meetings for the LM2500, LM5000, LM6000, and LMS100 gas turbines, the core of WTUI's technical program, begin Monday afternoon at 2:30 and run until 5:30 (user and GE attendees only). Sessions continue Tuesday morning for users and GE at 8:00 until a 15-minute break in the Exhibit Hall starting at 9:15. The meetings continue for users only from 9:30 until lunch at noon.

The Wednesday program features open-forum breakouts for all registered conference attendees from 8:00 to 11:45. In sum, that's more than nine hours of intense information transfer from engine experts to the user community. You can't get "training" of such high caliber anywhere else in the world.

The LM2500 program is guided by Joshua Svejcar, district manager for Ever-Green Energy in the Minneapolis area and recently appointed to the WTUI leadership team. Previously, he served in management positions at Veolia North America and Foster Wheeler. Ever-Green operates the energy systems for the University of Minnesota's Twin Cities Campus.

Svejcar takes over from Garry Grimwade, who was promoted to VP technical presentations for WTUI. Recall that Grimwade is responsible for four LM6000s, four GE10s, and a LM2500-powered combined cycle at Riverside (Calif) Public Utilities.

The LM5000 session is chaired by Perry Leslie, who watches over the Yuba City Cogeneration Plant. His responsibilities there include I&C, mechanical maintenance, and operations. Leslie has served that facility since 2004 while also managing the now-shuttered Binghamton Cogeneration Plant for a brief period. Before Yuba City, he spent six years as a field service technician for GE in the Bakersfield area working on LM1600, LM2500, LM5000, and LM6000 engines. He began his career with a six-year stint in the US Navy as a GT systems technician (electrical).

The LM6000 program is led by Breakout Session Chair Dave Fink, a gas turbine specialist at Allied Power (independent from AP4 Group) assigned to a team that supports the reliability and availability of Arizona Public Service Co's gas-turbine fleet. Previously, Fink was an I&C technician and operator at Southwest Generation's Fountain Valley (Colo) facility, and responsible for maintenance at that six-unit LM6000 peaking plant. His power-generation career includes six years as an electrician's mate in the US Navy and a decade as I&C technician at Calpine's Gilroy facility (1 × 1 7EA-powered combined cycle and three LM6000 peakers). Fink also spent eight years with F W Marsh LLC, supporting GE in the commissioning and field service of LM engines.

The LMS100 session is guided by Jason King, a plant manager for Onward Energy. The only attendees invited to LMS100 sessions are GE employees and users.

Special technical presentations

Tuesday afternoons at Western Turbine meetings are reserved for nine Special Technical Presentations, approved by WTUI leadership, to extend the meeting's content beyond the four GE aero engines on the program. The hour-long presentations (with Q&A) are arranged in three parallel sessions beginning at 2:30, 3:30, and 4:30. Slide decks are posted on the WTUI website, but access requires an email request to Webmaster Wayne Feragen at wferagen@wtui.com.

2:30-3:30

Best practices, *Scott Schwieger, general manager, CCJ.*

Best practices submitted to CCJ by aero users as part of the annual awards program sponsored by the periodical and WTUI, will be reviewed, with open discussion to follow. Attendees are invited to share their best practices impromptu from their seats. Challenges and experience gained during the recent Los Angeles fires will be a special focus of the session. Those lessons learned are sure to help others in developing procedures to deal with unusual events—such as floods, fires, hurricanes, tornados, earthquakes, etc. *Promenade 101*

Flow modeling for aero powerplant performance optimization, *Matt Gentry, engineering manager, Airflow Sciences Corp.*

(Continues on p 20)

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Exhibit hall: Al Van Hart, *Parkway Generation/CAMS*

Western Turbine's leadership team consists of the officers, directors, conference chairpersons, and support personnel who plan and execute the world's largest and most comprehensive technical meeting on GE aeroderivative engines for electric power production, gas compression, and ship propulsion. Day-to-day operations are managed by an experienced support staff.

The individuals in this army of volunteers dedicate hundreds of hours of personal time annually to keep you informed on engine technology, operation, and maintenance.

The material presented by owner/operators, the OEM and its authorized service providers, and independent third-party providers of products and services is important and conducive to your success. Participation in WTUI meetings will help you manage your plant in a manner that maximizes revenue, efficiency, and availability/reliability, and minimizes pollutant emissions—all while maintaining the highest degree of safety.


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Feragen


Fink


Jackson


Grimwade


Gundershaug


Johnson


King


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PIC's dry ice blasting service provides a highly effective and non-invasive solution for removing stubborn deposits in boilers and heat exchangers. This method uses dry ice pellets that sublimate upon contact, breaking down tough buildup without damaging sensitive surfaces or generating secondary waste. This approach keeps boilers and heat exchangers operating efficiently, minimizing downtime and extending the lifespan of critical components

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(Continued from p 14)

Gentry will focus on the advantages of CFD and physical modeling as tools for optimizing the performance of plants powered by aero engines. His presentation will include SCR ammonia injection system design options and discuss issues specific to gas-fired units. Topics will include the following: pressure-drop minimization, AIG design, common issues that can result in performance degradation, and the benefits of flow modeling and testing.

Both simple- and combined-cycle plants will be addressed, with several aero projects reviewed. These examples will highlight the performance gains achievable with sophisticated flow modeling—either to solve an ongoing problem or to support unit commissioning.

Additionally, a recent project profiled will show how CFD modeling was used to redesign an ammonia injection grid. Plant operating experience has confirmed that since installation of the redesigned AIG, NOx control has improved and ammonia usage has decreased by 15% to 25%—depending on load and other conditions. Plus, ammonia salt formation on the tube banks downstream of the SCR catalyst has been reduced, cutting plant operating costs in terms of pressure loss and tube cleaning. *Promenade 102 B/C*

Improving HRSG efficiency with operational and design modifications, *Jack Odlum, northwest regional manager, HRST Inc.*

Many factors, including HRSG design, operation, and ambient conditions, can impact a combined-cycle plant's output and efficiency. It's common for plants to continue to operate under inefficient conditions, with significant losses in production, when there is no readily discernable symptom; tube leaks come to mind.

Some efficiency losses can be restored with relatively inexpensive corrections—such as by changing tuning set points or by modifying operating parameters. Others, such as component retrofits, require more significant changes to improve heat rate.

Odlum will focus on pathways to improve the efficiency of a typical combined-cycle plant via operating and design modifications. These may involve changes in economizer design and operation, attemperator configuration, exhaust gas bypass, exhaust backpressure, and exhaust leaks. Case studies will offer quantitative examples of heat-rate improvements. *Promenade 103*

3:30-4:30

Troubleshooting 101: What do I do next? *John Stulp, senior staff application engineer, and Brooks Hoffman, sales manager, Woodward.*

Imagine you're an operator and it's 4 p.m. Friday. After a long week, you're ready to wrap up for the weekend. Suddenly, the control-room horn goes off and you quickly scan to the HMI, finding that the gas turbine has tripped. You reach out to support contacts, but no one answers their phone, having already left for the weekend. You begin to wonder, "What do I do next?"

The Woodward team will cover the basics of troubleshooting and how you can begin to narrow down and pinpoint the issue at hand. Stulp and Hoffman will cover the key techniques and thought processes that Woodward's engineering and field-service organizations follow while troubleshooting. Plus, the information that should be retrieved and saved from an event that all providers of controls support will want.

Goal of the presentation is for attendees to leave the session better equipped to solve their own onsite issues while ensuring that critical information is gathered and retained to share with supporting parties, if need be—thereby eliminating delay in third-party support. *Promenade 101*

Aeroderivative airfoil repair options and best practices, *Scott Hastie, engineering manager, Liburdi Turbine Services Inc.*

Hastie will provide a comprehensive non-commercial review of the typical failure mechanisms that impact the lives of airfoils in aeroderivative gas turbines, and the options available for reliably extending the service lives of these mission-critical components.

Increasingly, options for extending the lives of critical components are being requested both by operators and service providers. However, the metallurgical complexity and geometry of these parts demands an expertise and understanding of how to successfully maintain their integrity while ensuring an expected service interval when the part is returned to operation.

The presentation will provide photographic examples of both the typical and atypical wear and tear exhibited by blades and vanes after their use in industrial aero turbines.

Options will be explored for how to evaluate and ultimately repair these parts with examples of the same parts returned to service over and over again, instead of simply being replaced with new.

Consideration will be provided for concerns such as coating integrity, maintaining OEM-required wall thicknesses, and restoration of part geometries that ensure post-repair performance restoration. *Promenade 102 B/C*

How to prevent catastrophic failure during extreme conditions—wildfires, for example, *Allyse Wilcox, western regional manager, and Paul Klick, power-gen manager for the Americas.*

Many LM2500 and LM6000 turbines are operating with a static filtration system and have no ability to pulse. Wilcox and Klick will highlight the steps owner/operators can take to keep turbines generating at peak performance even when encountering difficult environmental challenges—including wildfires, a coastal (corrosive) environment, industrial chemicals, hydrocarbons from vehicle exhaust, and cottonwood.

The speakers will share their expertise on how to optimize fuel consumption, extend filter service life, differentiate between F9 and HEPA, and how predictive, reliable maintenance can extend your turbine's life and lower the total cost of ownership. *Promenade 103*

4:30-5:30

Aeroderivative generator challenges, *W Howard Moudy, managing director, National Electric Coil.*

The generator component of aeroderivative gas turbines has received much less attention than the engine as these machines have grown in popularity—especially regarding maintenance, upgrade, uprate, and life extension to meet current and future expectations. Moudy will focus on specific challenges facing generators for aero units.

His presentation will begin with a well-illustrated review of aero generator components which will be familiar to participants with a working knowledge of generators, their functions, and characteristics.

Common generator issues, including cycling, will be shared along with guidance on maintenance and options for long-term solutions. Most generator issues discussed will be applicable across most makes and models, but some unique differences will be identified and guidance provided.

Considering many aero generators are approaching, or have passed, their design lifetimes, a primary focus of Moudy's remarks will be generator life extension through rewind, with the rotor and stator explored individually.

Key technical characteristics, planning details, and execution factors will be shared relating to successfully achieving performance and quality expectations, while at the same time working within schedule and budget parameters. *Promenade 101*

Maintain, monitor, and modernize to make aging switchgear safer, *Umer Khan, PE, global product manager, ABB Electrification Service.*

Khan aims to fulfill three learning objectives in his time at the podium. They are:

- Explore challenges associated with maintaining legacy switchgear.
- Learn how equipment maintenance plans can enhance electrical safety.
- Come up to speed on the impact of modernization and digitalization to enhance optimization and effectiveness of equipment maintenance plans.

Reliability and safety are critical topics

(Continues on p 24)

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(Continued from p 20)

when it comes to optimization of switchgear asset performance and lifecycle. Today's asset managers face economic limitations that require deeper analysis to prioritize investment needs. In many cases, traditional practices—such as reactive and even preventive maintenance—may appear the most cost-effective solutions; however, in practice, they may compromise performance targets for reliability and safety, leading to economic setbacks in downtime and overall operating cost.

Conversely, switchgear modernization and monitoring can support equipment maintenance practices that lead to robust performance and lifecycle extension of the equipment. Through modernization and digitalization of their equipment, asset managers can optimize their equipment maintenance plans (EMP) for a more reliable, safer, and cost-effective result.

Design and implementation of an effective EMP is critical. A robust plan requires consideration of many factors—including the following:

- NFPA 70B, "Standard for Electrical Equipment Maintenance."
- NFPA 70E, "Standard for Electrical Safety [in the workplace]."
- Manufacturer recommendations.
- System conditions.
- Workforce availability.
- Outage restrictions.
- Budget constraints.

Maintenance plans are complex to build and require continuous improvements as the processes and methodologies are implemented. Additional topics to be discussed include these:

- Condition monitoring for safety and reliability.
- Infrared and partial-discharge monitoring.
- Maintenance optimization to meet safety KPIs.
- Repair/overhaul optimization by design.
- Operational safety by design and spare-parts management.

Developing a strategic asset management plant that considers lifecycle costs, risk-mitigation strategies, and technology trends is essential for informed decision-making. Major challenges include these: obsolescence of parts/equipment, lack of technical documentation, expertise gap, reliability and safety, and sustainability and environmental impact (SF6 gas, asbestos, etc).

Bear in mind that aging switchgear typically undergoes a gradual decrease in reliability, causing unexpected downtime and failures. Additionally, electrical safety codes and standards evolve over time. While these do not mandate replacement of legacy equipment in most cases, ensuring the safety of personnel and equipment becomes increasingly difficult with older switchgear not built to comply with today's codes and standards. *Promenade 102 B/C*

Predictive analytics: Applying SI processes in ORAP® with the national labs, *Salvatore A DellaVilla Jr, founder, chairman, and CEO, Strategic Power Systems Inc.*

SPS has been working with DOE, National Energy Technology Laboratory (NETL), and Oak Ridge National Laboratory (ORNL) in the development and application of artificial intelligence (AI) techniques to demonstrate the predictive value of the time series data available for analysis in the ORAP system. This effort focused on the following:

- Development of Machine Learning (ML) models to predict "when" an unexpected outage event will occur, and what will be the cause of that event at a component level.

Acronyms to remember

AGB—Accessory gearbox (also called the transfer gearbox)
AVR—Automatic voltage regulator
CCM—Condition maintenance manual
CCR—Customized customer repair
CDP—Compressor discharge port
CFF—Compressor front frame
COD—Commercial operating date
CPLM—Critical-parts life management
CRF—Compressor rear frame
CWC—Customer web center (GE)
DEL—Deleted part
DLE—Dry, low emissions combustor
DOD—Domestic object damage
EM—Engine manual
FFA—Front frame assembly
FOD—Foreign object damage
FPI—Fluorescent penetrant inspection
FSNL—Full speed, no load
GG—Gas generator (consists of the compressor and hot sections only)
GT—Gas turbine (consists of the gas generator pieces with the pow er turbine attached)
GTA—Gas-turbine assembly
HCF—High-cycle fatigue
HGP—Hot gas path
HPC—High-pressure compressor
HPCR—High-pressure compressor rotor
HPCS—High-pressure compressor stator
HPT—High-pressure turbine
HPTN—High-pressure turbine nozzle
HPTR—High-pressure turbine rotor
IGB—Inlet gearbox
IGV—Inlet guide vane
IPT—Intermediate-pressure turbine (LMS100)
IRM—Industrial repair manual
LM—Land and marine
LCF—Low-cycle fatigue
LO—Lube oil
LPC—Low-pressure compressor (not on LM2500; just LM5000 and LM6000)
LPCR—Low-pressure compressor rotor
LPCS—Low-pressure compressor stator
LPT—Low-pressure turbine
LPTR—Low-pressure turbine rotor
LPTS—Low-pressure turbine stator
MCD—Magnetic chip detector
MOH—Major overhaul
NGV—Nozzle guide vane
OEM—Original equipment manufacturer
PN—Part number
PT—Power turbine (turns a generator, pump, compressor, propeller, etc)
PtAl—Platinum aluminide
RCA—Root cause analysis
RDS—Radial drive shaft
RFQ—Request for quote
RPL—Replaced part
SAC—Single annular combustor
SB—Service bulletin
SL—Service letter
SUP—Superseded part
STIG—Steam-injected gas turbine
TA—Technical advisor
TAT—Turnaround time
TAN—Total acid number (lube oil)
TBC—Thermal barrier coating
TGB—Transfer gearbox (also called the accessory gearbox)
TMF—Turbine mid frame and thermal mechanical fatigue
TRF—Turbine rear frame
VBV—Variable bleed valve (not on LM2500; just LM5000 and LM6000)
VBVD—Variable bypass valve doors
VIGV—Variable inlet guide vanes
VSV—Variable stator vane
VSVA—Variable stator-vane actuator

- Use of Natural Language Processing (NLP) processes to improve the quality and standardization of outage-event descriptions reported by participating operating plants.
- Defining the use of AI and Large Language Models (LLM) for training, ORAP data processing and preparation, and interpretive data assessment.

DellaVilla, whose involvement with GE aeros predates the formation of the Western Turbine Users Inc, will focus on project results, feedback from an advisory board of operating companies, and the readiness for beta field testing and demonstration. *Promenade 103*

Acknowledgement

The heart and soul of WTUI, Jim Hinrichs, the organization's second and longest-serving president, told the editors years ago, is the dedicated user who understands that helping a colleague is an investment in his or her own company and expertise. "What's Joe's problem today, could be mine tomorrow," he said.

In the opinion of the editors and others, it is unlikely the aero engines served by WTUI would have achieved commercial success as quickly as they did without dedicated owner/operators contributing to the solutions implemented by the OEM and others to improve their operability and maintainability.

The Honor Roll salutes the WTUI officers and members of the board of directors, who have contributed mightily to the success of this organization since its founding in 1990, and to the industry at large. If you see the nametag of anyone on the list in your travels, please thank them for their productive and unselfish contributions to the successes enjoyed by the greater LM community.

Strategic Power Systems, led by CEO Salvatore A DellaVilla Jr, is due special recognition for its work in tracking and reporting accurate and unbiased availability and reliability data since WTUI's founding. SPS's Operational Reliability Analysis Program (ORAP®) provides users the data and metrics they need to extract top performance from their aero engines.

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WTUI 33 (2024)

The basic structure of WTUI's 33rd Annual Conference and Expo at the Renaissance Palm Springs Hotel and Conference Center, March 24-27, 2024, mirrored that of Western Turbine's traditional in-person meeting format described beginning on p 6 for the 34th conference. Focus here is on the breakout sessions for the LM2500, LM6000, and LMS100 engines that followed lunch and a visit to the exhibit hall on the first full day of the meeting (March 25).

Note that mention of the LM5000 is not included because that machine no longer was supported as an integral unit by the OEM or its Authorized Service Providers (IHI, MTU, and TCU). According to the most reliable industry data available to the editors, only 28 of the 102 LM5000s produced by GE for service were still operating at the end of 2022.

Owner/operators basically are on their own to arrange for repairs and parts. GE, MTU, and a few specialty maintenance and overhaul shops may still have interest in what business there is, say industry sources.

Staffing challenges prevented CCJ from sitting in on the user group's discussions.

The LM2500 breakouts were organized and conducted by Garry Grimwade of Riverside Public Utilities while the LM6000 sessions were managed by Dave Fink, who was associated with Onward Energy at the time (today Allied Power). They included engine-specific presentations by GE, TCT, MTU, IHI, and Strategic Power Systems Inc (SPS), plus robust open discussion.

Jason King of Onward Energy was appointed chair for the LMS100 breakouts beginning with the 2024 meeting. Important: The units in this fleet (81 at the time of the 2024 meeting) are supported only by GE.

Finally, keep in mind the ASPs have not participated in WTUI events since the conclusion of the 33rd Annual Conference. This may be of importance to you because the findings and work profiled as it relates to the LM2500 and LM6000 will no longer be readily available to users.

LM2500, GE

GE kicked off the LM2500 session with several of its engineers presenting. Product Leader Nam Tram began the company's participation with a safety moment and GE Vernova fleet overview: More than 40 million operating hours (in round numbers) recorded by1161 LM2500 base, LM2500+, and LM2500+G4 machines. Highlights of the presentation include the following:

Completed engine programs

- Multiple spline wear events in the field, usually detected when the engine is unable to start after shutdown. Wear is caused by inadequate oil bath levels in the spline area. Enhancements and recommendations are offered to correct the issue.
- Gas fuel hose contact wear on DLE engines caused by small variations in length of individual hoses. Procedure for checking the clearance between adjacent fuel hoses is provided along with enhancements to correct the issue—including a new P-clamp assembly.
- Wire-mesh ejector screen to prevent ingestion of foreign objects into the sump pressurization system has suffered damaging flow-induced vibration in many cases, causing wear at the wire filament crossings. Guidance on identifying wear, and screen replacement, are provided.
- Some engines were shipped with lube and scavenge pumps that have non-conforming drive keys installed on the shaft driving scavenge element. Operation with heavily contaminated lube can shear keys prematurely and flood the engine sumps with oil. Cause: A heat-treat anomaly. Recommendation: Check OEM correspondence to see if your unit has been identified for replacement.
- Nitride bearings 4B, 5R, and 7B have been identified with several "events" caused by hard-particle contamination. Recommendation: Install nitride bearings in accordance with Service Bulletins, 304, 305, 306, and 309.

Active engine programs

- Displaced fuel-manifold hinged brackets can cause contact between the bracket and liquid-fuel tubes, possibly contributing to fretting wear and a fuel leak. Flex brackets without hinges are in development. Stay tuned.
- Reports of leakage from the flexible hose integral to the sump vent manifold are attributed to fretting wear between the corrugated hose and protective braid. Inspect for manifold leaks and replace with current configuration until new hardware is available.
- Fracture of the TLO lube-oil pump spline manifold causes oil loss and potential clutch starvation. Belief is that miss-handling/installation created a preload on the tube. Instructions for proper installation are reviewed; possible solutions are under review.
- LM2500+G4 HPT first-stage blades have experienced trailing-edge oxidation, especially in wet SAC applications. Early maintenance and higher scrap rates are concerns. Service Bulletin was expected end of last year, assuming availability of spare blades.

Completed package programs

- Be on the lookout for 360-deg crack/damage on the inner skin of the exhaust tunnel at the gas-turbine end, which was reported on one unit in the fleet. Dissimilar thermal growth between two liner sections welded together are the apparent cause. Retrofit instructions are presented for this repair.
- Control software has been updated for implementation of the logic to add resettable start (cycle) and hours counters on the HMI screen for subassemblies (LPC, HPC, combustor, LPT, and HPT). Recall that counters and timers, and run hours, for the subassemblies must be easy to reset when parts are swapped or replaced. Field recommendations for software updates are covered in Product Bulletins 325-327.
- Quality issues identified with the large quick-disconnects for the hydraulic starter motor, vent van motor, and liquid boost skid pump have been corrected. The installation procedure for the disconnects was a major contributor to the distresses documented. Consult Product Letter IND- 24-001 to dig deeper.
- Blowdown hoses between the pulse header tank and the blowdown pipe supplied with the air inlet houses from one GE subcontractor had inner diameters too large to fit securely to the connection points at each end of the hose. Fix is simple: Replace hoses with those of smaller ID. Consult Product Letter IND-24-002.
- Mixed fittings for Hamlet (Ket-Lock) and Swagelok connections in LM packages, not endorsed by GE Vernova, may contribute to leaks. Recommendation: If mixed fittings are identified, rework the components to assure Swagelok only hardware. Consult Product Letter IND-24-003.
- Investigation of distressed power-turbine blades concluded that uncompensated combustion during startup, which could be caused by any significant disturbance in fuel-nozzle flow, thermally distressed the blades. Issues can be avoided by use of the latest software to monitor individual T48 probes and spread during sub-idle operation and to shut down the unit if limits are exceeded. Consult Product Bulletin IND-328.
- LM/TM2500 product bulletins released since the 2023 WTUI conference and not mentioned in the completed package programs listing immediately above:
  - IND-317, "LM2500 turbine enclosure air flow improvement," which provides instructions for modifying some components to improve ventilation air flow inside the turbine room.
  - IND-319, "LM2500 liquid fuel supply flex hose/pipe replacement," to mitigate fuel leak distress on units designated as TM2500 GEN8.
  - IND-320, "LM2500 and TM2500 exhaust-collector tunnel repair," provides instructions for repairing the exhaust-collector tunnel when cracks are in evidence on the front end—specifically on the inner liner.
  - IND-323, "LM2500 Xpress/K115 relay dial settings." Purpose is to introduce the latest settings for relay K115 for

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proper reset action after emergency shutdown.
- IND-324, "TM2500 GEPC generator cooling-fan blade liberation," references the relevant customer technical communication letter from GEPC.

■ LM/TM 2500 product letters released since the 2023 WTUI conference and not mentioned in the section immediately above:
- IND-24-004, "LM2500 Xpress gas fuel manifold leakage, hose leak TP" provides guidance on gas-fuel leak checks for the LM2500 Xpress.
- IND-24-005, same as 004 except for the LM2500 Universal.
- IND-24-006, same as 004 except for the LM2500 Gen 8.

Active package programs

■ Vibration monitoring. Introduces Orbit 60 as the latest vibration monitoring system to replace the BN3701, declared obsolete by Bently Nevada. At the time of the 2024 WTUI meeting, GE was developing instructions to replace BN3701 with Orbit 60.

■ Ethernet configuration mismatch in the vibration signals from the turbine rear frame, gas generator, and power turbine being communicated between Bently Nevada and the HMI. Crossed signals affect HMI readings, high-speed data logs, and onsite monitoring. The good news: Vibration protection of the unit is not impacted. Suggestion: Implement the product bulletin when it is released (was targeted for the second half of last year).

■ An Rx3i firmware update is required by those TM2500 Gen8 units running with Rx3i controls. The issue: A group of signals were shown as "0" and then recovered back to previous values a few seconds later. Investigators found that Rx3i firmware was not updated across the fleet and a Peripheral Component Interconnect interface logic bug was found in certain I/O modules. Recommendation: Implement the product bulletin when released (was expected before the end of 2024).

Best practices

■ Preservation topics for installed units:
- For units in storage, (1) Ensure the gas turbine is preserved as recommended in GEK procedures presented in Appendix B. (2) Keep packaged systems dry using covers, silica bags, and/or heaters. (3) Protect from rain and direct sunlight. (4) Keep drains free and manual ball valves open.
- For units ready to run or in standby, merge operational needs with preservation activities. Example: Full speed/no load operation can be used to wet the gas-turbine and generator bearings.

Also, prepare your local preservation and maintenance plan according to site operational needs and standby time, with consideration for ventilation and the combustion path, fluids, electrical components, and motors.

Record activities performed during the standby period.

■ Air filtration systems:
- Perform regular inspections of the air filtration system—including hoods, dust hoppers, and conditioning coils/coolers. Remember that proper cleaning and maintenance facilitate filter-media performance.
- Conduct regular inspections of components downstream of the filter section. Be sure to look for and eliminate (1) gaps allowing ambient air to enter, (2) leaks and dirt accumulation in instrumentation, (3) buildup of foreign material in drain lines.

■ Lube oil maintenance recommendations provided in the last slide in this section of the presentation are critical to maintaining oil quality. Recommendation is to retrieve the presentation and develop a checklist.

Wayne Romeo, FieldCore's senior service manager for the East Coast, followed LM2500 Product Leader Nam Tram at the podium. He began with rules for lockout/tagout, cautions about using non-OEM parts, a look at typical unscheduled outage callouts for field services, and suggestions regarding forced-outage calls for assistance.

An important part of his presentation concerned conversion, modifications, and upgrades—CM&U in GE Vernova lingo. Access the presentation to learn about the following:

■ Four-hour lockout avoidance.
■ Fast starts.
■ Real-time tuning for emissions compliance and top performance.
■ Synchronous condensing for reactive power support with a clutch.
■ Control system replacement.
■ Autonomous DLE tuning.
■ Generator AVR upgrade.
■ Fire suppression upgrade for the package.
■ SAC to DLE conversion.
■ Repowering to other engine models.

Mark Patel, the LM2500 fleet manager, then moved to the front of the room where he discussed Service Bulletins and Letters. Recall that Service Bulletins focus on the engine and related hardware; Product Bulletins on the package and related hardware. The nature of the OEM's correspondence to customers is graded thusly:

Category. Alert, Campaign, Routine, or Optional. Alert bulletins are safety items that require prompt attention given safety concerns or operational reliability.

Planning. Immediate or Periodic.

Compliance action. Per timing code or Per timing code when convenient. There are eight numerical timing codes: (1) prior to startup, (2) at first opportunity, (3) prior to a time or cycle, (4) first exposure, (5) at component part exposure, (6) at component part repair or replacement, (7) when convenient, (8) at first depot visit.

Primary benefit. Safety, Reliability, Maintenance cost, Performance.

Here's a list of the engine service bulletins issued in 2023. Perhaps you missed one or two. A good place to start might be with SB 0, rev 104, "LM2500 industrial gas generator/gas turbine service bulletin index."

SB 243, rev 4, "Turbine mid frame strut No. 6 oval sleeve and rub button weld improvement."

SB 314, rev 2, "Introduction of VSV system actuator mount with improved ball bearing."

SB 322, "LM2500+G4 ejector screen."

SB 323, "LM2500 SAC fuel system improvement."

SB 324, "UPT speed sensor replacement."

SB 325, "HPT rotor thermal shield replacement."

A few Service Letters (3), Product Bulletins (3), and Product Letters (1) also were issued in 2023. You can get those by accessing the GE slide deck online.

LM2500, TCT

Craig Ramsay, director of projects, did the heavy lifting for TransCanada Turbines with a 38-slide presentation featuring a blizzard of meaningful photos. Titles of the subjects covered follow allowing you to decide if there are topics of importance to your plant.

■ HPC S16 vane platform wear.
■ HPC rotor FOD event.
■ Top-case benefits versus a depot visit.
■ Mid-flange cracking/wear.
■ Liquid-fuel-system improvement.
■ HPT twin shank to single shank, SB310.
■ MCD and particle interpretation and SOAP.
■ Lube system chip detectors—troubleshooting steps, action on chip-detector alarm, corrective action following component failure.
■ Oil analysis.

TCT also made a brief presentation on what to look for in periodic inspections and maintenance tips. It could serve as the start of a handy checklist.

LM2500, MTU

Nico Brademann of MTU's depot engineering team, and Oliver Eckert and Uwe Wassel from the company's field services group, co-authored a presentation of well over 40 slides that included a couple of topics not often covered at user-group meetings. Here's the lineup:

■ HPC spool rubbing.
■ Splined adapter failure.
■ DLE combustor/CRF burning.
■ Air starter chips.
■ Contamination of the air-intake filter house.
■ Offline water-wash best practice.
■ Efficiency improvement at partial power.

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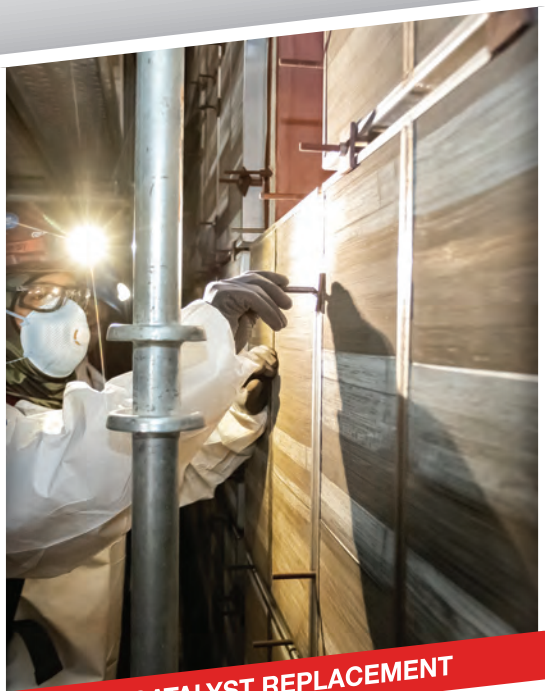

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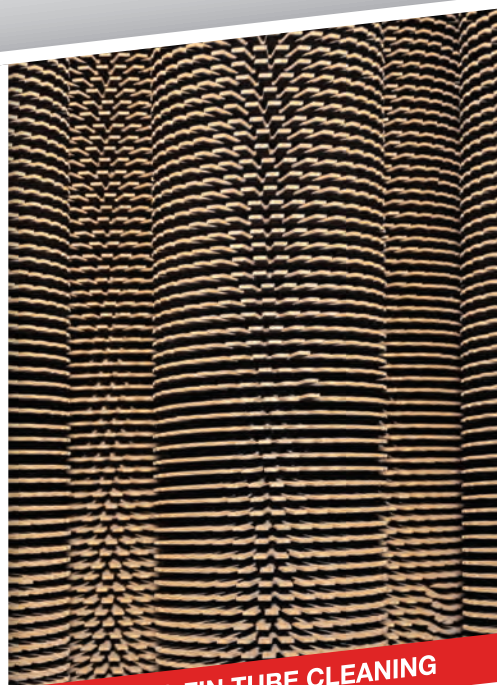

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AutoTune DLE

Jan Slagter, R&D projects leader and principal consultant for VBR Turbine Partners, an independent global maintenance provider for LM gas turbines, presented "AutoTune DLE," an automatic DLE optimizer for both LM2500 and LM6000 engines operating baseload or part-load.

Slagter described AutoTune DLE as real-time empirical combustion-based engine efficiency optimization, not model-based like digital twin and others. He said that this add-on to your existing LM unit does not interfere with control-system settings, day-to-day operation, or engine maintenance schedules.

Claimed benefits of AutoTune DLE were said to be the following:

- Optimizes combustion efficiency.
- NOx and CO remain in compliance continuously.
- Improves fuel saving during part-load operation.
- Reduces CO2 emissions when operation at part load.
- Eliminates the need for seasonal DLE mapping.
- Payback in two years.

Slides offer more information for decision-making. To dig deeper, contact competencecentre@vbr-turbinepartners.com.

LM6000, GE

The LM6000 sessions, organized and led by Dave Fink of Allied Power, began like the LM2500 program with presentations by the GE Vernova team, this group headed by Product Leader Nasser Chraibi.

GE's LM6000 is the world's largest land-based aero fleet for electricity production with more than 1300 SAC (single annular combustor) and DLE (dry low emissions) machines installed at the end of 2023. This includes models PA, PB, PC, PD, PF, PG, PH, and PF+. To this total must be added the number of machines in Baker Hughes' LM6000 PF+ fleet and ProEnergy's PE6000 family.

Active engine programs

Product Line Leader John Heaton was next to the podium with summaries of the active engine programs. Topics included the following:

- HPC S3-5 blades. There have been several blade-root events in the last decade which typically have been attributed to VSV off-schedule and contact between adjacent airfoils (a/k/a edge of contact—EOC). Presentation includes more detail and descriptive illustrations. Blade-coating refresh every 1500 starts is one of several recommendations included in the slide deck.

  The OEM offers a custom operational profile assessment to identify the causes of issues you might be facing. Enhancements include a change from titanium to Inco 718 for improved resistivity to fracture and wear and larger dovetail geometry. Fleet experience with enhanced hardware is reviewed.
- SAC combustor RQM experience. Recall that the Rich Quenched Mixed combustor was developed to reduce dry NOx production by the SAC combustor. Expectation is SAC engines will achieve 15 ppm NOx with CO within current guaranteed limits. Work continues.
- VSV bushing durability. Distress is driven by heat deterioration and wear. Enhancement plan involves an upgraded bushing design featuring tolerance and material changes.
- 11th-stage check valves. Intended to keep cooling air in place in the event of leakage from the HPC S11 air cooling tube. Valve flutter/vibration can drive valve replacement. Issues are mostly identified in the check-valve elbow area as indicated in Service Bulletin 261—required reading prior to installing enhanced check valves.

  These check valves remain a concern in PF1/PF2 engines. Issues have been identified during the 4000- and 8000-hr borescope inspections. Recommendation: Keep a spare set of check valves in the plant storeroom. Judging from the number of slides dedicated to 11th-stage check valves, plant staff might consider giving these issues more than just a passing glance.
- Thrust balance—ejector nozzle PF/PF2. Thrust balance is required to provide the LP thrust bearing adequate loading to prevent skidding/overloading. Thrust-balance tuning challenges have been identified. Specifically, system wants additional air with the maximum-size orifice installed. Work on a solution was well underway in 2024.
- T48 thermocouples. T48 probe tip issues have occurred periodically for years. Enhancements are noted in the applicable slide (34) with recommendations.
- Variable geometry pump issues have contributed to engine shutdowns. Details are presented. Recommendation: Keep a spare pump in on-site inventory.
- HPC S14 blade leading-edge distress typically is identified during the first or second borescope examination after an overhaul. A top case is suggested to exchange/repair distressed hardware. Investigation revealed tangs on vane end stops exhibited intergranular fracture.
- HPC VSV S1 and S2 inner-shroud bushing wear where the vane connects into the inner shrouds. Distress has been found during borescope examinations of engines in load-following/peaking service—earliest after 13,000 hours/1600 starts. Bear in mind that worn bushings allow the inner trunnion to move within the shroud. Field containment: HPC case removal and shroud exchange. Recommendation: Incorporate Service Bulletin 349 at the same time as the shroud exchange.

Active package programs

Jurgen De Ceuster, LM6000 package PSE lead, coordinated this portion of the program with Glenn Knight, LM6000 fleet manager. It addressed timers/counters for parts-life tracking, package compression-type tube fittings, product bulletins and letters, and provided instructions on how to locate technical publications and manuals in the customer portal.

- LM6000 Velox: Faster power to the grid. This is described as a key driver to reduce total installed cost. A 38% reduction in scheduled time and more than a 4000-hr saving in labor hours are promised. Specifics are provided in the slide deck.
- Timers/counters for parts-life tracking of engine subassemblies. Product Bulletin 362 pertains to GE software, BP 364 to Woodward software.
- Package compression-type tube fittings from two different suppliers (Swagelok and Let-Lock) were mixed at the supplier level. Belief is that leaks resulted from this mixture of parts. Users were told to follow Swagelok installation instructions for any replacement or retightening activity.
- Product bulletins and letters recently released are listed on Slide 46.
- Instructions on how to locate technical publications and manuals in the customer portal were presented in Slides 47-54.
- Service bulletins and letters recently released are listed on Slide 60. The compliance levels, categories, and timing codes associated with this documentation are the same as those presented earlier for the LM2500.

CM&U. Chraibi returned to the front of the room to lead the discussion on CM&U.

He began with a review of current and coming industry trends, suggesting to attendees that aligning with them increases your plant's future relevance. Here are the trends Chraibi sees and what might be your response:

- Increasing renewables penetration. Add synchronous condenser or inertia to plant equipment; provide faster startup or load-ramp capabilities.
- Plant held at low loads. Expand turndown capability and/or part-power efficiency.
- Electricity supply shortages. Increase plant output capability (peak or long term).
- Fuel supply curtailments. Alternative fuel capabilities beyond distillate—hydrogen, biodiesel, for example.
- Higher penalties for non-conformance to commitments. Invest in availability/reliability/maintainability improvements.
- More challenging to schedule maintenance outages. Eliminate or extend maintenance intervals.

Discussion continued with a focus on LM6000 upgrades. The highlights (relevant

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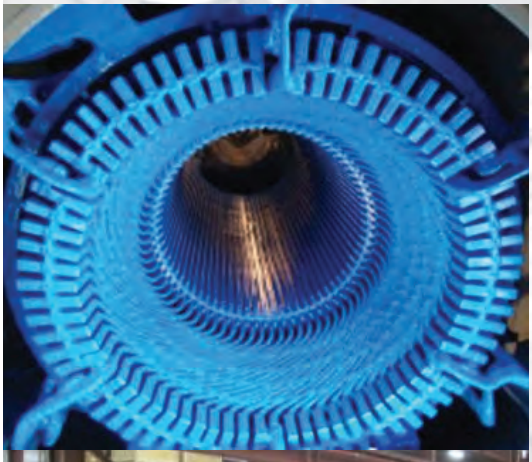

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engine models are in parentheses):

- AGP Xtend (PC). Upgraded combustor and hot section to extend maintenance intervals.
- OpFlex™ fast start (PC, PD, PF, PG, PH). Reduce the required startup cycle time to achieve full-load operation.
- OpFlex™ peak performance (PC, PD, PF). Increase power output by up to 5%; improve heat rate by up to 1.5%.
- Part-load efficiency (PD, PF). Improve heat rate by up to as much as 4% while operating at part load (60% to 90%).
- Synchronous condenser (PC, PD, PF). Grid support, especially for those with high renewables input.
- LM6000 PD to PF, PF1, PF2 upgrade. Engine upgrade for boosting output and reducing heat rate.

Wayne Romeo, FieldCore's senior service manager for the East Coast, closed out the GE program with much the same message that he had for the LM2500 group, which was outlined a couple of pages earlier.

LM6000, ASPs

The three Authorized Service Providers for the LM6000—TransCanada Turbines, Germany's MTU Power, and Japan's IHI—presented overviews of their companies' capabilities during the WTUI 33 General Session on Monday morning. Each later participated in the LM6000 Breakout Session with technical findings. Here's what each said during the technical portion of the program:

TCT made two presentations—one focused on field-service findings, the other on shop findings. Focus of the former was on these topics:

- Air inlet filtration.
- FOD sock cleanliness and replacement (Product Bulletins 173 and 345).
- Passive clearance control (PCC).
- PCC manifold update.
- PCC field inspections (Service Bulletin 351 for PA, PC, and PG engines and Service Bulletin 352 for PD, PF1, PF2, and PH machines).

Access the slide deck, the LM6000 PC O&M manual, and the documents referenced above for more detail.

Depot experience covered in the slide deck includes the following:

- Maintenance planning with identification of critical spares.
- Rotable asset backgrounder, advantages, and challenges.
- Corrosion challenges with some life-limited parts—such as LPC discs and shafts, LP mid shafts, and fan forward shafts.
- HPC S3-5 blade dovetail coating refurbishment, fretting between dovetail and blade slot, and accelerated wear from high start-cycle dispatch. Refer to Service Bulletin 310.
- SAC combustor development. Summary of known Jet-Rad issues, plus the intended benefits and observed challenges of Rad-Rad.
- Service Bulletin 340 update—HPTN2 full-wrap TBC.
- LPT S5 blade update with historical background and recent developments. Consult Service Bulletin 295.

MTU's presenters Ralph Reichert and Marco Mori spoke on these topics of significant interest to the user community:

- TRF repair to correct an excessive-gap condition associated with one of the mounting pins. Repair first involved removal of the LPT and TRF modules and disassembly of the latter, repair of the affected mounting holes, reassembly of the TRF module and its installation on the LPT, reinstallation of the LPT module, and finally engine test. This effort involved a joint effort with the OEM to develop a sustainable repair process for future use.
- Test issue concerning pre-synchronization vibration peaks.
- Test issue concerning lube-oil supply pressure.
- S3 nozzle airfoil liberation from a PC (SAC) machine. Key facts: Baseload service, 106,000 operating hours, 1165 starts, two previous overhaul cycles, high-humidity environment, water vaporizer to reduce intake temperature, fuel-nozzle water injection to reduce NOx. Metallurgical examination and tests were ongoing at the time of the meeting.
- HPC S1 blade replacement (before and after Service Bulletin 337). Primary reason for the onsite S1 blade replacement was worn/defective wear pads.
- SAC combustor: Splash/dome plate separation. Incident occurred within 2000 hours of quick-start peak-load operation after overhaul of the combustion chamber. Damage was found during a scheduled borescope inspection; there were no obvious abnormal readings observed beforehand. Presentation is thorough, detailing investigation results and assumptions made.
- Efficiency improvement at partial power. Method to improve part-load heat rate was to reduce the amount of bleed air. This included revising combustion-control algorithms, changing fuel flow, and other elements. Combustion modes were changed to better control fuel/air ratio. Data charts and tables provide details of interest. The bottom line: efficiency increased by 0.6% and fuel consumption was reduced by 65 lb/hr.

IHI made two presentations, like TCT and MTU, one on field service findings the other on recent shop experiences. Immediately below are the topics from field work:

- LP vibration issue emerged following a hot section repair on the HPT S1 nozzle assembly and combustor. It was observed at 12 MW load during engine warmup. No vibration was in evidence in the unit's 70k operating hours prior to the overhaul. Details provided included startup and shutdown data (vibration increased during deceleration) and polar diagram, plus the effect of countermeasures.
- L&S-pump oil leak. Observations included high oil leakage on the flange between the pump front case and the pump proper, loose bolts connecting the pump to the front case, and a through crack on the edge of the pump flange around the bolt hole. Investigation revealed this unit had counterbores for pump flange bolts which prevented the use of safety wire. Problem was solved by replacing the pump with one having no counterbores on the flange and by installing safety wire on the mount bolts.
- Starter-clutch scavenge-oil high temperature. Inspection revealed fretting on the quill-shaft spline attributed to metal powder, which restricted shaft movement and increased the load on the bearings. Result: Temperature of the oil passing through the bearings increased. Solution: More aggressive inspection of quill shaft condition to avoid unscheduled outages.
- VBV link distress attributed to rubbing on the CFF with the VBV actuation ring was corrected by replacing the rod-end bearing and actuator clevis. Inspection and calibration recommendations are provided.

Topics from IHI's shop experience:

- T800 fuel nozzle and combustor wear. Inspection of 30 fuel nozzles for a daily start/stop unit, following the finding of excessive wear and cracking of the primary swirler, found 21 in unserviceable condition based on GEK 105059, WP 4015. Recall that T800 is a hard wear coating (Service Bulletin 301). Shop visit was scheduled following more than 25k service hours.
- HPC S3-9 (P/N 1333M66G10) spool distress. The as-received part for this daily stop/start unit had damage to the S3, 4, 6, and 8 lock-and-load slots and was not serviceable. Root cause was under evaluation at the time of the presentation. Attendees were advised that a different type of spool (P/N L44659P01) should be repairable for the distress encountered.
- Fan mid-shaft pitting. P/N 47747P02 was considered unrepairable because of pitting on the forward spline flanks and concerns with the removal of plating and coating from aft tangs, grooves, and slots. Evaluation of shaft salvage considerations and removal of plating and coating were ongoing at the time of the presentation.
- LPT S2 disc denting and fretting on the outside dovetail lip was the reason P/N L47742P01 was deemed scrap. A root-cause evaluation is ongoing.

Woodward

Woodward's presentation on controls obsolescence and upgrades is "reader friendly" with a 50-slide overview of the company's many hardware and software products for

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all LM6000 models from PA through PF2. The PowerPoint is divided into the following sections:

- Service tool updates, focusing on MicroNet Plus enhancements.
- Support agreement and remote support, including cyber-secure remote access.
- Training.
- Valves and drivers—product descriptions and notes on obsolesce, driver details and upgrade paths, maintenance and overhaul, and storage.
- Blending of natural gas and hydrogen to reduce emissions with discussion of products compatible with up to 100% H2.
- Case studies on adaptive fuel metering, fast synch, smart synch for small-grid frequency support.

PROENERGY

Rob Andrews, chief technology officer, and Bob Bosse, VP aero products, presented "Resilience: Maintaining plant performance in extreme hot and cold weather." Quick recovery from difficult conditions is their focus.

If you're unfamiliar with the company, it has a portfolio of about 100 LM6000s in round numbers—including units it manufactured, operates, maintains, overhauls, uprates, etc. Catch up on what the company is doing by reading CCJ's reports on the PROENERGY conferences in No. 77, p 78 and p 96 this issue.

The WTUI presentation covers anti-icing options for the LM6000, the benefits of adding fogging and wet compression, fogger design and location—complete with photos and drawings.

LMS100, GE

The LMS100 sessions were organized and moderated by Jason King of Onward Energy. He assumed responsibility for the group when Steve Worthington's term ended in 2024.

The 81 units in this fleet at the start of 2024 are supported by GE; no ASPs are involved. However, the OEM works closely with members of the Aero Alliance Joint Venture between GE and Baker Hughes.

The GE Vernova team was led by Product Leader Tim Schneck and Senior Product Service Engineer Nate Yux. AAJV participants sharing their knowledge of the LMS100 were Ahmed Ghazi, senior product leader; Juan Trevino, VP safety, quality and process, and tools; and Glenn Knight III, fleet manager.

The first engine breakout session on Monday afternoon began with a fleet overview, reliability and availability statistics, and other general information. A handy chart (Slide 13) of value to users showed an engine horizontal cutaway drawing identifying, at a glance, about two dozen RAM programs—completed, in progress, and planned—component by component.

First technical topic was the durability of HPC S3-5 with short descriptions of related "events" and their status (such as VSV component wear and dovetail separations) and the underlying causes of them. Meaningful photos and drawings facilitate the understanding the challenges and solutions.

Later slides accessible by you are dedicated to the following:

- Intermediate-pressure-turbine (IPT) update.
- IPT frame bolt and securing hardware issue.
- HP recoup tubing and other piping.
- Power turbine S5 blade issue.
- LMS100 J3/J4 bearing tools.
- Trillium Flow Tech motor, pump, and drive for the water-injection system.
- Water-injection enhancements—pump and drive.

The AAJV's Ghazi reviewed LMS100 repairs developed in 2023—including a bellows gasket repair for the compressor front frame, blade and nozzle-assembly repairs for the HPT, and repairs for S1-5 blades. The repair development plan for 2024 was summarized.

Trevino reviewed key elements of the service center's overhaul process and data analytics before explaining the AAJV quality improvement plan.

Knight identified the bulletins and letters of importance issued in 2023. The Service Bulletins:

- SB 226. IPT frame strut No. 2, vent tube, and strut No. 9, pressurization tube improvement (at first exposure).
- SB 220. LMS100 HP recoup and thrust-balance variable orifice plate improvement (optional).
- SB 225. LMS100 HPT S1 nozzle vane baffle replacement (at first exposure; shop visit).
- SB 224. DLE fuel-nozzle premixer re-

placement (optional).
- SB 223. Introduction of combustor chamber assembly; P/N L38699G11 (at first exposure).
- SB 192-R4. LMS100 HPC VSV S3-5 lever-arm improvement (at component part repair or replacement).

The Service Letters issued in 2023:
- SL 23-002. Bellows shipping restraint/bracket tool.
- SL 23-003. Authorized GE aeroderivative service providers.

LMS100 Product Bulletins issued in 2023:
- PB 220. LMS100 top-mounted air filter 5-ton crane beam relocation (at first opportunity).
- PB 218. 50-MHz mineral lube-oil air/oil separator replacement (optional).

There was one Product Letter (23-001) issued for the LMS100 in 2023, Jacking-oil hoses for Brush DAX oil-fed bearings.

FieldCore field service and CM&U install slides were virtually the same as those for the LM6000.

Woodward also presented to LMS100 users, focusing on valves and the blending of natural gas and hydrogen. Most of this information was covered in the LM6000 program.

Special technical presentations

Tuesday afternoons at Western Turbine meetings are reserved for nine Special Technical Presentations, approved by WTUI leadership, to extend the meeting's content beyond the four GE aero engines on the program. The hour-long presentations (with Q&A) are arranged in three parallel sessions. Slide decks are posted on the WTUI website, but access requires an email request to Webmaster Wayne Feragen at wferagen@wtui.com.

Best practices, *Scott Schwieger, Combined Cycle Journal.*

Best practices submitted to CCJ by aero users as part of the annual awards program sponsored by the periodical and WTUI were reviewed and supported by active discussion. Focus was on LM6000 and LMS100 engines installed by Sentinel Energy Center, Lawrence County Generating Station, REO Cogeneration Plant, Worthington Generation Station, Wildflower Indigo (and Lockspur) Energy Facility, and Mariposa Energy Project.

Discussion topics included the following:
- Hiring and retaining a qualified workforce.
- GoPro camera for visual inspection of "hidden" areas in the turbine package.
- "Ladder Last" program contributes to fall prevention.
- Battery-powered tools protect personnel against extension-cord hazards.
- IR camera doubles as a safety tool.
- Focus on rounds to improve plant performance.

Get the details by reviewing the articles in CCJ No. 77 on pages 48-58.

Attendees not associated with the award recipients also were invited to share their best practices with the group.

Formaldehyde regulations and air testing on LM2500 and LM6000 turbines, *Blake Ericson, Montrose Environmental Group.*

New regulations require that many LM2500 and LM6000 gas turbines be tested for formaldehyde emissions. Recall that formaldehyde forms from the oxidation of methane and typically is found in concentrations of 200 to 800 ppb at the catalyst inlet. Also, that lean premix combustors emit lower levels than diffusion-flame systems.

One of the challenges faced by some owner/operators is that traditional testing methods cannot accurately determine formaldehyde emissions below several hundred ppb, let alone the 91-ppm threshold specified.

Ericson identified new optimized techniques for measuring formaldehyde

24STP-1. A new technique for reliably measuring formaldehyde emissions is said to be MAX-iR™ with TOM™. The instrument has a sensitivity of more than 100 ppb out of the box; TOM gets the sensitivity down to less than 10 ppb

emissions at much lower concentrations than are possible using standard methods (Fig 24STP-1). Some are said to provide continuous and real-time data useful in combustion tuning, compliance, engineering, and demonstration of combustion or post-combustion controls.

Advanced inspection ahead of major outages for maintenance planning, *Jack Odlum, HRST Inc.*

Aging HRSGs experience problems that require greater effort to find and assess compared to those associated with newer boilers. Pressure-part component degradation mechanisms like creep, fatigue, and pitting require advanced inspection tools—those that allow you to see what you normally would not—to detect problems early and allow adequate time for planning of repairs to coincide with already-scheduled major turbine outages (Fig 24STP-2). This approach saves time, money, and effort.

Presentation highlights several inspection techniques—including UT, borescope, pulsed eddy current, MT, PT, phased-array ultrasonic testing, infrared imaging,

24STP-2. Economizer drain leak, but where? All drains were removed to get the answer to that question. One drain was found leaking, the others extremely corroded

replication—and identifies strengths and applications, as well as the locations and timetable to target their use ahead of major turbine outages. Examples and photos of these techniques, significant findings, and the impacts they have on future outage planning are instructive.

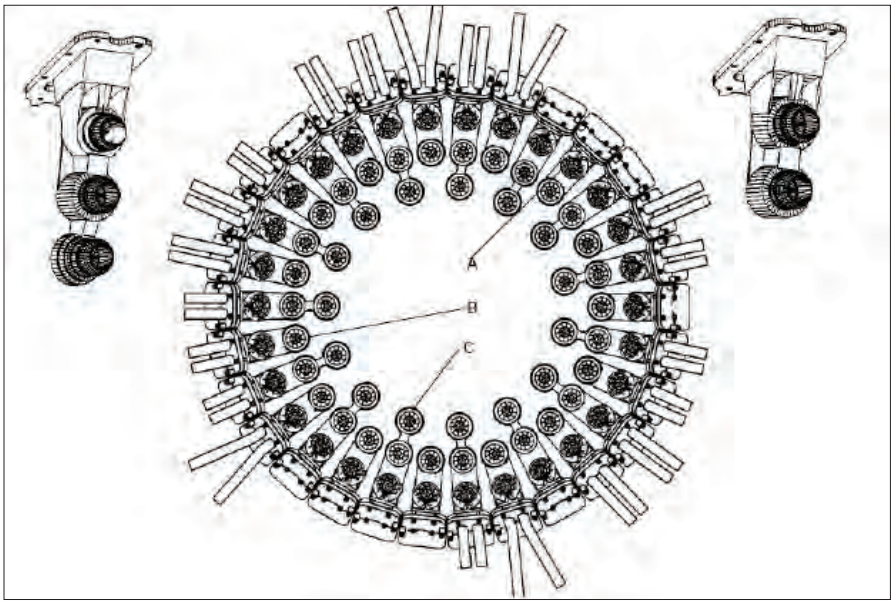
GE LM series DLE, "DLE 101," *Marc Forget, ENGIE Electrabel-EMS Aero.*

GE LM DLE technology differentiates itself from SAC (single annular combustor) by using lean premix combustion. Aim of the presentation is to educate DLE users and demystify DLE technology and controls, a goal achieved. It enables users to come away with a better understanding of operational issues they may encounter and be better prepared to efficiently troubleshoot problems.

The presentation is divided into the following sections and easy to follow:

- DLE introduction, including discussion of the NOx versus CO emissions compromise.
- DLE hardware (Fig 24STP-3).
- Flame temperature control.
- Controls protection.
- Mapping basics.
- Real world issues, including sulfur deposition, gas system fouling, premix air leaks, acoustic baffle liberation, etc.

Forget began by outlining the differences in construction and setup between the two



24STP-3. Hardware arrangement for a lean premix combustion system capable of operating on both natural gas and liquid fuel, the latter optional. The combustor shown has 75 air/gas premix cups packaged in 30 externally removable and replaceable modules (premixers). Arrangement is in three rings—outer, pilot, and inner (ABC in the diagram). You can't miss the 20 protruding acoustic baffles (a/k/a elk horns) for absorbing combustion noises

combustion systems—including combustors, premixers, and DLE fuel-system layout and controls.

The need for DLE unique instrumentation—such as gas-quality and combustion-stability measurements, GP sensors for fuel-flow calculation, and accurate fuel regulating valves—is discussed, as well as the impact of these instruments and components on gas-turbine operability.

Following an overview of the basic principles of DLE combustion controls, users are introduced to key system parameters—such as the different calculated flame temperatures, combustor staging, window operation, and fuel-flow regulation and distribution—as well as the impact of ABAL logic.

The takeaways:

- It's important for plants to invest in DLE system knowledge, focusing on the following;
  - Control system and software logic/algorithms.
  - Specialty instrumentation and control system components.
  - Mapping process.
  - Troubleshooting tools. A monkey wrench is not an appropriate tool in the DLE troubleshooting toolbox.
- Small deviations can have big consequences, making it important to ensure proper component (calorimeter, premixer, etc) maintenance.
- Finally, do not map until the problem at hand is understood.

Predicting failures and minimizing downtime with remote M&D,

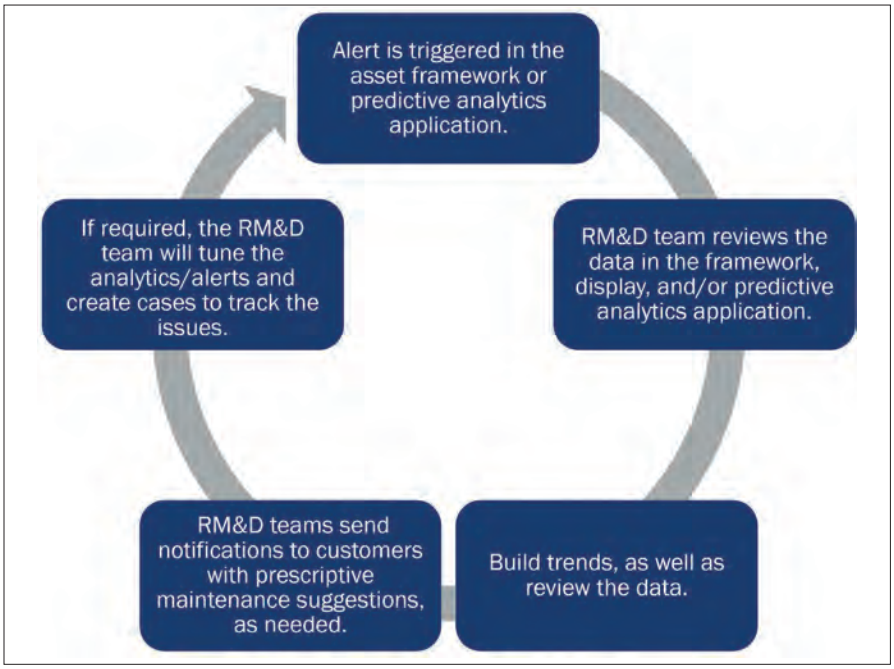
Donovan Duncan, PROENERGY, and Steve Worthington, Arizona Public Service Co.

Duncan noted that the demand for

dispatchable power generation continues to increase. Witness the record starts, stops, and overall usage of aeroderivative gas turbines nearly each quarter for the past three years. A result is an increase in equipment wear and tear.

This is important: The power market's reliance on aeros means WTUI members cannot afford unplanned outages caused by being blind to actual equipment condition between inspections, the speaker said. That would force them operate reactively to alarms or failures.

Remote monitoring and diagnostics (RM&D)—proven outside of peaking applications—enables users to take a proactive approach, predict when problems are developing, and give operators the opportunity to mitigate those problems until a planned outage is possible (Fig 24STP-4). True predictive analytics have proved elusive to peaking facilities because of their very nature—including change operating profiles, run times, and varied stops and starts.



24STP-4. How RM&D creates data-based insights to emerging issues

Duncan discussed the application of intelligent technology—such as predictive analysis, machine learning, and advanced pattern recognition—to discern the asset's operating profile, subtle performance variations, and actual condition. The data result in accurate site-specific trend analysis, a failure-severity analysis, an estimated time to failure, and real-time performance deviations.

Plant Manager Worthington followed Duncan. Note that he has since moved on from APS, where he was responsible for a wide range of generating assets—including 10 LM6000s and five LMS100s. Worthington's presentation focused on run profiles and engine performance, issues encountered, and solutions. Review of the charts presented is instructive. A stat that stands out: An increase in starts for his LM6000 fleet of 40% since the fourth quarter of 2016.

Another: 831 events associated with his former units that have occurred since October 2016 caused a failed start or lost

24STP-5. Environex added to the earlier discussion by Montrose Environmental on the removal of formaldehyde by CO catalyst, noting that users should expect 60% to 80% capture of CH2O. Toback added that removal depends on the starting concentration. Further that most turbines are below the 91-ppbv limit at baseload, but low-load emissions can be very high

generation. Reliability issues were studied via apparent, root, and/or common cause analysis. The last identified the following as the Top Five issues:

- Failure of the vibration monitoring system.
- Failure of turbine package instrumentation.
- Failure of the ammonia system.
- Failure of the gas regulating station.
- Failure of the power-block gas delivery system.

How NOx and CO/VOC control have changed in the post-2020 world,

Andy Toback, Environex.

Emissions control technology has advanced considerably over the past several years to meet the power industry's ever-evolving challenges. The need for operational flexibility and the advent of low-carbon fuels has created even more challenges for catalytic emissions-control systems already being pushed to their limits (Fig 24STP-5). Catalyst technology researchers and suppliers have stepped up with new formulations and designs to meet the industry's latest demands.

Toback brought aero users up to speed on the new tools available to help them meet current and expected emissions-control challenges—including the following:

- High-temperature dual-function catalysts developed especially for use in simple-cycle peaking plants. Experience and data provided will help users decide if high-temperature dual-function catalysts are viable for their plants.
- Hydrogen fuel blending. Integrating hydrogen into the fuel mix may help to reduce carbon emissions, but CO2 is not the only emissions consideration involved with using hydrogen. Be aware that the higher firing temperatures associated with burning hydrogen increase gas-turbine NOx emissions which, in turn, increase the NOx conversion requirements for SCR systems.

  Toback discussed the impact hydrogen blending has on SCR/CO systems and the factors to consider when evaluating what changes may be needed to ensure reliable emissions performance with hydrogen use.
- Other catalyst technology developments—including low-DP designs along with their intended and unintended consequences, new catalyst formulations and designs, changes to the supplier landscape, etc.

Optimized insulation for gas turbines,

Pierre Ansmann, ARNOLD Group.

Ansmann began by pointing to the problems ARNOLD's insulation systems avoid with the company's highly engineered 3D-shaped blankets that fit perfectly to the shape of exhaust system components (Fig

24STP-6)—including the following:

- Interlocking steps between blankets, and use of stainless-steel coil and super-tight wire mesh to virtually eliminate vibration damage.
- Blanket damage requiring repair/replacement every outage.
- Surface hot spots conducive to insulation damage.
- Overheated noise enclosure.
- Loose fibers and dust that can cause health and safety issues.

24STP-6. ARNOLD Group insulation systems for LM2500 and LM6000 engines are designed for a perfect fit to the gas turbine, thereby maximizing the lifetime of the thermal shield

Photos and drawings abound in this detailed presentation likely to answer any questions related to the design and effectiveness of the ARNOLD insulation system.

More sustainable aero-turbine operation through lubricant chemistry management, *Dr Matthew Hobbs and Peter Dufresne, EPT Clean Oil.*

While aeroderivative GTs (LM2500, LM6000, RB211/Siemens A35, and PW4000) are efficient, aero lubricant monitoring and maintenance practices lag behind those established for analogous industrial gas-turbine oils, according to the experts at EPT Clean Oil (Fig 24STP-7). Most jet oil programs neglect the application's primary cause of failure: Inadequate

24STP-7. EPT Clean Oil focused on more sustainable aero turbine operation through lubricant chemistry management

management of the GT's lifeblood—its oil. Because maintenance and sustainability go hand-in-hand, methods for better oil management can have a significant positive impact on aero engine operation.

Hobbs and Dufresne stressed that business as usual isn't good enough and that owner/operators can close critical gaps in their lubricant chemistry programs to operate more reliably, profitably, and sustainably. Their recommendations:

- Run the tests presented in the slide deck and act on results.
- Apply your maintenance budget towards the causes of failures and address the root causes of oil and equipment failure

The speakers recommended that EPT Clean Oil's oil conditioning skid (SVR-JET) is critical to successful lubricant chemistry management. It uses engineered ion-exchange media (ICB-JET) to remove varnish and acids and a dry nitrogen generator to manage water and oxygen content to prevent varnish and acids.

BRUSH® power generation: Solutions, *Ian Golightly, Baker Hughes.* Golightly's presentation is all about helping you mitigate unscheduled generator outages with an excitation controller upgrade. As your generator's excitation controller ages, he said, the need for maintenance increases, as does the chance of components becoming obsolete or unusable. Regular maintenance and repairs are important to ensure longevity and optimal operation. Another option is to replace your analog controller with a modern digital-based version. The focus of that recommendation is the Brush Prismic® A3100 excitation controller (Fig 24STP-8).

The senior controls engineer began with a look at today's Brush, which is considerably different than the 1957 version of the company which traces its roots to the UK and Hawker Siddeley. The latest iteration is Brush Power Generation, purchased in 2022 by Baker Hughes as part of its vertical integration strategy. The highlights of Golightly's presentation:

- Evolution of the excitation controller product.
- NERC compliance.
- Modern digital excitation controllers.
- Upgrade methodologies.

Plus, an overview of Brush's solution offering and service support. CCJ

24STP-8. Excitation controllers and their upgrades is the focal point of the Brush presentation. Shown here is the company's Prismic® A3100 dual redundant offering

Worthington Generation Station

Owned by Hoosier Energy Rural Electric Co-op Inc
Operated by NAES Corp

174 MW, gas-fired facility equipped with four LM6000 simple-cycle engines for meeting member peaking-power needs, making off-system sales, and satisfying generating reserve requirements. Station is located in Green County, Ind, and connected to Hoosier's 138-kV transmission line

Plant manager:
Robert VanDenburgh

Relocating NOx-water pressure transmitter eliminates freeze-up concerns

Challenge. Worthington Generation is exposed to harsh winter conditions, so plant operators are well aware of the potential for freeze-related trips. The packages have heaters installed, and heat tracing, but cold temperatures always are a concern—specifically with the NOx-water injection system. It injects demineralized water into the combustor through the fuel nozzles to regulate flame temperature, thereby helping to keep NOx emissions within regulatory limits.

The NOx-water pressure transmitter is located 25 ft from the sample location, so ¼-in. tubing is run to provide the pressure signal required by the instrument. This tubing is a major freeze-up concern because of its length, small size, and location at the bottom of the package. Challenges facing plant personnel were these:

- How to prevent water in the tubing from freezing in the package.
- How to prevent the pressure transmitter from freeze-up in the gage panel.

Solution. Relocate the NOx-water transmitter and ¼-in. tubing to a warm location (photos). Staff researched areas near the package and discovered that the NOx-water building was a perfect place: Temperature is above 70F year-round and the tubing can be completely removed from the package. The steps taken:

- Relocate the NOx-water pressure transmitter from the gage panel to the heated NOx-water building.
- Remove the ¼-in. sensing tube from the package and install it in the NOx-water building.

Results. All NOx-water pressure-transmitter freeze concerns were eliminated.

Project participants:
Matthew O'Hara, lead O&M technician
Jason Robertson, Worthington Generation O&M/IC&E technician
William Hooker, Worthington Generation O&M technician
Garett Ray, Worthington Generation O&M technician

NOx-water pressure transmitter was relocated to protect against freeze-up

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Edgewood Energy LLC

Owned by J-Power USA Development Co
Operated by NAES Corp

88 MW, gas-fired 2 × 0 LM6000-powered peaking plant, located in Brentwood, NY

Plant manager: Kenneth Ford

Relief-valve monitor protects against fluid spills

Background. Edgewood's gas-compressor (GC) skid is comprised of three screw-type compressors served by a common system for removing lube oil entrained in the natural gas at the skid discharge by way of coalescing scrubbers.

Challenge. During a routine startup, a mist was noticed emanating from the relief-valve discharge piping of one compressor. The mist was quickly determined to be compressor lube oil and the GC skid was shut down by manual E-stop.

Staff investigated the event and concluded that one relief valve had lifted prematurely, causing a spill of approximately 50 gallons of lube oil spread over a large area within the facility. The site's spill vendor was mobilized and the affected area cleaned up—including the removal of several drums of blue stone from the site. Personnel sent the affected relief valve offsite for a standard overhaul and testing.

A post-incident review found that the GC skid controls did not receive any alarms, nor any indication, that the relief valve had lifted. Manual intervention was required to stop the incident and prevent additional release.

Had this occurred in the evening, the likelihood of the spill going unnoticed would have been extremely high, with the anticipated spill volume being far greater than for this incident. Personnel focused on how to control such an event in the future, where a potential spill would be detected early enough to initiate an automatic shutdown of the skid.

Wireless position monitor (left) is installed on one of the gas-compressor discharge headers; pressurized enclosure cabinet at right contains the wireless gateway and Modbus interface

Solution. Management evaluated several options to prevent a recurrence of the event—including acoustic monitoring of downstream relief-valve piping to detect flow, and physical monitoring of relief-valve position. Wired and wireless installation was considered for both options.

Following research that included consultation with potential vendors and other power-plant managers, Edgewood management decided the most suitable option was to install wireless monitors on each of the valves to detect when any one moved from its closed-seat position. Minor modification of the relief valves was required to allow installation of position-detection hardware.

The monitoring devices were installed and connected through a wireless gateway to the GC-skid control system. Finally, system logic was modified to automatically shut down the skid should any of the valve monitoring devices detect a valve not in the closed position. Additional alarms and shutdowns were created to support the effort.

Results. Since system installation and commissioning, no relief valve has lifted unexpectedly. Annual checks of system functionality are conducted to help ensure the system will continue to function as desired.

Project participants:
Michael Citarelli
Anthony Angieri
Ed Lozada

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Equus Power 1 LP

Owned by J-Power USA Development Co
Operated by NAES Corp

48 MW, dual-fuel 1 × 0 LM6000-powered peaking plant, located in Freeport, NY

Plant manager: Kenneth Ford

Access platform replaces ladders to help keep personnel safe

Challenge. Equus' Higgot-Kane anti-icing system is mounted on the gas turbine exhaust section and relies on exhaust gas to heat air drawn into the machine for combustion. The system relies on a motor-driven blower and mechanical damper, both of which must be maintained. Unfortunately, anti-icing system components are located on the top of the exchanger, approximately 16-20 ft above grade.

Solution. Install a fixed platform with ladder to allow safe access for maintenance and troubleshooting of the motor, blower, and damper.

Results. Plant engaged a local fabricator that has manufactured and installed other fixed ladders and platforms for other J-Power assets on Long Island, NY. It designed, fabricated, and installed a suitable platform to allow safe access to system components.

Project participants:
Nicholas Muccio
Dan Frederick
Brett Miller

Ladder and work platform, a safety initiative, were mounted on the gas-turbine exhaust section (left). Platform provides direct access to the blower fan and motor for maintenance (right)

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REO Cogeneration Plant

Owned and operated by Lansing Board of Water & Light

100 MW, 2 × 1 LM6000PF-powered combined cycle equipped with IST once-through steam generators, located in Lansing, Mich

Plant manager: Tom Dickinson

Cleaning of fuel-gas pipeline reduces emissions

Challenge. The REO Cogeneration Facility, COD 2014, in 2018 began experiencing operational complications that, in hindsight, could be attributed to oil contamination of the fuel-gas pipeline supplying its gas turbines. Subsequently, the plant had to replace combustor fuel nozzles at an accelerated rate to stay within emissions limits, as well as to operate its duct burner. Emissions of both CO and NOx consistently were at the upper acceptable limits and the plant was mapping and remapping excessively.

Numerous efforts were made to eliminate or mitigate oil from making its way past the gas turbines' final fuel-gas filters. Below is a list of improvements that were made with varying degrees of impact on emissions:

- Installation of an additional horizontal fuel-gas filter.
- Gas supplier installed an additional upstream filter.
- Gas supplier enhanced maintenance activities on its equipment.
- Fuel-gas filters always are smoke tested to evaluate their integrity.
- Upgraded fuel-gas filters to specifically remove compressor oil.
- Replaced all valves on fuel-gas conditioning equipment that could allow for leak-by of filters.
- Hydrolazed and chemically cleaned fuel-gas lines.

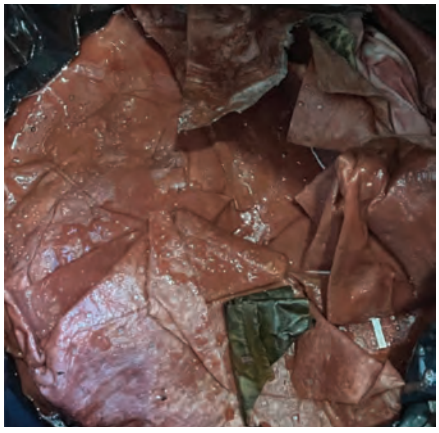
Solution. All the improvements made over the last few years had at least some positive impact on mitigating or removing oil from the fuel-gas lines. However, only cleaning of the fuel-gas lines significantly reduced emissions.

Pipeline cleaning started at the outlet of the plant's gas compressors. An underground portion of pipe spanning about 400 ft with no low-point drain was cleaned first, followed by flow through the new horizontal filter and then through each gas turbine's dedicated vertical final filters up to the wye strainers in each turbine package.

The pipeline was cleaned thusly: The underground portion was hydrolazed and the rest chemically cleaned. The first segment of pipe contained an estimated 300 gallons of dark oil and particulate matter (photo). Red compressor oil found in the remainder of the piping was manually removed from the recirculation tank during the chemical-cleaning process—not a typical task.

Results. Cleaning resulted in an emissions reduction: 24.8 ppm CO to running consistently between 5.8 and 9 ppm. Plant had not seen emissions this low since its first year of operation.

Project participants:
Rachel Sayen, Lansing Board of Water & Light
REO maintenance team
Contractor personnel from OhmHub and RelaDyne



Black, oily waste collected during hydrolazing of the fuel-gas pipeline was disposed of in an environmentally sound manner

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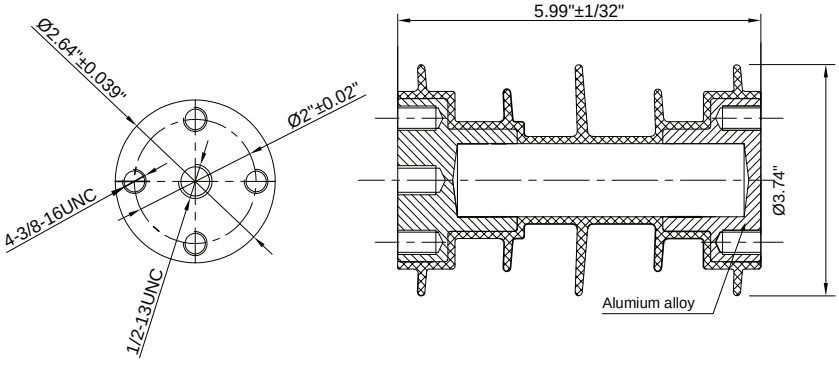
Min creepage distance	11.8inch
Acring distance	6.14inch

The color of weather sheds is light gray

Standard applied: ANSI C 29.1

2.5lb



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Shoreham Energy LLC

Owned by J-Power USA Development Co
Operated by NAES Corp

90 MW, 2 × 0 LM6000PC-powered peaking plant equipped to burn only liquid fuel, located in Shoreham, NY

Plant manager: Kenneth Ford

FOD-screen access-door mod enables safe opening/closing

Challenge. Shoreham's gas turbines were supplied with FOD-screen (foreign object damage) access doors designed for manual installation/removal to permit semi-annual inspections. Historically, these doors had been maneuvered using a rope and pulley arrangement. The possibility of injury given the pinch points and muscle strains created by awkward body positioning was concerning. The original setup (photo, left) also required that two or more employees had to work collaboratively in a very narrow space, thereby contributing to the risk of injury.

Solution. Install a handle and hinge bracket (middle photo) allowing the door to be opened easily to access the FOD screen. Not only would the weight of the door be supported fully by installing a dedicated hinge bracket, but a single employee would be able to open the door for inspection, and then secure it afterward.

Results. The site engaged a local fabricator that has manufactured similar equipment in the past and asked it to develop and install a hinge bracket and handle assembly on the inboard FOD screen access doors of each GT. The hinge assembly developed (photo, left) was a success, allowing easy opening and closing of the door without any additional manipulation.

Project participants:
Michael Citarelli
Anthony Angieri

FOD-screen inspection door before addition of handle and hinge (left). After several years of manually removing the door, personnel began using a hook and pully system to lower the door. While safer, the task still presented a moderate risk of injury to staff if not properly planned and executed. Contractors install pre-fabricated handle and hinge assembly in center photo. Finished product is at right

Unlock Maximum Efficiency: Maximize Turbine Performance with Dry Ice Blasting

Premium Plant Services, following its acquisitions of US Cleanblast and Polar Clean, has expanded its capabilities, geographic reach, and expertise to better serve the power industry. With a rich history and strong foundation, Premium Plant Services continues to be a leader in industrial cleaning solutions. We bring unmatched expertise, backed by proven case studies and measurable results, to every project.

With a focus on gas turbines, including the LM2500, LM6000, and LMS100 models, Premium Plant Services is a trusted vendor of GE. We have conducted comprehensive pre- and post-performance analyses, consistently demonstrating substantial gains in turbine efficiency after using dry ice blasting for compressor cleaning.

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- **Faster Cleaning:** Clean an entire High-Pressure Compressor (HPC) and casing in about 18 hours, compared to up to a week with hand cleaning.
- **Improved Efficiency:** Enhanced mass airflow, increased power output (up to 3-4 MW), and better stall margins.
- **Surface Protection:** Gentle on turbine components, preventing damage to critical parts like compressors and casings.
- **Safety:** Reduced injury risks compared to manual cleaning.
- **Waste-Free Process:** No secondary waste or need for containment systems.
- **Power Gains:** Post-cleaning power gains often reach up to 4 MW.
- **Maintenance Optimization:** Effective for borescope inspections (4K+ hours), top-case cleaning (16K hours/starts), and hot section exchanges (25K hours).
- **Cost Efficiency:** Significant time and cost savings.
- **Operational Benefits:** Prevents decreased stall margins, reduces fuel consumption, and meets contractual performance requirements.

Performance Feedback

- "The unit had about a 3 MW increase from a phone update I just a got from the Plant Manager; he is very happy with these results."
- "You can never get it as clean by hand as dry ice blasting"
- "This LM cleaning resulted in 4 MW regained!"
- "We had substantial buildup from airport issues. We got back 2 MW and great improvements overall."

Dry ice blasting has proven to be a superior method for cleaning gas turbines compared to traditional hand cleaning. It delivers faster, safer, and more efficient results with minimal disruption to plant operations. This method leads to increased power output, improved compressor efficiency, and enhanced turbine performance. Whether for routine maintenance or tackling severe dirt and hydrocarbon buildup, Premium Plant Services provides a trusted solution for the power industry.

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Mashav Energy

Owned by Mashav Initiating & Development
Operated by Mashav Energy

122 MW, 2 × 1 LM6000PF-powered combined cycle with a Siemens 300 steam turbine/generator, located in Ramia, Israel

Plant manager: Yohay Aviguy

Water conservation program saves millions of gallons annually

Challenge. Water is the lifeblood of powerplants, especially those located in desert environments. Every effort must be made to conserve this important resource. Mashav Energy focused on these three areas:
1. Reuse of blowdown from cooling towers serving the gas-turbine air inlet chillers (Figs 1 and 2).
2. Recovery of water from the steam-quality monitoring system (Fig 3).
3. Recovery of water from desalination-plant instrumentation (Fig 4).

Solution. 1. Blowdown from the two-cell cooling tower, totaling about 3.3 million gallons annually, first was sent to a collection tank and then piped to a nearby cement plant for process use. Looking for a better application of the resource, plant opted to install a small reverse-osmosis (RO) system to recover about 50% to 60% of the blowdown stream for cooling-tower makeup (30 µS conductivity and 9 pH). Reject water from the RO system is pumped to the cement plant for process use as before.
2. Water collected in a small tank from instrumentation in the steam-quality monitoring system is pumped to the cooling tower.
3. Water from instrumentation in the desalination plant are collected and pumped back to the potable-water holding tank which serves as a reservoir for the desal plant.

Results. 1. Payback for the RO system recovering water from the cooling-tower blowdown stream was only 14 months. The system now is in its third year of service.
2. All water used in the monitoring of steam quality is recovered.
3. Water recovered from instrumentation serving the water treatment system shown in Fig 4 totals about 1.6 million gallons annually. The system provides, in round numbers, 60 gpm of RO-quality water and 70 gpm of demineralized water.

Project participants:
Yohay Aviguy, plant manager

1. Cooling tower serving the gas-turbine inlet-air chillers is critical for producing maximum power

3. Water collected from the steam-quality monitoring system is sent to the cooling tower

2. Reverse-osmosis system recovers tower makeup water from the blowdown stream

4. Water treatment system can produce 60 gpm RO water and 70 gpm of demin water

Ammonia injection system improvements reduce operational risk, cut cost

Background. Mariposa is required to start and come to full load within 30 minutes. The plant uses 19% aqueous ammonia for NOx control in its SCRs and is equipped with CO catalyst.

As designed, when a start command was issued both of the unit's dilution-air fans would start. When they were in service, the dilution-air heater would begin heating the air supplied to the ammonia injection grid (AIG). The ammonia heater has three heating elements attached to the piping into the AIG: an in-duct heater that uses gas-turbine exhaust as the heat source, a 90-kW heater, and a 9-kW band heater. These elements were programmed in the DCS to maintain the pipe section at 800F.

The ammonia-system injection permissive requires the AIG temperature to reach 540F and the ammonia 350F before reagent injection can proceed. Warmup typically took between 12 and 15 minutes. In normal operation, the system was able to adequately control NOx and CO emissions.

During shutdown, the original design called for closing the ammonia-supply block valve when the 52G generator breaker opened. This control scheme effectively cuts off ammonia flow to the SCR while the GT is in its 5-minute cooldown period.

Challenge. Mariposa had been experiencing difficulty holding CO and NOx emissions within permit limits during plant startups and shutdowns. The issue had slowly been getting worse over time, and despite a recent CO catalyst replacement, continued to present risks to site availability and reliability.

Solution. The first step was to determine if 24/7 operation of electric heaters was required. Staff timed system warmup with the piping preheated versus the warmup time if the system started from ambient temperature. This test determined there was no benefit from 24/7 operation of the electric heaters because both warmup times were about 15 minutes.

The first improvement to the system: Turn off the 90-kW and band heaters when the unit was offline. While doing this, personnel found that all units showed significant distortion of the 6-in. piping downstream of the ammonia injection point. The distortion was attributed to the continuous heating of the band-heater section to 800F when the unit was offline with no air flow through the piping; plus, insufficient piping support (photo).

The second improvement was to reduce the 15-min warmup time for the ammonia injection system. When the plant received normal dispatch instructions 30 minutes prior to breaker closure, they enabled preheating of the ammonia injection system to begin 15-20 minutes before initiating a unit start.

While doing this, personnel observed ammonia injection becoming available within 5 minutes of engine start. Seeing the positive results from initial testing, staff added a button and programming to the DCS which would put all units, or an individual unit, in preheat condition prior to startup.

The third improvement was to address shutdown emissions for NOx that were close to the permit limits. This change focused on the ammonia block valve, which closed during the normal cooldown cycle. As valve closure essentially allowed 5+ minutes of uncontrolled emissions, personnel changed the auto close to be based on the GT fuel-gas valve rather than "breaker open." This controlled emissions during engine cooldown with minimum ammonia flow (30 lb/hr) to the SCR during the turbine cooldown period and did not allow ammonia flow when the engine was offline.

Mariposa Energy Project

Owned by Diamond Generating Corp
Operated by DGC Operations

200 MW, gas-fired 4 × 0 LM6000PC-powered (Sprint equipped) peaking plant, located in Alameda County, Calif

Plant manager: Justin Crook

Results. *1.* By only running the electric heaters during plant operation, plant auxiliary load was reduced. Warped piping was replaced before its inevitable failure.

2. Reducing the start time for ammonia injection from 15 to 5 minutes greatly reduced emissions during startup evolutions, which now fall well with permit limits.

3. Changing the shutdown logic has given the facility additional margin in the shutdown emissions limits.

The three improvements together have reduced the plant's parasitic load, annual emissions, and potential for a notice of violation and forced outage. Cost of the improvement was minimal because the projects were completed with plant staff and current equipment.

When this best practice was submitted for judging, there was insufficient data for 2024 to determine the actual cost saving associated with the reduction in parasitic load and the value of annual emission credits.

Project participants:
Justin Crook, plant manager
Fred Yarcho, O&M manager
Oliver Caoili, IC&E technician

Distortion of the 6-in. piping downstream of the ammonia injection point was attributed to the continuous heating of the band-heater section to 800F when in the offline condition with no air flow through the system

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O&M advice free for the asking

Online forums sponsored by gas-turbine user groups are of increasing value to owner/operators, especially given today's smaller O&M staffs at simple-cycle, combined-cycle, and cogeneration plants and the loss of experienced personnel to retirement and better opportunities. Long gone are the days of on-the-job training when new employees would tag along with experienced crews to grow their knowledge over time.

Thus, today you may be at a loss on whom to call with an important question. If that's the case, try posting that question to the forum serving your engine model. Oftentimes you'll receive expert advice at no cost within a day or two. Most likely your issue is not unique. Also, in need of a part in a hurry? Ask colleagues online to loan you their spare until you can replace it.

Forums serving the larger user groups typically provide the best results by virtue of their global reach. To illustrate the value proposition, CCJ editors selected a few questions posted to WTUI's LM2500, LM6000, and LMS100 Forums in 2024 along with a summary of the guidance offered. To join, go to www.wtui.com/forums. Questions? Contact Treasurer/webmaster Wayne Feragen at wferagen@wtui.com.

Feragen

LM2500

Sump temperature spike

Question: Has anyone experienced a rapid temperature increase in the A sump and accessory gearbox (AGB)—sometimes referred to as the transfer gearbox? Normally, AGB temperature is about 200F (round numbers), but in just a few minutes it jumped to 300F and stabilized. The A sump temperature exhibited the same behavior, but the temperature increase was only about 60 deg F.

Replies:

The first respondent said he witnessed the same at his plant for one unit packaged by Baker Hughes and installed in 2019. "We will see everything run fine for a period of time after a startup," he said. Then, all of a sudden, AGB temperature will increase to about 300F. Lately, there also has been a loss in SLO tank level at the same time, with no leak apparent. We have been doing some troubleshooting, but have not found anything definitive, yet.

The exchange continued with the questioner, a senior rotating-machinery engineer (RME), asking the first respondent if he also saw a rapid temperature in A sump. No immediate answer was forthcoming.

The RME added that clutch temperature also had increased while tank level decreased. At first, he believed there might have been a failure inside the AGB causing friction and the temperature increase. Or, it might be reduced oil flow causing the temperature increase. However, he considered the rapid increase in temperature without warning "puzzling". One more observation: A minor increase in gas-generator vibration.

A second user joined the conversation with the following opinion: Sounds like either your air ejector has cracked internally and is not drawing in compartment cooling air or your No. 3 air seal has failed and you're pushing air out of the ejector instead of drawing cool air into it.

One way to check is by putting your hand—protected by a welding glove—over the ejector screen to see if air is being pushed out while the engine is operating. If the engine is not operating check to see which side of the screen is dirty. If it's the outside then air is being draw in; if inside, the opposite.

The first respondent returned to say, "That something we are looking into but I would have assumed that if the ejector tube had cracked we should be seeing an increase in all sumps."

His experience was the same as that of the questioner: Major increase on the AGB drain temperature, minor increase on A sump temperature, and virtually nothing to speak of on B/C sumps.

A user with relevant experience asked to join the dialog offered the following: "Although air from the A/GBX cavities does communicate to the other sumps, the "low" temperatures in the A sump and GBX areas are cool enough to act as a tell-tale, moving temperature up noticeably, whereas the aft sumps are so hot that the casualty only moves the temperatures a few degrees, or maybe even imperceptibly. Also, the fact that the temperature stabilized and didn't run away tells us that it's a cooling step change and not a bearing welding itself to a shaft."

Concluding remarks from the questioner: A seal and/or ejector failure may explain the 60 deg F increase in the A sump temperature; however, "I'm still struggling to understand the rapid increase in AGB temperature. Finally, we have seen this rapid temperature increase two times in June, never before.

LM6000

MetalSCAN: What's your experience?

Question: We saw a presentation on MetalSCAN at WTUI and wanted to see if anyone else uses this system for debris detection in their sumps. If you have the system, do you have any pros or cons with it to share?

Editor's note: If you are considering a MetalSCAN system for your plant, the responses below may prove helpful in your evaluation. Bear in mind that some of the respondents have deep experience with the system, some have a deeper understanding of the technology and its limitations than others, some have legacy knowledge from a time when the system was not as sophisticated as it is today. If you have questions after digesting this material, consider posting them on the Forum.

Replies:

Respondent A said his plant installed MetalSCAN more than 10 years ago and had a wealth of experience. GE does not take the information the diagnostic system delivers seriously, he added, but in most cases the system will let you know when "something is happening." This plant operates 24/7.

Respondent B agreed with A's comment, saying the system is sensitive and will indicate issues days ahead of chip detectors. This site has experienced two bearing failures over the years. While using MetalSCAN to detect and monitor progression of the issue plant personnel were able to mobilize a replacement engine and resources before the unit was removed from service. Chip detectors did not identify the problem until the late stages of the failure.

OEM Gastops Ltd provided this user metal analysis support, helping to identify which bearings were liberating material.

Respondent C said his plant recently installed MetalSCAN and had no issues to report, but also little operating history to share. The driver for installing the system was the number of chip-detector alarms typically received after an outage which required shutdowns to investigate. Because most of these alarms had been triggered by non-bearing material, the expectation was that Gastops' technology would help plant personnel decide if a shutdown was necessary.

Respondent D. The MetalSCAN multi-sensor system is a valuable contributor to turbine operational management. It detects particles in the oil early, warning of potential bearing damage, thereby allowing staff time to plan maintenance and avoid more significant damage and costly unplanned

shutdowns. Magnetic chip detectors do not indicate an increase in temperature or in vibrations.

Respondent E. For what it's worth, we had an early iteration of MetalSCAN and it was nothing but distracting and unreliable. I cannot speak to the usefulness of current versions. Also, I would not dismiss a chip-detector alarm just because MetalSCAN was not indicating the presence of chips.

Respondent F charged out of the gate, so to speak, with a stinging rebuke of MetalSCAN, saying he did not know of any successful installations. It's been around for over 20 years, he said, adding that "GE tried to sell it as an upgrade, but I think there were lots of false positives."

A day later, in a second post, F dialed back on his assessment explaining why he believed false positives occurred. One reason, based on his findings, was that the system has difficulty identifying the source of ferrous particles when multiple components are ferrous.

He also questioned the reliability of the system's particle counting capability and its differentiation of particle sizes.

While all of this might be true, it appeared to the editors that most users view MetalSCAN much like the proverbial canary in the coal mine: To warn of potential danger. They did not seem to regard particle characteristics as important, generally speaking.

Respondent G offered a very detailed assessment of MetalSCAN, one totaling more than two typewritten pages. Here are a few takeaways from that response:

- MetalSCAN does what it is designed to do: Detect all particles, Fe and nonFe, and warn at predefined Fe mass limits. It will enable you to understand where you are in the degradation process of a bearing failure to better guide corrective action and minimize the impact.
- It will not avoid bearing damage, but will avoid secondary damage and its cost.
- Once installed, life gets easier, reducing the downtime required to stop and pull chip detectors, take oil samples, perform analyses, etc.
- System results are good and sufficiently correct to predict and recognize a bearing failure at a very early stage.
- Fleet experience included several catastrophic bearing failures with significant secondary damage prior to MetalSCAN installation; after installation, there were no *catastrophic* failures.
- Interpretation of the data gathered can be learned quickly; plus, you can always send the data to Gastops for their opinion.
- MetalSCAN and other actions allowed this user to extend maintenance intervals, reducing the number of outages that had been taken previously.
- Recommendation: Opt for the multi-sensor version of the system, not the single-sensor offering, which will not tell you which bearing is failing.

VFD pump versus pressurized loop

Question: We have two dual-fuel units that use a variable-frequency drive instead of a pressurized loop and metering valve to supply the fuel nozzles. According to the previous operators, the VFD configuration has reliability issues, especially on startup.

We are considering upgrading the system and returning to a traditional pressurized loop and metering-valve arrangement. Are any users with a VFD configuration for liquid fuel delivery experiencing reliability issues?

Replies:

Respondent 1. We use a common pressurized header to supply all seven of our LM6000 PC machines ultra-low-sulfur diesel fuel. The three forwarding pumps are equipped with VFDs and a return line with a metering valve and flowmeter—all to maintain 70 psig on the common header. Pumps at each unit boost fuel pressure from 70 to about 1000 psig.

Loop pressure is tied into the DCS, along

with the metering valve and flowmeter. As the turbines ramp up, this arrangement keeps system pressure stable and starts closing the return line to maintain a flow rate of 95 gpm. There have been no issues since installation about 15 years ago.

Respondent 2, first post. I won't use a VFD/pump arrangement: You always will have problems. GE had this design 20 years, or so, ago for its Gen 3 trailer-mounted TM2500s; no longer. I think that says a lot.

Remember that gas turbines often require very precise fuel delivery, and during startup and low-load operation there won't be much flow going to the combustor. The VFD might struggle to maintain the required accuracy because of pump characteristics at the lower speed.

Regarding dynamic response, on rapid changes in demand during load changes the pump inertia with VFD may give a slower response time than Woodward metering valves.

Finally, pump speed control might be an issue. Mechanical inertia and the VFD's ramp-up time might still lag rapid load changes—especially on transients.

Respondent 2, second post. If you are planning an upgrade, note that it is crucial to ensure the return line is routed back to the tank rather than to the suction. This approach reduces the heating effect and mitigates stability issues with the lead-lag operator in the fuel control software for the core.

Although routing to the tank may increase piping costs, it's worth the investment. This method improves fuel-regulator dynamics, making the system's gains smoother and more stable. My experience suggests this consideration is very important for achieving optimal performance.

GoPro cameras

Question: Does anyone have the information/layout for installing GoPro cameras inside the gas-turbine enclosure?

Replies:

Respondent 1, first post. GoPro cameras are not certified for IECx or ATEX, so they are not intrinsically safe to use in gas-turbine packages. The lithium-ion battery in these cameras can be dangerous because of the heat.

Respondent 2. We use AXIS cameras. Access this late November post on WTUI's LM6000 Forum to see the photos provided by the respondent. The cameras are kept on magnets so they can be moved around conveniently for troubleshooting.

Respondent 1, second post. If you need cameras for a gas-turbine package, consider ATEX-certified explosion-proof cameras that meet the requirements for hazardous zones. Use of a non-certified device in a GT package is a significant liability and can lead to claim denial, regulatory penalties and operational risks.

How to heat liquid fuel

Question: We are designing liquid fuel systems for two LM6000 PCs located in west-central Arkansas and trying to figure out what makes economic sense by way of heating. There will be two large fuel tanks for a seven-day supply. Winters usually are mild, but there are times when temperatures can turn brutally cold.

We think we'll need to add electric heaters but aren't sure it makes sense to heat the entire tank.

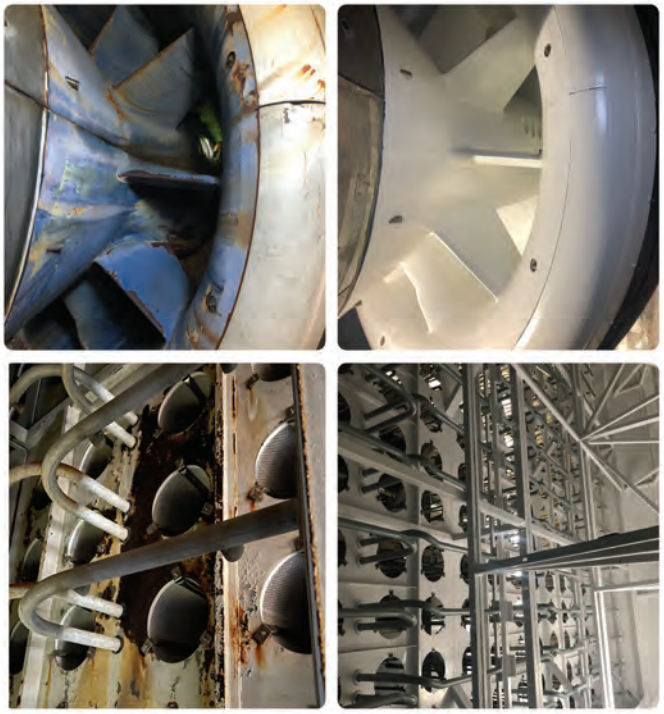
Are any users heating their liquid fuel systems? If so, is heat added at the tank, or are you using some type of inline heating to keep the fuel above the wax point?

Replies:

Respondent 1. We are in New Jersey and have 440-V inline heaters installed just before fuel enters the packages—one per package. We do not heat our 3.1-million-gal tank.

Respondent 2. We're in Nebraska and have two 700-kW heaters arranged in parallel ahead of our packages, not in, or upstream, of the storage tanks. Usually only one heater is in service; heating elements are cycled up and down.

Respondent 3. I agree with Respondent 1: No need to heat or insulate the whole tank. Electric heaters, properly sized, should do fine. There are fuel additives available to extend the pour point down another 10-15



deg F if that makes you feel better.

Keeping water out of your system is very important, as it will promote microbiological growth. Should that become an issue, you'll need another additive to keep it under control.

For large tanks, stratification is another possible issue to consider. Having a recirculation line in service on each tank helps alleviate it.

Finally, be sure to allocate enough O&M labor man-hours in your plant budget for fuel maintenance—it's a time-consuming task.

Respondent 4. We are on the eastern shore of Virgina and have five above-ground unheated diesel storage tanks. Normal winter temperatures are around 30F but it can get into the single digits. Uninsulated piping from the tanks to unit heaters travels about 20 ft before entering the HP pump skids. Piping after the heaters is insulated. Works fine.

Respondent 5. Immersion heaters and inline fuel heaters are the most efficient and reliable options. Another is to buy winter diesel which has the wax removed. Still another is to use waste heat from the generating unit or elsewhere to preheat the oil. My experience suggests that if you don't heat everything you end up concentrating the wax over time.

Respondent 6. We have two 250,000-gal insulated storage tanks with 40-kW immersion heaters to keep the oil at 60F, thereby ensuring consistent starts on diesel. We used to maintain the oil cooler than this, but over time realized that 60F assures reliable starts on oil, even during extreme cold.

The 40-kW heaters can maintain temperature if we are not turning over the oil, but when burning diesel, the heaters can't keep up. Our fuel terminals are more than 90 minutes away and we can consume oil faster than we can receive it. Thus, as the fuel tankers travel and line up to offload, the oil often is at less than 10F, waxing everything it touches. So, we usually have to pull the suction strainers from the unloading pumps to keep oil flowing.

Recently, we installed a fuel unloading heating and recirculation system. It allows us to move oil through two 150-kW heaters as it is unloaded, helping the immersion heaters and hopefully keeping oil above its waxing temperature. Larger heaters would have required more modifications to the MCCs and switchgear.

Once unloading is finished, we can use the new heating system to recirculate oil in the tanks to both filter and heat it, thereby helping the immersion heaters maintain fuel temperature.

A side note: During extremely cold conditions we may get only one start attempt. With fans flowing 60 kscfm of air at well below 0F through the package, water piping will quickly freeze-up, even with heat tracing and insulation. So, it's a race against time to get water flowing before it freezes. If you have a failed start, you may not get another opportunity.

When to pull your generator rotor

Question: One of our Brush BDAX generators is reaching 50k hours of operation in more than 12 years of service. The OEM says the rotor should be pulled for a major inspection at this time but we are reluctant to do this and instead perform a "minor" service. What do you think?

Replies:

Respondent 1. Officially, a "rotor out" inspection is specified after 50,000 hours. However, the OEM has a robot crawler that can go down between the stator and rotor windings and do some in-situ functional testing using a small hammer. Perhaps a positive result may allow you to put off the major inspection to 100,000 hours.

In any event, I recommend pulling the DE and NDE bearings, which can be completed with the rotor installed.

Respondent 2. Besides any electrical testing, the exposure to ambient air must be considered, unless you have a TEWAC cooler and air is recirculated, thereby reducing the amount of new air pulled through the unit. Depending on the nature of deposits found, you might consider going from a generic F9 filter towards HEPA.

Also, the number of starts will influence generator wear and tear. For our 7EAs, we reached the need to rewind at about 2000 starts and less than 15,000 service hours, some 30 years after COD—with heaters on while offline.

Note that having heaters on while offline seems to matter. I do not have a factor for how to account for time offline, and it seems strange that a generator would age with the heaters on, but that seems to be the case.

Turning-gear time also must be factored into your thinking. In our case, TG hours are a multiple of run hours.

Don't forget to check the bearings.

Respondent 3. We pulled all eight of our rotors at 12 years—12k to 15k hours and 5500 to 6000 starts. All units tested satisfactory, just needed a good cleaning. We replaced bearings, jacking-oil lines, vibration

probes, soft goods, and the insulation on generator leads. In-house maintenance did the work because the company had its own maintenance shop at the time.

This participant in the online discussion offered a PowerPoint presentation on the work conducted. You can view it on the Forum.

Respondent 4. Having a 12-yr-old peaking unit with 50k hours of service, you should be looking at doing a major inspection or a RoGIS (Robotic Generator Inspection System) plus borescope.

Bear in mind that a RoGIS can be unreliable and if any issues surface you have to pull the rotor anyway.

Jacking hoses should be changed every five years, at a minimum, because hose insulation breaks down in the oil—especially that on the old-style hoses. There's a service bulletin for hoses of latest design which have an extra layer of sleeving on them.

Respondent 5. We just completed our first rotor-out major inspection on a unit with 138k service hours, following regular inspections at 50k and 100k hours—during which we performed RoGIS inspections, removed bearings and seals for inspection/replacement, conducted electrical inspections of the stator, rotor, and exciter, and replace jacking-oil hoses.

Our findings from the first rotor-out major were minimal with just minor cleaning required. We're not necessarily recommending going as long as we did, but we've been fine getting by with the RoGIS in place of a rotor-out.

Follow-up note: With the unit back in service for a few weeks staff discovered multiple bolts that hold the exciter frame to the stator had snapped off—presumably over-torqued on reassembly and failing when the unit reached operating temperature.

Visit the Forum if the views of LM6000 colleagues on the following 2024 topics are of interest to you:

- Lube and scavenge pump leak
- LPT PCC system
- Leakage on the HLO hose
- Gas control valve
- Turbine and generator vent fans
- Meggitt CDP bleed-valve failure
- P48 failure and LPT damage
- Alstom 72.5-kV breaker repair or replacement needs
- CEMS issues
- Clam-shell welding
- Brush generator BDAX7 rotor-out interval
- Fuel-gas supply quality—superheat measurement and control
- Depot repair duration
- Trane CDHF chiller electric motor issue
- Aftermarket silencer
- Sprint demin water flow
- Lockout avoidance upgrade
- Issues with air permit while using leased engine
- Hydraulic rectifier for four-hour lockout avoidance
- Operator rounds
- Roto-jet pump rebuild
- VBV null current shift alarm and VBV position error alarm
- TGB/A sump aluminum?
- Liquid-fuel storage AFFF fire suppression PFAS abatement
- Flame detection logic
- PX36 sensor overhaul or qualification
- SB239 Inco-718 LPT coupling nut
- GoPro in package system
- Problems with the VBV feedback signal
- Ninth-stage HPC end gap
- FOD sock assistance
- LP rotor not rotating
- DLE mapping training
- PF fuel-line contamination
- LTSA/CSA contracts
- Hose management
- SB316/SB352
- Filter house plenum
- Compressor deposits
- HPC blade failure
- Wiring flame detector
- Air inlet freezing conditions
- Staffing
- Hydraulic starter and clutch
- Hydraulic starter filter leaks
- Inlet canister filters

LMS100

Intercooler seal section missing

Question: We have about a 2.5-ft section of the picture-frame seal missing from our intercooler, made by Industrial Heat Transfer (IHT). Because we have a forced outage to fix a tube leak, we wanted to replace this seal, but just received an extremely high quote from GE, plus a very long lead time. There are other sections on the seal that are getting brittle and starting to tear. In addition, there's also a large section of the lower seal missing. Photos are available on the Forum web pages.

While there definitely some air bypassing the intercooler, we haven't noticed a huge amount of power loss because of this.

Note that T25 has been running at about 95F to 100F. Temperatures on TE9001B (just after the intercooler and before the transition pipe) are 85F on A1/A2 and about 118F on B1/B2.

Has anyone had a similar experience? Have you been keeping up with these seals and getting them repaired? Have you found a supplier other than GE for the seals?

Replies:

Respondent 1. We've had an almost identical experience.

Respondent 2. No need to get from GE; it's just high-temperature rubber. We use material from McMaster Carr for those repairs (find link to catalog on the Forum). Also, we have established a proven method for intercooler tube cleaning, repairs, and plugging using a turnkey contractor. Connect with this respondent via the Forum for contact information.

Respondent 3. Similar experience with the seal deteriorating and breaking off. We have not had an outage long enough to make the replacement and have been filling in the gaps with high-temperature fast-drying silicone.

We keep up with the cleaning of intercooler tubes and don't notice any major losses at these seals. We get the heat transfer needed despite the poor condition of door-frame seals.

We would like to replace the seals around the door at some point, but with cutting and welding of stainless steel involved, we keep pushing this out until we have a longer outage planned for something else.

Response from the person asking the question. We finished the intercooler outage and the unit was returned to service. There was good improvement in the intercooler exit temperature after the tube cleaning (TE9001B). It had been running at about 117F and now is 90F; T25 is 85F.

We were unable to do any repairs to the picture-frame seal this time. It still has significant damage to it, but a large derating is not a result—at least now while the weather is mild. A reply from GE as to how critical this seal is for power output had not been received by the end of 2024.

Respondent 4. Dropping from 117F to 90F is a huge difference. We did some tube cleaning as well, but did not see a performance improvement as dramatic as yours.

Do you have the high-temperature intercooler? When you did your tube cleaning did you notice a heavy build-up? Were a lot of tubes clogged prior to cleaning?

Response from the person asking the question regarding the questions asked by Respondent 4. The intercooler is of IHT's original design, built in 2008. There was a lot of buildup in the tubes with most in the front row clogged. We were able to clean out all but 17 of the 2596 tubes. However, an additional six tubes had to be plugged because of leaks detected. Initially, we used the GE procedure to weld plugs to the tubesheet, but then switched to a pop-a-plug kit, saving a significant amount of time.

Visit the Forum if the views of LMS100 colleagues on the following 2024 topics are of interest to you:

- Does anyone in colder climates change their generator turning-gear lube oil to a thinner oil?
- Battery explosion during testing
- Tempering-air fan damper?
- LMS100 HPC eighth-stage failure X2
- GE familiarization training for operators
- Intercooler tube inspection

O&M solutions evolve to fit needs of power generators

The gas turbine industry is at a critical juncture. With increasing operational demands, workforce shortages, and evolving maintenance challenges, ensuring the reliability and efficiency of aeroderivative gas turbines, particularly dispatchable assets like the LM6000 and LMS100 fleets, has never been more vital. Luckily, some creative outfits are adapting to the new paradigm with the right mix of proficiency and flexibility.

Allied Power's (Baton Rouge, La) expertise and innovative solutions are addressing these issues head-on, offering end users a path to improved operations and maintenance. CCJ editors had the opportunity to sit down with John Clutts and Dave Fink to discuss fundamental challenges facing the industry, effects of cycling on turbine components, and comprehensive offerings to ensure operational excellence.

Key challenges in the gas turbine industry

Escalating Operational Demands. Gas turbines are increasingly tasked with supporting grid stability through load-following operations, leading to more frequent starts, stops, and rapid load changes. This operational profile accelerates wear on components, reduces maintenance intervals, and necessitates a proactive approach to asset management.

Workforce shortages. The industry has witnessed a significant loss of experienced field engineers and technical advisors over the past decade. As Clutts notes, "Eighty to ninety percent of the experienced GE field guys that did installation and commissioning during the GT boom of the early 2000s have left the company. This creates a knowledge gap that makes it challenging to support the new units coming online." Many end users are understaffed, resulting in missed inspections and suboptimal outage management.

Knowledge silos. Organizations often suffer from compartmentalized knowledge. Maintenance, engineering, and operations teams fail to share critical information, resulting in incomplete outage planning and inefficiencies. Clutts explains, "If you don't know the history of an individual package, it's difficult to prepare adequately for an outage."

Effects of cyclic operation on key components

Cyclic operation presents significant challenges for the LM6000 and LMS100 fleets, resulting in accelerated wear and decreased reliability across critical systems, some of which are discussed below.

High-pressure compressor (HPC). The frequent movement of variable stator vanes (VSVs) leads to significant wear on parts like bushings, hydraulic actuator guides, and rub buttons (photos). Additionally, the inner and outer shrouds in Stages 2 and 3 of the compressor face increased wear, leading to a shortened operational lifespan.

Combustor. The thermal barrier coatings (TBCs) in the combustor are particularly vulnerable to rapid temperature changes, which cause cracking and spalling. This degradation heightens the risk of inner liner failure. Similarly, nozzles and swirlers experience increased stress and wear during frequent start-stop cycles.

High-pressure turbine (HPT). The outer shrouds in Stages 1 and 2 of the high-pressure turbine are susceptible to cracking and material loss. Blade tips and trailing edges are also compromised by thermal cycling, which exacerbates erosion and impacts efficiency and overall performance.

Auxiliary systems and balance of plant (BOP). Frequent cycling reduces the lifespan of variable geometries and auxiliary skids, leading to decreased reliability of the overall plant system.

The need for a broad range of specialty services

Allied Power has developed a robust portfolio of services to address these challenges, say Clutts and Fink, combining technical expertise with a deep commitment to customer-centric solutions.

Customer-centric borescope inspections are a cornerstone of their service offering. As Clutts emphasizes, "We use an industry-leading menu-driven inspection

Meet John Clutts and Dave Fink

Clutts

Fink

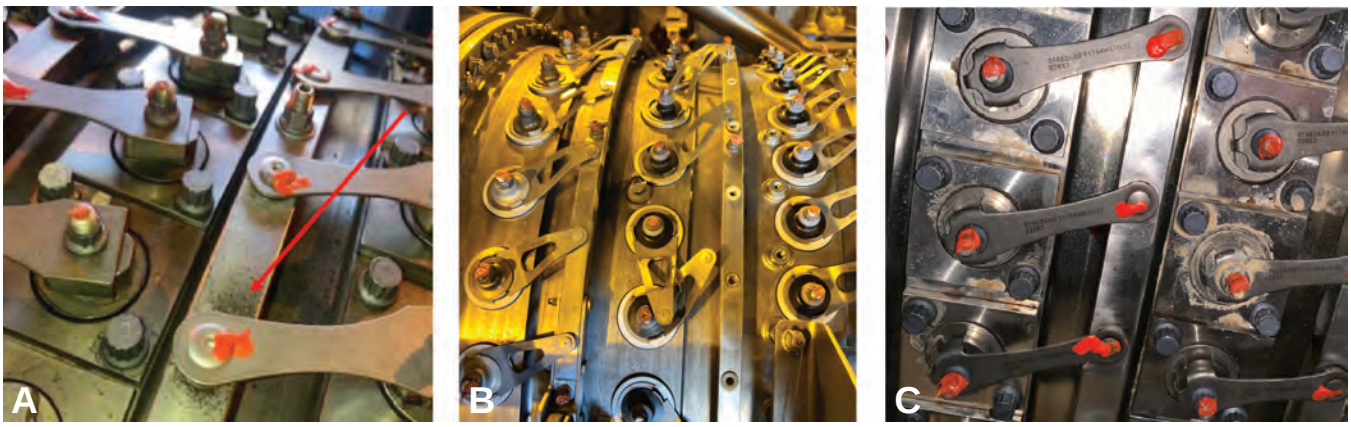
Clutts is the company's regional project manager for the desert southwest, a hotbed of activity in deploying dispatchable aeroderivative gas turbine assets. Ready for a double-take? His team has performed 87 "over-the-wall" LMS100 engine swaps in the past 8 years.

His professional journey began in the US Army, working in aviation and the Apache training brigade, gaining experience with aircraft engines and maintenance. After military service, he transitioned to Iraq for two years, focusing on fuel distribution systems, engineering processes, and constructing large-scale fuel tank facilities.

Subsequently, he pursued an aerospace technology degree from the National Aviation Academy. This credential launched a career with GE, initially in services before transitioning to installation and commissioning for 17 years. They progressed to leadership roles, including lead and site manager, and ultimately served as the installation and commissioning excellence manager for GE worldwide.

This role entailed extensive contributions to the OEM training program where he spearheaded development and implementation of GE's training curriculum for alignment, installation, and commissioning, as well as comprehensive manuals still in use today. Notably, Clutts credits teamwork, highlighting contributions from colleagues who continue to collaborate with them.

Fink, Allied's aero controls manager, is best known to CCJ readers as the session chair for WTUI's LM6000 engine roundtable. He most recently spent nine years as I&C technician and operator at Onward Energy's Fountain Valley (Colo) facility and was responsible for maintaining the six-unit LM6000 peaking plant, along with CEMS maintenance and reporting.



Effects of increased cycling on VSVs: (A) Black carbon "smoking" around the lever arm is a clear indication of wear and helps with all tubing and piping inspections as well. "If its smoking, its rubbing," Clutts remarks. (B) VSVs not secured correctly and/or inspected will cause a stall. (C) Signs of contaminated water intrusions noted during VSV inspections

process that not only identifies issues but also serves as a training opportunity for customers." These inspections feature real-time feedback via external monitors, enabling clients to observe and learn as engineers explain findings in detail.

Pre-outage inspections. Comprehensive reviews identify potential issues before they escalate, streamlining outage planning and minimizing downtime. This proactive approach ensures smoother operations and cost savings.

Detailed package inspections. Weekly or monthly inspections tailored to site-specific needs help maintain operational integrity and identify early warning signs of component failure.

Engine and package familiarization course is a four-day training program consisting of three days of classroom instruction and a full day of hands-on package walkdowns. Fink notes, "Our training immerses participants in real-world scenarios, equipping them with the knowledge to perform effective daily inspections."

Onsite training is tailored to the specific needs of a facility centered on building operator confidence and expertise in alarm monitoring, system diagnostics, and best practices for optimizing performance.

Expert outage management and oversight. Outage services are designed to eliminate inefficiencies and ensure seamless execution. Coordinated outage scopes manage communication between stakeholders, ensuring alignment and timely execution. Daily POD (plan-of-the-day) and EOD (end-of-day) reviews ensure that all aspects of an outage are tracked and adjusted as needed.

Filling workforce gaps with experienced personnel consists of routine site visits and fulfillment of staffing gaps, ensuring that critical inspections and maintenance are not neglected. Cross-training initiatives promote cross-functional knowledge sharing, Allied Power helps end users reduce reliance on external contractors.

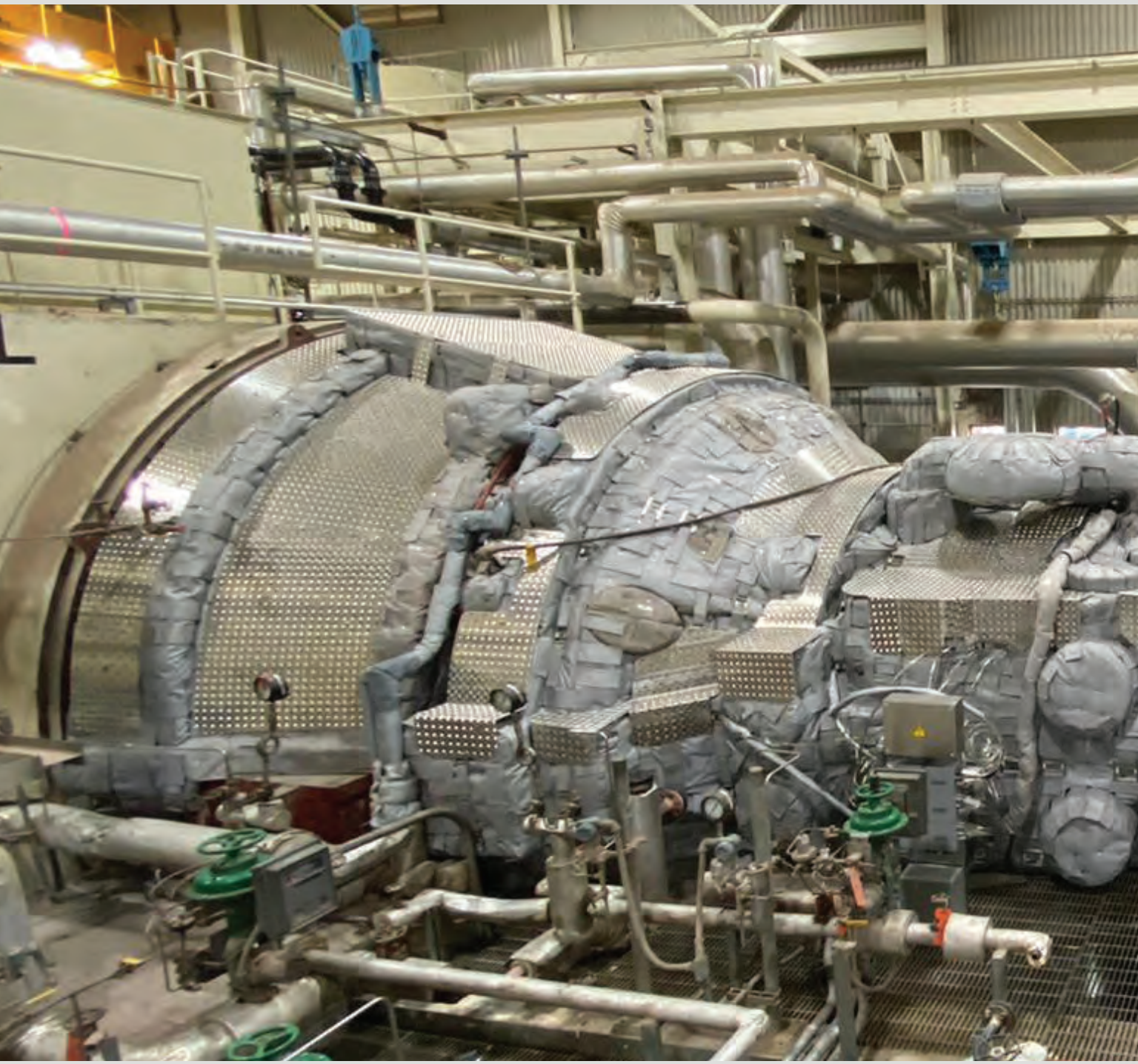
Troubleshooting with technology and experience. Remote and onsite diagnostics quickly identify root causes through comprehensive trend analysis and system history reviews. As Fink highlights, "We often solve problems remotely, saving clients days of downtime." Building on growing operating experience allows for tribal knowledge integration to address recurring issues with tailored, effective solutions.

Innovating for the future

Looking ahead, Allied Power is committed to advancing the reliability and performance of the LM6000 and LMS100 fleets. By addressing workforce challenges, improving training, and enhancing inspection and maintenance practices, they are contributing new standards for operational excellence.

Fink captures the ethos of Allied Power's approach: "We want the customer to be as educated as possible about their unit. That not only helps them, it helps us." Clutts adds, "If it comes down to the end user or the turbine, we will always side with what's best for the turbine." CCJ

Advanced Single Layer Steam



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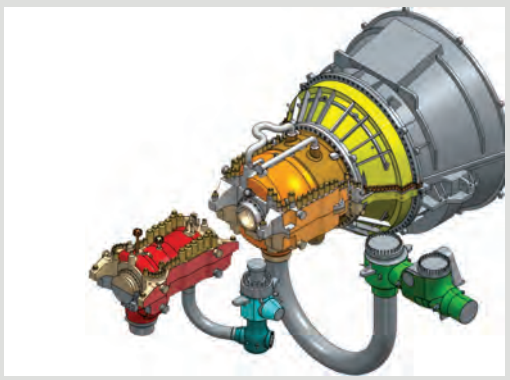


ARNOLD GROUP

CPV Towantic Energy Center

Owned by Competitive Power Ventures and Osaka Gas
Operated by NAES Corp

805 MW, gas-fired 2 × 1 7HA.01-powered combined cycle equipped with DLN2.6+ AFS combustion systems, GE D602 steamer, and John Cockerill (formerly CMI) HRSGs, located in Oxford, Conn

Plant manager: Larry Hawk

Operator requalification focus of continued education program

Challenge. During commissioning, CPV Towantic plant operators completed initial qualification cards to demonstrate the necessary site-specific knowledge to work as an auxiliary operator or control room operator.

With no requalification program in place, there was no way to ensure the operators would stay knowledgeable on the systems they interact with daily. Seven years after COD, plant management wanted to ensure the knowledge received in 2017 wasn't getting lost in the normal day-to-day site activities. This was a concern echoed by insurance carriers.

Solution. Plant management reviewed the qualification program in place, which focused on initial qualifications, and set out to find a solution to maintain site knowledge through a requalification program. The site team looked for a solution within NAES corporate and other facilities that had addressed operator requalification. It didn't want to have the operators complete the same qualifications they initially performed because of the time involved; rather it wanted to introduce a program that had enough substance to refamiliarize the team with information useful in their work environment.

Management worked with the operations team and the union to create a program that addresses all of management's concerns, can be done on shift without jeopardizing operations, and is built to continue operator training for the foreseeable future.

Working with NAES corporate and using some other sites' methodologies, management was able to identify technical training courses available in the computer-based program GPiLEARN+ used for some of the plant's safety training. In addition to the courses already available on GPiLEARN+, staff wrote 22 exams covering each system at Towantic Energy Center that can be completed on that platform. Working with corporate, plant personnel created a learning plan involving the computer-based training courses and exams that are broken down to auxiliary operators and control room operators.

Monthly, for a period of two years, operators complete the training courses assigned. When that program is finished, two years of training are completed. The training cycle then starts over and is completed again. Training procedures were updated to include the new requalification section.

Results. Continuous plant-level training is important to ensure operators retain the tools and knowledge to complete their work effectively. With the requalification program, operators review the skills required, and the resources available, to perform their daily tasks to best respond to upsets that may occur.

With the new requalification program in place, the management team continues its efforts to revise and modify requalification training to remain current on the systems in place at Towantic Energy Center.

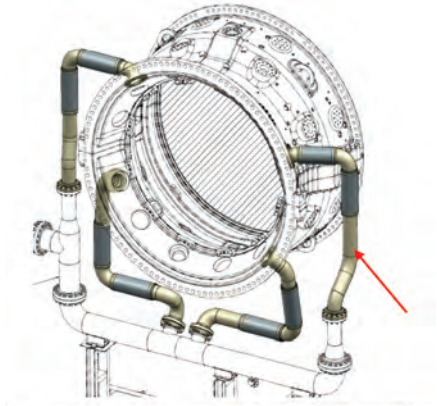
Project participants:
NAES corporate staff and plant O&M personnel

GT enclosure cameras critical to plant's participation in dual-fuel market

Background. CPV Towantic is an outdoor facility with two 7HA.01 gas turbines and one D602 steam turbine. The OEM released TIL-2299 in response to the 7HA inlet bleed heat (IBH) flexible-metal-hose failures experienced by some users while operating baseload (Fig 1). Hot compressor discharge air leakage from the failed flex hoses pressurized the gas-turbine enclosure and caused compartment doors to open.

To remedy this, GE released TIL-2299-R1 to communicate the availability of an improved "dog-legged" style flex hose to address torsional stress caused by the original hose configuration. Another IBH flex hose event was reported with the improved dog-leg design and the root cause analysis of determining the factors associated with that failure were still under way when this best practice was submitted to CCJ.

Challenge. TIL-2299-R2 recommends a "15-ft exclusion zone around turbine enclosure doors to keep personnel at a safe distance in the event of unexpected turbine operation." This prohibited operators from running on No. 2 diesel fuel oil if need be. Reason: There was no way to inspect for leaking fuel oil at the combustor locations inside the compartment. Plus, it prohibited



1. Location of IBH flex hose failures is indicated by arrow in the drawing; a flex hose failure is shown in the photo

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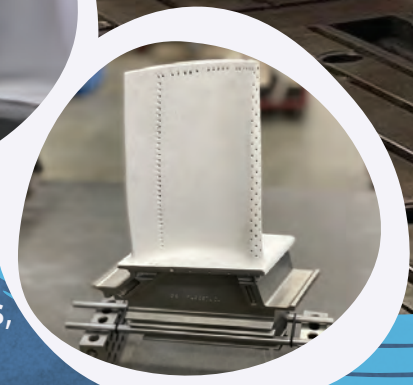

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the plant from taking advantage of a lucrative market that the site was designed to compete in.

Solution. Cameras to provide visual access to the combustors was the solution favored by plant personnel. Coincidentally, Towantic already had under contract a new security partner to install site-wide cameras, badge readers, and remote visuals. However, an obstacle to this solution was a very short turnaround time of about 3.5 weeks to procure and install the equipment—without the ability to provide a good walk-down of the enclosures.

Equipment had to be run in rigid conduit and hermetically sealed according to plant specifications. The security vendor was able to procure eight Axis P1468-XLE explosion-protected bullet cameras with zoom capability that allowed 4K vision under any light conditions.

The security vendor and the site's electrical contractor partnered to complete installation of conduit and cameras inside the GT compartments within the short outage window provided. Four cameras were installed in each GT compartment—one in each quadrant allowing visual access to the combustors (Fig 2). Shortly afterwards all the exterior equipment was run, and data links provided, to send visuals to the control room and staff computers.

Results. Towantic has eliminated the hazards and risks to personnel while operating on liquid fuel. GT enclosure cameras allow operators to use the CTs to their full potential and participate in the dual-fuel market.

Project participants:
Plant O&M personnel

2. Visual of combustors as seen by control room operators

QR coding enables fast, easy access to Towantic's SDS library

Challenge. With approximately 200 chemicals located onsite, maintaining and using the physical SDS binders became a time, paperwork, and organizational challenge. There's the issue of how to organize the binder, how to incorporate new SDSs, how to maintain the most current SDSs on file, and how to use the SDS binders to find pertinent information promptly.

Another challenge: To access the SDS binders, one must travel to a location where they are stored to access the information. This can add time to the response of a spill or inadvertent contact.

Solution. The site had two SDS libraries that filled two 3-in. binders located at both the entrance of the administrative building and the control room. Towantic personnel conducted a full audit of all chemicals onsite to ensure there were SDSs available and that they were current. Staff found that the amount of time it took to coordinate this effort was excessive given that two sets of SDS binders required updating.

Once the chemicals were inventoried and the SDSs updated to their most recent revisions, staff began the process of organizing the binders and realized yet another 3-in. binder was required to accommodate all the SDSs onsite. In addition to updating the binders, the SDSs were uploaded to the online "eBinder" to have a third location for all the SDSs onsite. Using eBinder, personnel are able to load any SDS to a site-specific library.

3. Access to Towantic's SDS library via QR code speeds access to critical information

When staff realized they now had three binders of SDSs to keep updated in two different locations, personnel wondered if there was a way to make the eBinder accessible to all to make the process of using the SDS libraries faster and easier to maintain.

Using a QR code that linked to the site-specific eBinder was an effective way to access all the SDSs for the site and made searching for an SDS easier than using the hard-copy binders (Fig 3). The control room still has a physical copy that is sorted alphabetically, but when you're searching for a chemical, you might not know the vendor's name for it and finding it can take considerable time away from the work necessary. Using the QR code and doing a search in the library takes seconds and you can access any of the SDSs on file quickly and from anywhere onsite.

Having one QR code, staff made signs to post at multiple locations around the site, in particular where you may encounter a chemical or substance you may need an SDS for.

Results. The SDS library of all chemicals onsite is available for any employee or contractor at any time, thereby reducing the time needed to access the information required. Whether the need for the SDS is for disposal considerations, to respond to an emergency, or for general information purposes, it's now much easier to get the information needed.

Not having two separate locations saves staff time in organizing and updating the libraries. While the plant still has one physical copy, maintaining it takes half the time as it did before.

Project participants:
Plant O&M personnel

Fairview Energy Center

Owned by Competitive Power Ventures, Osaka Gas, and DLE
Operated by NAES Corp

1050 MW, gas-fired 2 × 1 7HA.02-powered combined cycle equipped with a GE D602 steamer and John Cockerill (formerly CMI) HRSGs, located in Johnstown, Pa

Plant manager: Irvin Holes

Enclosure improves air-compressor reliability in winter

Challenge. Fairview's Atlas Copco air compressors were installed with special cold-weather packages that had a minimum inlet air temperature of –6F. However, during several severe cold-weather incidents, the plant was unable to keep the compressors running continuously, ultimately resulting in a full plant trip attributed to a loss of instrument air supply.

Solution. Initially, the plant tried using large heaters to add heated air to the compressor inlets, but that was unsuccessful. An alternative solution involved erecting scaffolding around all three compressors and wrapping the structure in plastic. This allowed the structure to use the exhaust heat from the motors to heat the enclosure (Fig 1 left). To prevent other unwanted issues and maintain an optimal temperature of 50 deg F, the plastic wrapping had to be adjusted by rolling it up and down as needed.

Results. When the temporary structure with plastic proved successful for two consecutive winters, the site team decided to make the solution permanent. Working with a local packaged steel building contractor, the team designed and constructed a permanent building around the air compressors. The building is heated using the waste heat from the compressor motors, resulting in no additional heating costs, and the temperature is controlled using a combination of roll-up doors and louvers (Fig 1 right).

During the initial design process, the maintenance team worked with its operations team and its compressor maintenance service contractor, Air Technologies, to ensure the building was constructed so as not to impede equipment maintenance or operation. The result has been continued plant operations during long, sustained cold weather without further compressor trips.

Project participants:

Rick Marshall, maintenance manager
Travis Rudick, maintenance technician
Jeff Dipaolo, maintenance technician
Joe Zahoran, maintenance technician

1. Temporary enclosure around compressors is at left, south side of finished enclosure at right

Bulk holding tank facilitates CCW system maintenance

Challenge. Maintenance personnel at Fairview recognized early on an inconvenience in the design of its closed cooling-water (CCW) system: The lack of a permanent holding tank for storing liquids during preventive or corrective maintenance. Whenever Fairview had to perform maintenance on its inlet strainers, pumps, or plate-and-frame heat exchangers, extra steps were needed to drain the glycol mixture into 300-gal portable totes.

A job as simple as cleaning a dirty pump strainer, or draining 1500 gal of glycol to open a heat exchanger, took significantly longer than necessary. Reasons included:

- The temporary totes, hoses, and portable diaphragm pump would have to be gathered by the maintenance team and brought to the job site.
- Transferring glycol out of the system into multiple containers, and then transferring it back, posed environmental spill concerns. Extra precautions, at added expense, were always implemented to minimize spills during fluid transfer.

Solution. Plant personnel determined that the optimal solution to both maximize efficiency and minimize leaks when performing maintenance would be to install a bulk holding tank along with permanent drain lines and a permanent transfer pump (Fig 2). An outside engineering firm worked with the plant engineer and operations team to develop the project, which included installation of a 3000-gal, double-wall holding tank shown in the photo.

Fluid handling equipment was designed to facilitate both the draining and reintroduction of glycol into the system. The design allows the draining of all three major maintenance areas by manipulating a couple of valves—thereby eliminating an environmental spill hazard and reducing significantly the time it formerly took to perform maintenance.

2. Holding tank is supported by a fluid system consisting of permanently mounted valves and pump

Results. The holding tank and pump skid were placed in a convenient location for plant personnel but away from vehicle and mobile-equipment travel corridors. All drain piping (Fig 3) was routed with safety in mind. Piping was routed away from walkways as much as possible. Where piping did cross walkways, pipe crossovers were built and installed to eliminate trip hazards in the walkways (Fig 4). Now with a simple change in valve lineup, the CCW system can be drained easily for maintenance.

The successful project has met expectations. The site was able to use the new holding tank during its most recent outage, which involved cleaning one of the heat exchangers. In the past, it took five portable totes to drain the unit. Today operators are able to easily operate the valves and pump glycol from the heat exchangers and into the holding tank. Not only was the turnaround faster, but material congestion and the potential for an environmental spill were eliminated.

Project participants:

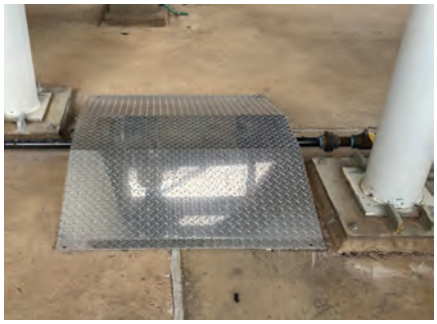
Curtis Spear, operations manager
Jeff Lellock, plant engineer
Shawn Simmers, EHS coordinator
Travis Rudick, maintenance technician
Jeff Dipaolo, maintenance technician
Joe Zahoran, maintenance technician

Handrail screen protects against objects/tools falling off catwalk

Challenge. The top of both Fairview HRSGs has one specific landing zone for the monorail chain hoists along the east-side platform. The landing zone is a narrow catwalk (4 ft wide) suspended in midair with a clear path to ground. While loading and unloading material from the hook, objects could easily fall off the grating between the open handrails. The landing zone's narrowness and open handrails (Fig 5 top) presented an inherent risk to personnel in the area below—even with the area on the ground being barricaded to prevent access.

Solution. Plant personnel engineered barriers to block the open space in the handrails, thus eliminating a large amount of the risk present. Stainless steel expanded metal sheeting was chosen for both its strength and simplicity. Along the lower edge, the expanded metal (Fig 5 below) was tucked between the toe kick and grating, resting on the structural beam work. It was also attached to the mid rail and underside of the top rail using band clamps. Rubber UV-resistant molded edging was used along the vertical sides of the expanded metal to prevent cuts and scrapes.

Results. The barricading has proven to mitigate risk atop the HRSGs, while adding a significant level of safety to the ground below. Working in the landing zone can be done now with greater confidence and less worry. It also offers protection for the worker who is simply carrying objects/tools through that zone while crossing those HRSG catwalks.



3, 4. Typical drain piping is at the top, a walkway crossover at the bottom

Project participants:

Rick Marshall, maintenance manager
Travis Rudick, maintenance technician
Jeff Dipaolo, maintenance technician
Joe Zahoran, maintenance technician

5. Landing zone (top) safety mod features an expanded metal barricade (bottom) to prevent objects from falling off the catwalk

Brush upgrade for steam turbine/ generator

Challenge. Generator brushes were chipping and breaking regularly (Fig 6), necessitating frequent brush checks and replacements, and causing plant technicians to work in close proximity to rotating and energized equipment more often than desirable.

Solution. The GE brush rigging (Fig 7 left) was realigned multiple times to try to correct the cracking, but that proved unsuccessful. The next approach was to have the rings trued and a Cutsforth EASYchange® Brush System (Fig 7 right) installed while the unit was offline.

6. Generator brushes (were chipping and breaking regularly

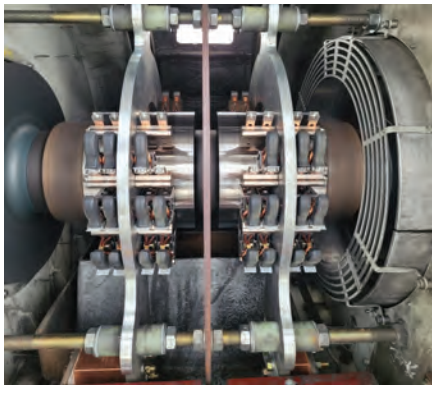
A Cutsforth Brush Condition Monitoring System (Fig 8) also was installed, providing a less invasive way to monitor brush conditions, and eliminating the need to expose technicians to rotating and energized equipment. The monitoring system, which uses a wireless sensor on the brush spring, provides feedback on brush percentage remaining, mils of vibration, and brush temperature.

Results. Ring truing and EASYchange have corrected the problem. Fairview has not had issues with brushes chipping or breaking since implementation of the Cutsforth equipment.

The Brush Condition Monitoring System also has a safety benefit, as brush checks can be completed by simply checking the monitor shown in the photo—thereby minimizing technician exposure to the potential hazards associated with rotating and energized equipment.

Project participants:

Rick Marshall, maintenance manager
Scott Zungali, E&I technician
Adam Heming, E&I technician
Aaron Roberts, E&I technician
Chad Appleton, E&I technician



7. GE brush rigging supplied with the generator was realigned multiple times to mitigate cracking (left) but that proved unsuccessful. Success was achieved by truing the rings and installing a Cutsforth EASYchange Brush System (right)

8. Cutsforth's Brush Monitoring System allows technicians to check brush wear via the display shown

2024 Conference Overview

The Australasian Boiler and HRSG Users Group (ABHUG) meets annually to review and examine significant developments related to heat-recovery steam generators and closely-related conventional fossil boiler technology and issues. High-energy piping, valves, cycle chemistry, and regulatory issues are also explored.

The annual meeting for 2024 was held December 3-5 in Brisbane, Australia, chaired by Bob Anderson, Competitive Power Resources (US) and Barry Dooley, Structural Integrity (UK).

ABHUG is supported by the International Association for the Properties of Water and Steam (IAPWS) together with local National Committees. It is held in association with the European HRSG Forum (EHF) and the US HRSG Forum (HF). Announced recently, this suite of events and global content will expand further in 2025 with HRSG Forum América Latina, September 23-25, in São Paulo, Brazil (https://hrsgamericalatina.com).

The first Australasian HRSG Users Group meeting (known at the time as AHUG) took place in 2009. The 2024 ABHUG event attracted 90 participants from Australia, New Zealand, Canada, UK, and US. There were 26 prepared presentations.

Detailed discussions on thermal transient issues with attemperators, condensate, superheater/reheater drain management, and steam-turbine bypass operation are always a highlight of these HRSG conferences, revealing common problems and areas needing improvement based on international operating data and research. Statistics on cycle chemistry follow the same pattern, with the goal of increasing the availability of both conventional steam and combined-cycle plants.

As noted by Dooley post-conference, "a follow-up to the chemistry statistics review provided detailed information on sampling, monitoring, and analyzing corrosion products. Here the new IAPWS decay map provides the first indicator to validate whether a plant's chemistry is optimized and provides a tool to quantify any benefits from an application of a film-forming substance."

He continued: "With the growth of renewable energy forcing a plant into more and more flexible operation, the benefits from understanding and then controlling the factors leading to corrosion-product transport will be very significant."

Recent advances in drone capability were also presented at ABHUG including new video capabilities, various testing methods and accomplishments, thermography, and accurate spatial measurements.

The use of DCS data from station instrumentation was examined to assist trouble-shooting of in-plant failures ranging from superheaters to desuperheaters to high-pressure pipe runs, reminding participants of the benefits of readily available information often not adequately analyzed.

There were a number of discussions on tube failures, including an important presentation on focused corporate-wide reduction programs to prevent repeat failures and increase fleet-wide plant availability.

Two presentations on internal HRSG tube inspections revealed capabilities of both viewing and removing severe internal deposits. Interesting discussions then explored further developments and specific technology refinements.

Regarding film-forming substances, Dooley's review included the following: "A detailed update was provided on the latest experience and knowledge on these substances which not only included the latest science and application results but also reminded the participants that failure/damage can result if the application does not follow a detailed review of current plant chemistry before application. It was great to see some results from Australian university research on FFS which supplement field trials in advancing the understanding of condensation and heat transfer."

Information was also provided on successful field tests of a new method to maintain high-pressure drum pressures during long-term wet layup using electric heating of external downcomer piping. Keeping HRSGs warm in this way avoids the large thermal fatigue damage accumulation in the HP drum associated with cold startup. Such units also can avoid air intrusion, enjoy more rapid restart, stable water chemistry, freeze protection, and reduction in pitting corrosion during long-term layup.

A number of specific case studies were presented and examined. One, for example, looked at damage caused by undrainable water accumulated in main steam pipework, leading to long deadhead sections upstream of isolation valves.

In another, looking at the fairly new technology of generating pressure waves to clean the gas side of finned tubes, details were presented on current in-depth testing to evaluate any propensity for component damage.

With international technical experts attending, solution sharing is a strong conference benefit for both users and service providers.

Looking back at this interactive 2024 event, Dooley summarized: "The excellent number of steam generator owner/operators at the conference was extremely pleasing as this enabled the information that was shared to be transferred to a wide range of plants, which must ultimately benefit the industry and the consumer."

An exhibition area was also provided and included Duff and Macintosh/Sentry, Flotech Controls, HMA Instrumentation, Intertek, Precision Iceblast Corporation, RTR, and Swan.

Sponsors for ABHUG 2024 were HRL, Swan Analytical Instruments, and TLG Engineering.

The event was organized by Mecca Concepts Pty Ltd, Australia. Combined Cycle Journal is the media partner.

A more in-depth review of this conference will follow this year in CCJ.

HRSG calendar. The next meeting of ABHUG will be in Brisbane in November 2025. The 11th European HRSG Forum will take place May 13-15, 2025, in Prato, Italy. The 2025 HRSG Forum (US) will take place July 21-24 in Houston. HRSG Forum América Latina will follow September 23-25, in São Paulo, Brazil.

For more information on the current and expanding suite of HRSG conferences, please contact Barry Dooley (bdooley@structint.com or bdooley@IAPWS.org) or Bob Anderson (anderson@competitivepower.us).

All events also will be announced on www.ccj-online.com and within Combined Cycle Journal. CCJ

Highlighting new challenges for HRSG reliability

The European HRSG Forum (EHF) held its 10th annual event May 13-14, 2024, in Prato, Italy, attracting participants from 18 countries.

EHF is conducted in association with the Australasian Boiler and HRSG Users Group (ABHUG) and the US HRSG Forum (HF), all supported by the International Association for the Properties of Water and Steam (IAPWS).

The event was chaired by Barry Dooley, Structural Integrity (UK) and Bob Anderson, Competitive Power Resources (US).

Key highlights included the ongoing challenges of flexible operation, the impacts of increased renewables capacity and decarbonization, the major concerns of heat-recovery steam generator (HRSG) tube failures, proper assessment of flow-accelerated corrosion and under-deposit corrosion, the importance of proper cycle chemistry, and operation and maintenance of attemperators and valves.

A few selected examples follow.

Tube failures and root-cause analysis

As explained by Dooley, HRSG tube failures (HTF) remain a major concern and many aspects were discussed during the conference. This included the importance of determining the failure mechanism during root-cause assessments. Case studies clearly demonstrated the criticality of using a metallurgist who understands the plant equipment and processes to avoid incorrect determination of the mechanism.

Jeff Henry, Applied Thermal Coatings (US), launched the technical discussions and explained the value of metallurgical analysis of failures, specifically how to extract the necessary information to support ongoing plant operations.

He stressed metallurgical failure analysis as "an essential component of a root-cause investigation, which is necessary to prevent repeat failures." Properly executed, this will identify the primary, and any secondary, damage mechanisms active in the sample prior to failure.

It will also explain the operating context in which the damage mechanisms developed. This allows "focus on information relevant to the failure sequence, avoiding unproductive diversions to non-relevant issues," he explained.

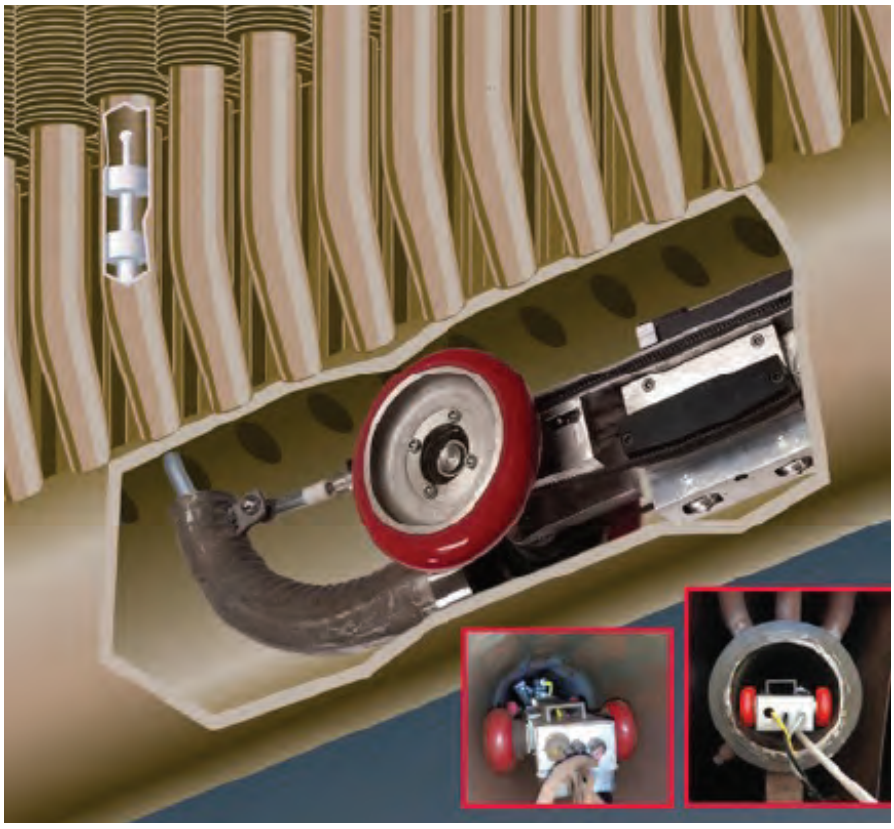
As an example: "An experienced analyst will not simply describe the physical characteristics of damage found in a sample (for example, a single, tight trans-granular fracture initiating at the toe of a weld), but will explain how fatigue cracking could have initiated under the operating conditions that prevailed immediately prior to the failure."

The analyst is therefore more than a metallurgist, and must understand the intricacies of equipment design, manufacture, and operation.

Henry then listed potential influences on pressure-part failures:

- Design deficiencies (and improper material selection).
- Deficiencies in original material processing (including heats).
- Imperfections in materials.
- Fabrication/assembly errors (weld defects, improper heat treatment).
- Operation-related issues (water chemistry, thermal shock, overheating).

This places a large and complex burden



1. HRSG internal access tool in an HP evaporator header

on the failure analyst, and information supplied by plant engineers, including failure and repair history, becomes critical input.

Henry explained the typical progression of failure analysis including macrostructural examinations, dimensional measurements, micro fractography and microstructural examinations, chemical compositions, hardness testing, and specialized tools for analysis, followed by specific case studies.

He ended with selected examples of when the analyst fails and avoidable repeat damage occurs.

Dooley summarizes: "While strong investigative capabilities historically have been readily available (though not always used), the presentation also highlighted industry challenges—such as workforce turnover, lack of corporate memory, and the risks of not understanding the implications of failure for future component reliability."

To emphasize topic importance, Henry's details would be presented again at the HRSG Forum in St. Louis, Mo, in June 2024.

Advanced inspection methods

Henry's presentation was followed by TesTex's Shawn Gowatski highlighting *New developments in HRSG remote inspections.*

Advanced inspection methods, including robotic waterside inspection of HRSG evaporator and economizer tubes for wall loss, were illustrated with much improved access to tubes. Discussion focused on developing the ability to robotically measure HP evaporator internal tube-deposit density.

One highlight was the Claw for inspecting tube-to-header welds with a balanced-field electromagnetic technique (https://www.ccj-online.com/how-to-quickly-inspect-for-cracking-at-tube-to-header-welds-in-hrsg/). Equipment size reductions (Mini Claw) are ongoing for expanded header/tube access in more restrictive areas.

In concert with EPRI, TesTex has continued to develop its HRSG internal access tool that inserts a remote field electromagnetic technique probe to inspect HRSG tubes from the inside (Fig 1).

This features a video camera, driver coil, pickup coils, and tail piece. Access is provided by cutting a hole in the HRSG casing and removing the endcap from the header. One example result shown was evidence of FAC and wall loss near the upper header (Fig 2).

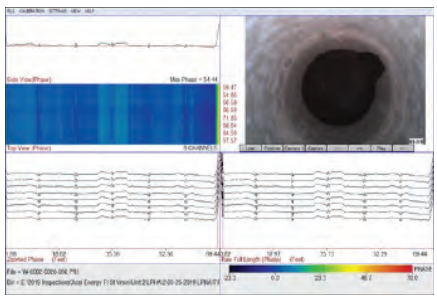
A new TesTex modular internal access tool can be inserted through a 203-mm-diam hole cut into the top, bottom, or side of the header (Fig 3). This was first tested in April/May 2024 in an LP evaporator showing FAC in several tubes.

Inspections have been performed in evaporator and economizer sections and a crew can examine all tubes in a header in three to four shifts.

Graeme Gordon (Altrad Babcock, UK) and Azahed Stofer (EdF, France) were also on hand to discuss an *HRSG inspection tool* used on four combined-cycle plants installed since 2011.

The desire is to gain access to tubes previously unable to be inspected, and to inspect a particular tube following an unplanned outage. The targets are FAC, pitting, and fatigue cracking.

The discussion centered around inspecting the internal surfaces of headers (full length) and multiple tubes. Field inspec-



2. Remote-field waveform showing 60%-65% wall loss near upper header

3. Modular internal access tool being placed inside header

tions are taking place at two locations in France.

Duct-burner aging

Zeeco Inc, with offices worldwide, has invested in physical modeling along with CFD software to analyze duct-burner systems and solve flow-related issues affecting performance. The basis: Burner performance depends largely on the O2 content and inlet temperature/composition of turbine exhaust gas calling for proper duct length and maintenance. Annual inspections with experienced personnel are critical for long-term, reliable operations.

Zeeco's Rick Fiorenza explained:

- Deterioration of burner elements/flame stabilizers can occur (Fig 4). Sagging of burner elements and flow baffles can also occur (Fig 5).
- Common reasons for upgrading or retrofitting duct-burner systems include GT upgrades, part-load operations, fuel modifications or hydrogen blending, and perhaps new emissions requirements.
- Modeling has led Zeeco to a "next generation technology" labeled TEG+ shown in Fig 6.

Case study: HRSG stack collapse

The rehabilitation of an HRSG following the collapse of its stack provided an interesting case study, focusing on challenges related to access, scoping of the HRSG impact damage, preservation of the damaged water/steam systems, repair/replacement strategy, and hydraulic waivers.

Sam Keyne, Uniper Technologies, Houston, presented *Integrity assessment and repair of the HRSG following the collapse of the stack.*

One of three HRSGs at a three-unit 442-MW plant located on the Isle of Grain in Kent (UK) suffered a collapsing stack during Storm Eunice in 2022. The Grain plant was commissioned in 2011.

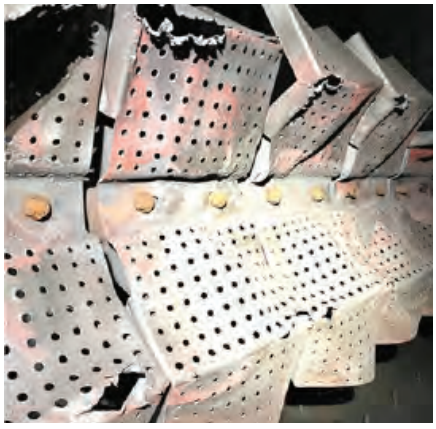
At first, damage was unknown and there was no access for complete HRSG inspection. Specifically, the top section of Unit 71 stack suffered a folding failure at its 42-m level.

There was significant damage to the HRSG building and debris removal delayed full detailed visual inspection during a time when Uniper was also performing other major outages.

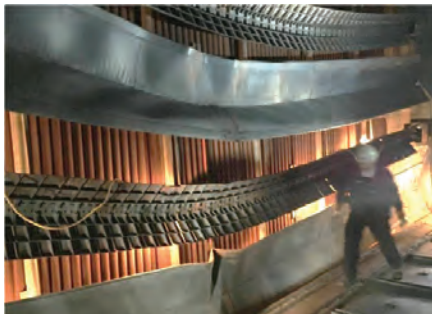
Primary damage areas included:

- Steam drum LP, IP, and HP safety-valve nozzles, pipework, and silencers.
- LP drum shell deformation.
- IP superheater outlet pipework; valves replaced.
- LP downcomer (replaced).

The return-to-service discussion reviewed inspection versus hydraulic testing and the rationale for various hydraulic waivers in line with UK utility practice. Many



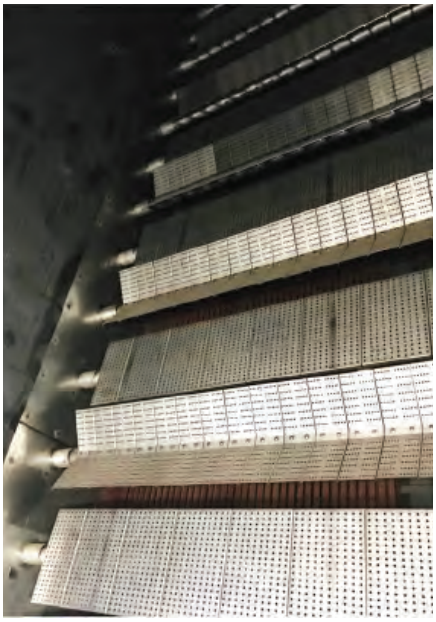
4. Deterioration of duct-burner elements



5. Thermal-growth issues and center-support-structure failures can result in binding and accelerate the rate of a complete failure of the duct-burner system

replacement components and sub-assemblies received shop hydraulic tests. Welds were subjected to enhanced QA and NDT. Details included HRSG preservation techniques while out of service.

A leak test was completed on all three pressure circuits and the unit was returned to service in August 2023.



6. TEG+ next-generation technology features self-supported burner elements and baffles

Hydrogen

Dooley's post-conference review explained the importance of hydrogen fuel blends as an evolving discussion. He stated, "Increased renewables capacity and decarbonization continue to be important topics for combined-cycle users, OEMs, and vendors. While not the highest priority for HRSG on-site teams today, EHF 2024 acknowledged growth of these will play a key role in how gas plants will be operated in the years to come. HRSG OEMs, vendors, and users need to be prepared for a future with GTs firing H2-blended fuels as well as carbon capture and storage plants. The HRSG challenges to be considered when firing blends of hydrogen in the gas turbine include NOx emissions, purging, duct-burner operation, and hazardous-area classification."

Kenneth Hutchison and Gian-Luigi Agostinelli, GE Vernova (Switzerland), discussed trends in decarbonization and, in their words, "why HRSGs need to be part of the H2 discussion today."

First, hydrogen content is important because burning low-percent blends of hydrogen will not significantly reduce CO2 emissions. Second, emissions compliance becomes more challenging at higher-percent blends of H2 as GT frame temperatures rise.

Therefore, "the aging combined-cycle fleet is asking today about future-proofing the installed base to run to and beyond 2040," they stated.

Put simply, hydrogen as a fuel will require changes to the fuel system (for example, more volume flow), combustion system (higher flame temperatures and wider flammability range), and emissions equipment (may increase NOx emissions).

Presenters explained a scope study firing up to 50% H2 by volume in the gas turbine, looking at various items including tube wall thickness, valves, catalyst systems, condensation and corrosion in the cold end, operational system safety, and HRSG operability.

They then discussed the Duke Energy DeBary Power Plant in Florida. (Coincidently, Anderson was plant manager there in the early 1980s when the units fired heavy oil.) In 2024, one of the plant's 80-MW gas turbines was scheduled to be capable of operating on natural gas, liquid fuel, 100% hydrogen, or a blend of natural gas and hydrogen.

Improving startup

Phil Arnold (ARNOLD Group, Germany) presented a discussion on *Advanced steam turbine shell warming system for significant plant startup improvement.* This is part of ARNOLD's comprehensive set of initiatives into HRSG warming, steam-turbine warm-

ing, and proper system-wide insulation maintenance.

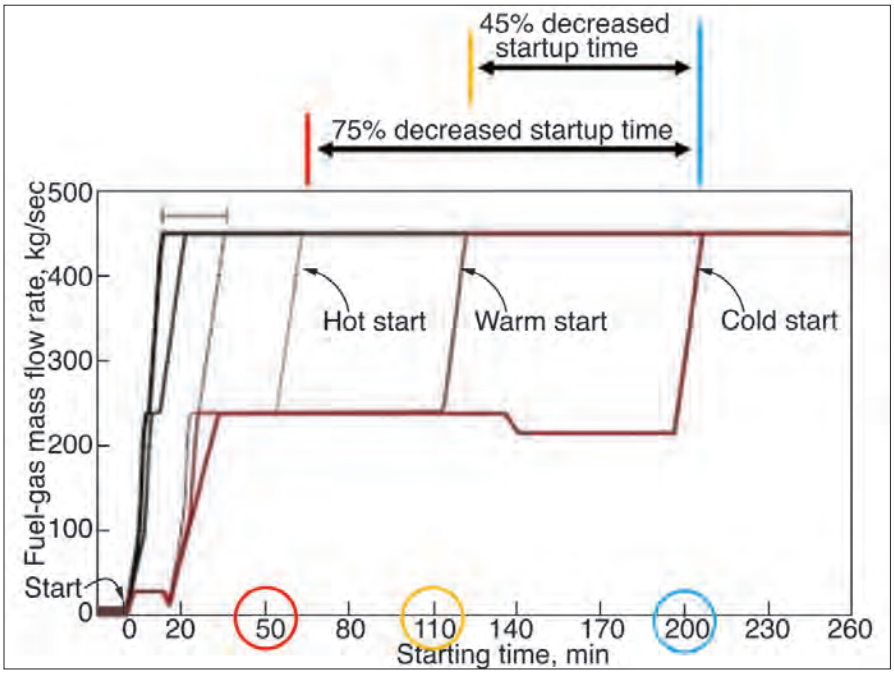
Arnold's question: "Why does anyone need a steam turbine warming system?" His answer was shown in graphic form (Fig 7).

Case studies included units by GE (Fig 8), Toshiba, Westinghouse, and Siemens.

Key takeaways included:

- Reduced startup times by up to 75% (D11 study).
- Reduced parasitic load at startup (200 kW reduced to 50 kW).
- Startup-fuel saving.
- Reduced startup CO emissions from the gas turbine.
- Less stress on the gas turbine's hot-gas-path/exhaust area.
- Reduced staffing costs for startup (less overtime).

He included details and benefits of a recently tested EPRI/ARNOLD Group HRSG electric warming system to maintain HP drum pressure during layup for faster startup (thereby reducing drum/piping fatigue) and freeze protection.



7. The positive impact of reduced startup time with a steam-turbine warming system

Branch tee workshop

A mini workshop was conducted on the cause of the many failures of branch tees in the combined-cycle fleet—which tees should be inspected, how to rank the risks, and provide corrective actions. This was presented by Ian Perrin, Triaxis Power Consulting (US), and John Siefert, EPRI.

Perrin gave an industry update on tee damage and discussed repair and replacement strategies for creep-damaged components.

The balance

Fulfilling the comprehensive 2024 agenda were the following:

- Emergency repairs for under-deposit corrosion (SVI Bremco, US).

- BOP screening for corrosion fatigue sensitivity (Framatome, Germany).
- HRSG upstream temperature control (IMI and A2A GencoGas, Italy).
- Cycle chemistry at CCPP Malzenice (ZSE Elektrárne, Slovakia).
- Latest activities on film-forming substances (Dooley, Structural Integrity, UK).
- Large-movement penetration seals (Dekomte, UK).
- Innovative HRSG upgrades (John Cockerill, Belgium).
- LP bypasses in start/stop operation (Advanced Valve Solutions, The Netherlands).
- Boiler feedwater valve upgrade design (Koso Parcol, Italy).
- Update on cycle chemistry and FAC (Dooley).
- HRSG life extension (NEM Energy, The Netherlands).
- Dissimilar welds by friction welding (John Cockerill and ENGIE Laborelec, Belgium).
- KinetiClean™ tube cleaning (Groome, US).
- Evaluation of explosive cleaning technologies (EPRI).
- Update on global HRSG thermal transients (Anderson, US).

Chairmen's review and EHF 2025

This year the EHF included 24 presentations. It was noted several times that more flexible operation (faster starts and more cycles) was being experienced and was anticipated to be even more challenging in the future for HRSG reliability, particularly for:

- Creep- and fatigue-related failures in superheaters and reheaters.
- Flow-accelerated corrosion (FAC)- and under-deposit corrosion (UDC)-related failures in economizers and evaporators.

The mix of the different topics (materials, cycle chemistry, operation, valves, tube failures and assessment techniques, inspection and remaining life aspects, and HRSG gas-side cleaning) kept the attendees interested, alert, and participating.

EHF again provided a unique opportunity for plant users to discuss questions relating to all aspects of HRSG operations with the industry's international experts. These discussions underlined once more the urgent need for the international exchange of information, which is well provided by this forum.

The EHF 2024 event was organized by Mecca Concepts, Australia. EHF had 13 sponsors: Dekomte, NEM, John Cockerill, Tuff Tube Transition, Precision Iceblast Corp, Altrad Babcock, TesTex, ARNOLD Group, Valve Pro/Conval, Advanced Valve Solutions, Cormetech, Groome Industrial Services, and Metroscope.

The eleventh EHF conference (EHF 2025) will be held May 13-15, 2025 in Prato, Italy.

Contact Barry Dooley (bdooley@structint.com or bdooley@IAPWS.org) or Bob Anderson (anderson@competitivepower.us) for further information. CCJ

8. Permanent placement of redundant sets of heating wires on the casing below the split line, plus the use of a heat-reflecting shield over the wires, assures optimal effectiveness and reliability of the warming system

Planning and implementing a GT-imposed HRSG modification

By Vignesh Bala, Vogt Power

Editor's note: Part 1 of this series (see CCJ Number 79, p. 72) explored the effects of gas turbine upgrades on heat recovery steam generators (HRSGs) and analyzed the key factors driving these GT upgrades. Part 2 (see CCJ Number 80, p. 81) focused on the concept of "re-rating" the HRSG and the associated steps. This included an understanding that the HRSG need not be a limiting factor in a gas turbine upgrade. Part 3 below will discuss the implementation of HRSG modifications and the associated planning considerations.

After completing the thermal, mechanical, and preliminary on-site evaluation of the HRSG as outlined in Part 2, a comprehensive scope of supply for the upgrade implementation must be developed.

Scope definition

The crucial point when finalizing the scope of supply is that every component in the re-rated system must comply with the latest codes and standards. This is especially critical in evaluating superheater components made of Grade 91 material. For example, if the HP system is being re-rated to a higher pressure, the suitability of reusing the Grade 91 component needs to be evaluated using the latest ASME stress values. The legacy stress values used in the original design cannot be reused. The use of the latest Grade 91 stress values for these components (which are significantly lower now than 20 years ago) means that thicker headers and tubes are needed. This will affect the steam velocities and pressure drop through the superheater system which could further increase the design pressure of the HP drum and superheater components. To avoid this, the use of other CSEF material like Grade 92 can be considered.

Similarly, if the RH system is being re-rated, the RH attemperator loop must conform with the condensate removal connection requirements stipulated in the PHRSG section of the latest ASME Section 1 Code. This code also dictates the minimum required drain pot size (Table).

Another important consideration relates to material upgrades and redesigns. For instance, if the re-rate requires a replacement of IP or LP evaporator harps, it is prudent to consider an upgrade to Grade 11 material to prevent flow-accelerated corrosion in the future. Similarly, if the re-rate requires replacing serpentine economizers or preheaters (Fig 1), consider redesigning to a fully ventable and drainable harp.

Construction planning

Once the technical scope of supply is fully established, it is crucial to begin early and specific construction planning. A common mistake made during redesigning and re-rate efforts is neglecting constructability until late in the process. The construction plan can significantly impact the design of the components being replaced. For example, a construction plan involving top access to the harps may require a different number and orientation of header lugs compared to a side access plan involving monorail steel (Fig 2).

Any special tools, equipment or frames required for installation should also be coordinated with the construction company and discussed at this stage. For replacing harps, strongbacks are often required to upright a harp. Without a strongback, the weight of the finned tubes will cause the tubes to bow and sag during uprighting. The extent of sagging can be seen in Fig 3 where an old harp that was removed from a unit is being lowered to the ground. While this is not a concern on a harp that is about to be demolished, such sagging can place undue stresses on the tubes and tube-to-header connections of the new harps.

During a re-rate, it is critical to involve a construction company early and execute the project in a turnkey fashion, as they are the R-Stamp holder responsible for signing off on the re-rate and affixing the new nameplate to the HRSG. Therefore, a vital step in the re-rate process is to ensure alignment between the quality departments of the S-Stamp holder, the R-Stamp holder, and the Authorized Inspector (AI) to clarify the NDE and hydrotest requirements.

Fabrication

Once preliminary construction planning is complete, it is important to establish a clear and viable sourcing strategy. Material sourcing restrictions can be accommodated but may add cost and schedule to the project. Another pertinent and relevant issue to

PHRSG-4 minimum drain pot size

Attaching drain pot size, NPS (DN)	Minimum drain pot size, NPS (DN)
4 (100)	3 (75)
6 (150)	4 (100)
8 (200)	6 (150)
10 (250)	8 (200)
12 (300)	10 (250)
14 (350) and larger	12 (300)

Minimum drain pot size on the attemperator loop (PHRSG, ASME BPVC Section 1)

1. Serpentine economizer section with return-bend tubes, a common failure point

2. A side-access vs top-access construction plan can have different design requirements

consider is the impact of tariffs on raw material sourcing, such as tubes. This affects both domestic and offshore fabrication, as North American tube mills are limited in their ability to offer lengths and grades of certain tubes. Since the imposition and extent of tariffs is currently uncertain, a common strategy is to exclude all tariff cost from the contract price. Should tariffs be imposed during the import of goods, it is usually passed on to the customer at cost. The initial exclusion of tariffs from contract price means that the customer is not paying tariffs if they are not imposed, or if tariff exemptions are subsequently obtained as is often the case.

Considering the fabrication location is also important. North America has many reputable fabricators specializing in pressure part fabrication. Although finished pressure-part goods from outside the US are not currently subject to tariffs, the biggest advantages of fabricating in North America include the ease of travel to the fabricator's facility for critical hold points or witness points, and typically shorter lead times. However, the main disadvantage is higher cost, which becomes especially significant for large and complex scopes.

Regardless of fabrication location, a hydrotest of the harps should be done in the shop and witnessed by an AI. A shop hydrotest that is not witnessed and signed off by an AI will not be considered a Code hydrotest.

Shipping

It is very important that a comprehensive shipping plan be formulated well in advance of delivery. Depending on the geometry of the components being replaced, thorough route surveys may need to be done in advance. Appropriate permits will need to be obtained especially when crossing state boundaries or country borders. Police escorts may be needed to ship components to site. A lack of planning in this regard can be very costly and cause significant project delays.

Lastly, it is also important to coordinate and stage the multiple deliveries appropriately. For example, if harps are delivered and staged out of sequence in a laydown yard (such that the first harp for installation is on the bottom of the stack), it would be expensive and time consuming to correct this.

To summarize the key messages of this series:

1. GT upgrades are becoming increasingly impactful, requiring a comprehensive HRSG analysis to quantify their effects.
2. HRSGs need not be your limiting factor when it comes to GT upgrades. Re-rating an HRSG can provide additional performance and lower your plant's levelized cost of electricity (LCOE).
3. The implementation of an HRSG re-rate needs to be planned properly, accounting for scope definition, constructability, fabrication and shipping.

3. Harp sagging when a strongback is not used

FT8 USERS GROUP

2nd Annual Conference
March 18-20, Charlotte, NC

2025 Steering Committee

Ramiro Gonzalez, plant manager, NAES Corp
Ahmed Ibrahim, director of operations, Middle River Power
George Shambo, plant manager, NVEnergy
Shawn Fowler, independent consultant
Richard Carter, director, Global Turbine Support

The first meeting of the FT8 Users Group took place on March 12-14, 2024, at EPRI's Washington DC office with the purpose of sharing collective expertise of end-users, consultants, and third-party suppliers in addressing the complexities of Mitsubishi Power Aero's (formerly Pratt & Whitney Power Systems) FT8 gas turbine operation and maintenance.

Attendance was impressive with 40 end users responsible for a large percentage of the operating fleet and over 20 companies focused on solutions for FT8-powered facilities (Sidebar). By pooling knowledge and leveraging shared experiences, the group dynamic fosters open dialogue, allowing users and vendors to share experiences and collaboratively develop solutions.

The group's collaborative discussion forum, accessible at https://forum.ft8users.com/ was lauded by users as a valuable tool for sharing insights, troubleshooting advice, and solutions to shared challenges. Case in point: the presentations referenced in this recap are available for download to registered users. Register for this free service via the QR code.

Setting the stage

The keynote presentation by EPRI's Bobby Noble delved into the evolving global energy landscape, highlighting the transformative role of gas turbines in the energy transition. Addressing a "perfect storm" of challenges and opportunities, Noble underscores the necessity of collaboration, innovation, and a balanced approach to achieve decarbonization goals.

The energy sector is rapidly transforming as global efforts prioritize reducing carbon emissions and adopting low-carbon technologies. Since the early 2000s, the transition from coal to cleaner fuels like natural gas and the integration of renewable energy sources have driven significant progress. By 2050, most countries aim to achieve net-zero emissions, though substantial infrastructure and technological gaps must be addressed to meet these ambitious targets.

Gas turbines are positioned as essential enablers of this transition, offering flexibility, resilience, and cost-effective solutions. Advances in low-carbon fuel technologies, such as hydrogen compatibility and carbon capture and storage (CCS) systems, enable gas turbines to complement renewable energy sources, ensuring reliability and grid stability.

Despite these innovations, challenges remain, including the developmental stage of advanced energy storage and hydrogen production technologies. Accelerating the energy transition without fully mature solutions risks reliability issues, emphasizing the importance of strategic deployment and robust infrastructure development (Fig 1).

2024 Solutions Providers

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Baseload Power
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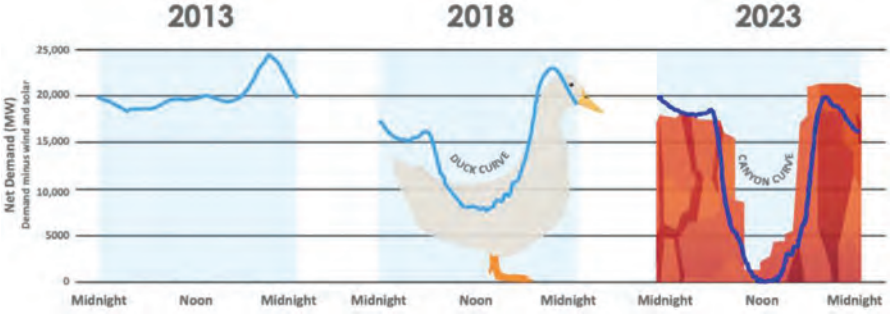
HPI Energy Services
KDN Global Gas Turbine Support
Liburdi Turbine Services
National Electric Coil
SJ Turbine
Sulzer Turbo Services
Van Hydraulics
VAW Systems
Woodward

Noble called for the electric sector to lead decarbonization efforts through global collaboration and phased integration of emerging technologies. This approach will facilitate a sustainable energy future by balancing innovation with strategic planning.

Key issues facing this aging fleet

Much of the discussion over the three days highlighted key operational and mainte-



1. Challenges posed by the steepening "canyon curve" will require a hefty dose of gas-turbine-based generation assets to fill in the inevitable gaps from intermittent renewable energy sources and peak demand

nance challenges while emphasizing the value of collaboration among users. One recurring theme was the inconsistent performance of FT8 units, even under similar conditions. This variability underscored the importance of standardized maintenance practices and detailed diagnostics.

Attendees emphasized the need for proactive maintenance, open collaboration, and adaptation to the evolving demands of FT8 operations, particularly in the context of renewable energy integration. By implementing these measures, users can enhance unit reliability, reduce costly downtime, and address recurring challenges effectively. The user group's efforts to share knowledge and advocate for improved practices are vital to achieving these goals and ensuring the long-term fleet performance.

Components like thermocouples and exhaust gas temperature (EGT) sensors emerged as critical to turbine performance but were also frequent points of failure, necessitating careful monitoring and timely replacement.

No surprise to anyone in the gas turbine industry, the group identified challenges related to sourcing and maintaining specific components. Replacement parts, such as cold air buffers and thermocouples, often had long lead times and high costs, which complicated maintenance schedules.

Some participants explored third-party alternatives, like Conax Technologies, which demonstrated improved reliability in certain cases. Additionally, innovative repair strategies, such as creating custom wiring harnesses, were discussed to reduce dependency on the OEM.

Upgrades to control systems sparked mixed reactions among the participants. While some facilities benefited from enhanced functionality, others faced difficulties integrating new systems and troubleshooting issues. This highlighted the importance of tailoring upgrades to the specific operational needs of each facility.

Training and knowledge sharing were emphasized as vital to effective turbine maintenance. Ensuring that operators and maintenance teams understand key aspects of FT8 systems, such as thermocouple positioning and calibration, was deemed essential for consistent performance.

FT8 gas turbines have experienced several recurring issues over the years, particularly in bearings, compressors, combustion systems, and synchronous condensing operations. Among these, bearing failures have been a consistent concern.

Carbon oil seals and bearings often fail due to wear, leakage, and coking, which block oil flow and cause severe damage (Fig 2). Insufficient lubrication during synchronous condensing is a major contributor to catastrophic failures such as rotor lock-ups. To mitigate these issues, users were advised to replace carbon oil seals and bearings during hot section inspections and improve oil mon-

2. FT8 bearing issues like carbon seal wear can impact oil flow and cause scoring. Proposed solutions include seal replacements and material improvements to address vibration along with closely monitoring oil consumption and particulate

itoring systems to detect anomalies early.

Compressor-related problems were also prominent, with inlet icing, airfoil fatigue, and blade failures in stages 8 and 9 being common. These issues often result from vibration and fatigue. To address these, regular maintenance practices such as testing solenoid valves, performing thorough borescope inspections, and implementing strict policies after surge events were recommended.

In the combustion system, challenges such as gang channel rivet loosening, combustion chamber mounting pin liberation, and bolt failures frequently caused consequential damage downstream. Proactively upgrading components, adhering to OEM recommendations, and replacing worn parts during inspections were deemed essential to minimize these risks.

Synchronous condensing, increasingly utilized due to the growing adoption of renewable energy, presents additional challenges. This operational mode often led to significant wear on the gas generator because of inadequate lubrication and overheating during windmilling.

High-severity failures, including rotor lockups and downstream damage, were reported. Recommendations included modifying units with SSS clutches, installing supplemental lubrication systems, and conducting regular maintenance to ensure reliable operation.

O&M limitations

FT8 gas turbines are well-suited for frequent starts and stops, but they struggle under conditions requiring rapid load changes or load-following capabilities. Such operations exert excessive wear on bearings and rotors, adversely affecting reliability.

Users noted that the current maintenance schedule, based on a fixed 25,000-hour interval for hot section inspections, is outdated and unsuitable for plants operating in peaking or cyclic modes and advocated for maintenance schedules based on operational cycles rather than hours to reflect the real stresses experienced by these units.

Rotor and tie-rod failures emerged as a particularly severe issue. Overheating and insufficient lubrication during synchronous condensing led to tie rod failures, rotor misalignment, and blade damage, often requiring complete overhauls. These failures highlighted the importance of adapting maintenance practices to the operational demands of modern FT8 usage.

Proactive recommendations proposed to address these challenges included:

- Collaborate with OEM to update maintenance practices, improve material designs, and resolve component limitations.
- Proactively replace critical components such as carbon oil seals, bearings, and gang channel rivets during inspections.
- Modify units to improve compatibility with synchronous condensing, including installing SSS clutches and enhancing lubrication systems.
- Monitor vibration, oil consumption, and chip detector alarms closely to detect early signs of failure.
- Align maintenance schedules with the operational realities of peaking and cyclic operations, rather than relying on fixed-hour thresholds.

Anatomy of a controls upgrade

One of the highlights of the user session, illustrating to those reading the true value of attending, was a presentation from an owner/operator with over two dozen engines which outlines the process and outcomes of upgrades to control systems, automatic voltage regulators (AVR), and SEL synchronizers. The slides provide a comprehensive look at the pre-installation, installation, and post-installation phases, highlighting both successes and challenges.

The controls upgrade began with a straightforward pre-installation process, including scope definition, material acquisition, and contractor coordination. Delays in acquiring materials required custom-made Micronet cables to ensure readiness. Installation, initially planned for 12 weeks, was completed more efficiently, with the time required per unit dropping from 14 days for the first unit to 7 days for the last.

The upgrade involved system backups, hardware enhancements to processors and

communication modules, and software updates from GAP 3.0 to GAP 4.0, along with functional and operational testing. Post-installation, the upgraded systems demonstrated faster, more reliable performance and improved visibility into system functionalities. However, wire management remained tedious, complicating maintenance.

AVR/synchronizer upgrade also faced logistical hurdles during pre-installation, including equipment verification and material delays. Despite an initial schedule of 37 days, the installation was completed in 14 days due to increased efficiency. Major upgrades included replacing the Brush A30 AVR with the Brush A3100 and upgrading the synchronizer to the SEL 700G.

Challenges arose with relay functionality, communication issues, and wiring complexities introduced by the new AVR's dual communication runs. Post-installation, the systems displayed enhanced functionality, more refined control steps, and better visibility through the Brush HMI and software.

However, lingering issues such as CITECT command oddities, relay wiring errors, and compliance challenges with NERC standards required further attention. Unit 2's AVR faced manufacturing defects, which led to warranty claims and delays in obtaining replacements.

Overall, the upgrades significantly improved system performance and reliability but highlighted challenges with material delays, compliance requirements, and post-installation troubleshooting. These experiences provide valuable lessons for future upgrades, showcasing the importance of meticulous planning and adaptability.

Not all who wander are lost

Power industry consultant Campbell Archibald eloquently reflected on the evolution and growing significance of independent support services in the gas turbine industry. Drawing from decades of experience, Archibald shared his journey from an apprentice in 1989 to his leadership role at Alba Power, illustrating a career dedicated to advancing turbine support and repair services. Now, he advises companies such as Liburdi Turbine Services and HPI Energy Services to better position themselves for aftermarket MRO opportunities.

The speaker touted the advantages of independent service providers over traditional (oft-degrading) OEM aftermarket support. Trust forms the foundation of these relationships, enabling clear, client-aligned objectives and consistent over-delivery of results. Independent providers excel in offering comprehensive solutions tailored to the unique needs of entire stations, fostering deep collaboration and delivering measurable benefits in cost, efficiency, and reliability.

The principles for successful independent support are steeped in building trust, understanding client needs, and delivering holistic station support. These strategies strengthen long-term partnerships and ensure high-quality service. A case study of collaboration between FT8 users and Liburdi detailed later in this article exemplifies the impact of innovative problem-solving and effective partnerships.

To close, Archibald emphasized the transformative potential of trust-based partnerships, showcasing the pivotal role of independent service providers in shaping the future of the energy industry, perfectly teeing it up for the ten presenting companies, outlined below, focused on the FT8 aftermarket.

FT8 solutions providers showcase deep experience

AGTServices

Industry veteran Jamie Clark, in his classic style, emphasized the critical importance of thorough and expert-driven generator testing and inspection processes to ensure reliability and prevent costly failures.

Experienced specialists are irreplaceable in identifying issues and stresses the value of leaving visible clues, like dirt, untouched during initial inspections to uncover diagnostic insights. A clear message is that there are no shortcuts in generator maintenance—speed and extended intervals between inspections often compromise quality

and reliability.

Early detection of potential issues to avoid serious damage ensure confidence in the generator's performance and planning future upgrades or repairs. A variety of tests, including electrical, mechanical, and visual inspections, are essential components of this proactive approach.

Specific electrical tests such as winding resistance (Fig 3) and insulation resistance are critical for diagnosing imbalances, contamination, or damage, while advanced methods like DC leakage tests and polarization index measurements provide deeper insights into insulation health and failure risks.

Clark expounded on the value of advanced diagnostic tools, such as the EL CID for identifying lamination shorts and end-winding resonance tests for optimizing stability. Techniques like robotic inspections, surge tests, and acoustic surveys represent evolving technologies improving reliability and detection precision.

Key takeaways include the necessity of addressing identified issues promptly through actions like cleaning, soldering, or reassembly to maintain generator integrity. Examples of good and bad test results emphasize the importance of diagnostic accuracy and corrective actions.

Ultimately, this very detailed slide deck serves as a reminder that diligent and well-executed testing is indispensable for generator reliability. It advocates for a meticulous approach, avoiding shortcuts, and leveraging expertise and advanced technologies to ensure sustainable and cost-effective operation.

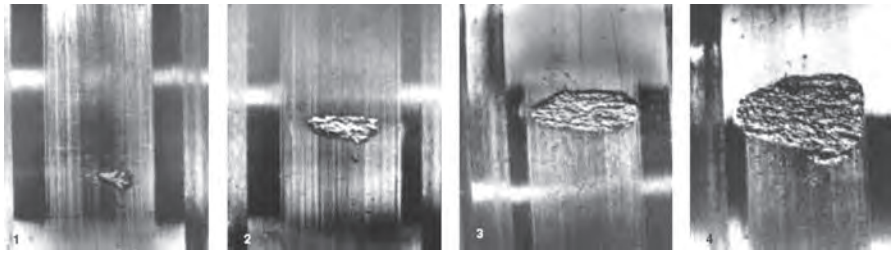
GasTops

Simon Wilson and Zachary Reesor present compelling case studies on company's renowned MetalSCAN Oil Debris Monitoring System, highlighting its innovative approach to monitoring critical rotating components. MetalSCAN addresses the limitations of traditional methods by offering 100% detection of metallic debris and precise particle classification, enabling early damage identification and risk mitigation.

Features such as real-time monitoring, remaining useful life prediction, and maintenance-free operation allow operators to plan maintenance effectively, reducing costs and downtime. Case studies illustrate MetalSCAN's success in proactive maintenance, avoiding secondary damage, and ensuring operational continuity (Fig 4).

GasTops combines monitoring technolo-

3. Endwinding resonance testing using calibrated hammer impacts to analyze frequency and amplitude responses ensures proper tuning for stability, minimizing operational risks and enhancing performance



4. The criticality of detecting bearing surface fatigue damage early is on display here. Its role as a leading cause of unplanned engine removals and severe consequences from missed detections in aeroderivative engines reinforce the importance of proactive monitoring systems

5. Visual inspection of SCR catalyst shows critical need for maintenance (cleaning, repacking, restacking) to restore lost performance from plugging and structural issues

gy with laboratory services, providing detailed analysis to enhance diagnostics and decision-making. This integrated approach significantly improves equipment reliability and efficiency.

Groome Industrial Service Group

Matt Cohen, technical sales lead, emphasized catalyst cleaning and lifecycle management's critical role in maintaining industrial system efficiency. Groome specializes in services like HRSG tube cleaning, SCR catalyst maintenance, and CO catalyst washing. Key factors impacting performance include non-uniform gas flow, temperature variations, and catalyst deterioration caused by fouling, poisoning, and structural damage (Fig 5).

Groome's maintenance programs address these challenges through advanced cleaning techniques and system optimization. For CO catalyst systems, methods like acid washing and gasket retention improve backpressure and extend component life, while AIG cleaning and tuning ensure precise ammonia distribution to enhance SCR performance.

Cohen stresses the importance of regular catalyst testing and system analysis. Testing enables the identification of catalyst versus system problems, guiding corrective actions and preventing costly downtime. By integrating visual inspections, operating data analysis, and sample testing, Groome provides a comprehensive evaluation of system performance.

The financial impact of maintenance was shown in a case study of an ethylene plant that achieved a nine-day payback period through catalyst cleaning, significantly boosting daily revenue. Additionally, the cost of pressure drops across turbines is quantified, showcasing the economic benefits of maintaining optimal system conditions.

Ultimately, proper catalyst maintenance and lifecycle management ensures improved performance, reduced operational costs, and extended system life.

KDN Global Gas Turbine Support

Company namesake Karel de Nave emphasizes its comprehensive capabilities in supporting gas turbine operations, including field services, parts supply, equipment retrofits, troubleshooting, design improvements, and training. KDN positions itself as a reliable partner for customers requiring advanced technical solutions and lifecycle management of turbine systems.

Key offerings include annual inspections, borescope evaluations, preventive maintenance recommendations, and retrofitting mechanical and control systems. KDN's expertise extends to disassembly and assembly of components such as GG, PT, combustion chambers, and fuel nozzles. By implementing OEM service bulletins and performing critical alignments and repairs, the company ensures optimized equipment performance.

Retrofit projects, such as the installation of offline water injection systems and collector box seal replacements (Fig 6), highlight KDN's innovative approach to enhancing turbine efficiency and reliability. The offline water injection system improves maintenance accessibility, reduces costs, and enhances emission control.

KDN's spare parts and repair capabilities further support its commitment to operational efficiency. The company provides components like hydraulic starter motors, combustion chambers, and fuel nozzles, while offering repair services for critical parts, reducing downtime and costs.

Case studies demonstrate the success of KDN's solutions, such as projects in Germany and Romania where retrofitted systems achieved long-term operational benefits. The company's focus on reliability, cost-effectiveness, and tailored customer support ensures its solutions meet diverse industry needs.

Through a combination of expertise, innovation, and commitment to customer success, KDN delivers high-value services to optimize the performance and longevity of gas turbine systems globally.

Liburdi Turbine Services

Jeff Chapin, business development manager, and former plant manager Shawn Fowler updated attendees on advanced solutions for repairing and optimizing FT8-3 dual-fuel nozzles, addressing challenges related to fuel system backflow and component failures.

Liburdi, a leading provider of turbine component repair services since 1979, supports industries like oil and gas, power generation, and aerospace with cost-effective maintenance and repair strategies.

Of great interest to end users is the issue of liquid fuel backflow into the gas supply system, causing coking and blockages in nozzles, headers, and hoses. Testing revealed that internal stress cracks within fuel nozzles allowed cross-talk between liquid and gas flow paths, exacerbating the problem. Early indicators showed localized coking in specific nozzles, with further test-

6. Redesigned collector box seals eliminate axial and radial stress, minimize misalignment risks, and extend component lifespan, offering significant cost savings over time

ing demonstrating that rebuilt nozzles often failed within short operational timeframes.

To address these issues, Liburdi developed advanced repair processes. The repair strategy includes rigorous inspections, material verification, cleaning, dimensional assessments, and application of wear-resistant coatings (Fig 7). For severely damaged nozzles, advanced techniques such as weld repair of internal housing cracks and reassembly ensure leak-free operation. This approach significantly extends nozzle life and mitigates failure risks.

Liburdi's solutions also emphasize cost savings. Repairs typically cost 25%-30% of replacement parts, providing significant financial advantages. Root cause analysis and redesigned components further enhance reliability, reducing maintenance cycles and operational disruptions.

The presentation highlights successful implementation of new and repaired nozzles in 16 of 24 engines at one particular site, with operational tests confirming the effectiveness of these interventions. By combining technical expertise, rigorous testing, and innovative repair solutions, Liburdi supports customers in maximizing turbine efficiency, minimizing downtime, and extending component life.

National Electric Coil (NEC)

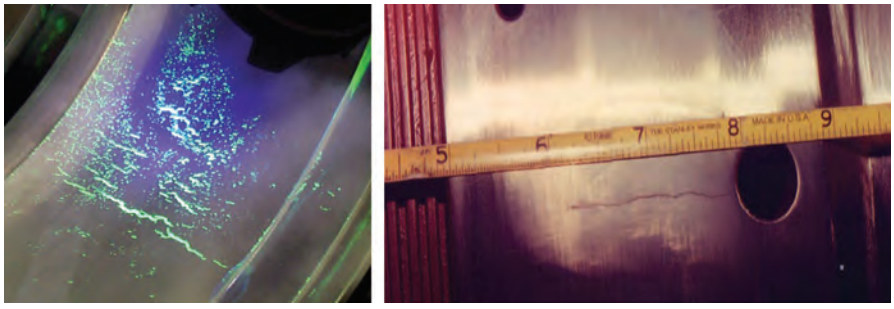
Generator guru Howard Moudy addressed critical concerns and solutions for FT8-applied generators, emphasizing contamination, partial discharge, rotor and stator maintenance, and tailored repair methodologies. As a global leader with over a century of experience in generator technology, NEC focuses on quality, performance optimization, and longevity.

Key challenges highlighted include contamination from operational environments and aging systems, leading to issues such as partial discharge, corona damage, and cooling inefficiencies. NEC employs advanced cleaning methods like CO2 cleaning to safely remove contaminants without damaging components. For partial discharge and corona concerns, NEC leverages IEEE standards and engineered solutions to mitigate damage and improve insulation longevity.

The presentation features case studies illustrating common issues and their resolutions. For example, rotor challenges such as magnetic retaining ring stress corrosion cracking (Fig 8) and tooth-top fatigue are addressed through advanced engineering solutions like replacing fabricated assemblies with solid billets and implementing new retaining ring designs.

Stator issues, such as coil damage and end-winding failures, are tackled using tailored repairs involving high-quality replacement coils, outer corona protection systems, and slot-side packing upgrades.

Through innovative approaches and proven expertise, NEC enhances generator reliability, reduces maintenance costs, and extends service life. The presentation underscores NEC's commitment to delivering world-class solutions for generator repair, maintenance, and component manufacturing, solidifying its position as a trusted partner in the power generation industry.



8. Rotor magnetic and vented retaining rings in EM generators are subject to stress corrosion cracking in 4340 steel retaining rings due to high stress. Inspect with dye penetrant and replace with new 4340 forgings as needed to enhance durability

Sulzer Turbo Services

Matt Walton, gas turbine metallurgy and repair expert, highlighted the company's ongoing efforts to provide extensive maintenance capabilities for FT8 users, including depot-level services, component repairs, and reverse engineering (Fig 9). These developments, unknown to many attendees, were met with great interest and excitement, spurring a valuable exchange of ideas, suggestions, and ambitions.

Sulzer's field service team, with a long history of aeroderivative expertise, offers borescope inspections, module swaps, installations, commissioning, and troubleshooting. While describing this group dedicated to specialty aeroderivative field work, Walton reiterated their commitment to this market, "If you want to be in an engine, you have to be in the engine all the way."

The company's service roadmap includes ongoing development of reverse engineering capabilities, heat treatment validation, coating advancements, and the production of new parts like gas generator components and bearings.

A key focus is Sulzer's ability to reduce turnaround times and costs for depot-level services. By integrating reverse engineering and precision manufacturing, Sulzer addresses issues of OEM scrap, financial inefficiencies, and delayed service delivery. Walton invited users to engage in shaping Sulzer's offerings, highlighting a collaborative approach to better serve the FT8 community.

Baseload Power

Bob Vandenable's presentation on Baseload Power focuses on the company's expertise in aeroderivative gas turbines and its comprehensive inspection and repair services. Emphasizing adherence to ISO 9001 quality standards, Baseload Power delivers specialized support across various operational domains, ensuring effective turbine management.

Key services include interval-based inspections, from 8,000 to 100,000 operational hours, tailored for turbines like the FT8, LMS100, LM6000, and LM2500 series. Maintenance processes such as generator field inspections, retaining ring reassembly, and exciter armature repairs highlight the company's precision and thoroughness. Advanced diagnostic methods, including borescope evaluations and high-potential testing, ensure component reliability.

Baseload Power integrates cutting-edge tools and rigorous quality standards, positioning itself as a trusted partner in enhancing aeroderivative gas turbine performance through innovation and expertise.

HPI Energy Services

Wayne Tomlinson, senior GT specialist, introduced its ARMADA remote monitoring system, showcasing advanced capabilities in

7. Post-repair flow testing and matching ensure "new" fuel nozzles with no internal cracks and within specified tolerances for optimal combustion performance

reliability-centered maintenance. Built for scalability, ARMADA offers real-time diagnostics for gas turbines, steam turbines, and diesel generators, combining high-speed data gathering with advanced analytics such as vibration and oil debris monitoring.

ARMADA's cybersecurity features, including ISO-27001 compliance, ensure secure client connections. Early issue detection minimizes downtime, reduces costs, and enables precise maintenance scheduling. A case study demonstrates ARMADA's effectiveness in optimizing maintenance schedules, reducing lost revenue, and limiting equipment damage.

HPI integrates root cause analysis with advanced monitoring technologies, transitioning clients from reactive to proactive maintenance strategies. This approach enhances reliability, operational efficiency, and overall asset performance.

9. FT8 engine purchased by Sulzer for purposes of reverse engineering development starting with component repair, tooling design and fabrication, and eventually, new parts manufacturing

Woodward

Brooks Hoffman, sales manager, featured the company's longstanding expertise in energy control solutions across aerospace and industrial sectors. Advancements in control systems, such as the MicroNet Plus platform, enhance reliability and support energy transition technologies.

The presentation details advancements in Woodward's control systems, including the evolution from the NetCon platform to the current MicroNet Plus system, which offers superior performance and redundancy for critical applications.

For products facing phased obselecence like the LON LinkNet and 3103 Fuel Metering Valve, Woodward has introduced replacements such as the rugged LINKnet-HT modules and GS40/GS50 valves. These upgrades enhance reliability, performance, and compatibility, with the GS50 valves supporting hydrogen-methane blends up to 50% and 100% hydrogen-compatible options.

Ask the experts

The Ask the Experts panel at the 2024 FT8 Users Group provided valuable insights into operational challenges and maintenance strategies for aeroderivative gas turbines. Panelists, who were experts in areas such as hot section inspections, generator maintenance, advanced repairs, and control systems, made themselves available to end users for two hours of Q&A to close out the conference. Thought leaders included:

- Dave Budreau, Power Control Services and Electric
- Richard Carter, Global Turbine Support
- Bob Tollet, Liburdi Turbine Services
- Karel de Nave, KDN Global Gas Turbine Support
- Jamie Clark, AGTServices
- Ahmed Ibrahim, Middle River Power

One key area of discussion was varnishing issues in turbine oil systems, caused by high temperatures, contamination, and frequent cycling. Recommendations included monthly oil sampling, advanced filtration techniques, and using high-quality lubricants like Mobil Jet II.

Additionally, panelists emphasized proactive measures such as employing varnish mitigation systems and maintaining clean oil supplies.

Servo valve failures were another critical topic, with panelists identifying varnishing and contamination as primary causes. Solutions included recalibration, preventive maintenance, and improvements in hydraulic system design to enhance reliability.

Challenges during start-up and shut-down procedures were highlighted, particularly with lean fuel mixtures leading to ignition failures. Adjustments to tuning blocks, minimum stops, and start-up fuel rates were proposed as effective remedies, alongside seasonal tuning strategies to ensure consistent performance.

The panel also addressed single crystal blade repairs, emphasizing that these components are repairable but require careful evaluation of stress points and repair locations. Finite element analysis (FEA) and a thorough understanding of material properties were deemed essential for successful repairs.

Generator maintenance and inspections were another focus area, with discussions on robotic and borescope technologies for rotor evaluations. Panelists stressed the importance of tailoring inspection schedules to operational history, starts and stops, and environmental conditions.

Persistent issues like first-stage turbine vane erosion and cold air buffer seal challenges were explored, with proposals to redesign seals and reverse engineer components to improve performance. Attendees were encouraged to retain replaced parts for analysis and future use.

Throughout the discussion, the importance of operational data collection and interpretation was emphasized. By standardizing data metrics and leveraging collaborative forums, operators can optimize maintenance schedules and address recurring issues more effectively.

The panel concluded with recommendations for fostering collaboration within the industry and with OEMs to develop innovative solutions. Suggestions included testing improved cooling mechanisms, advanced seal designs, and sharing best practices to address the evolving needs of FT8 turbine operators.

What's in store?

The 2025 FT8 Users Group conference is set to take place March 18-20 at EPRI's Charlotte campus. The format will mirror that of the first meeting with some added training modules, so expect a great deal learning opportunities for those new to the engine and seasoned veterans. Details and registration are readily available at https://www.ft8users.com/. Email ft8@ft8users.com with any questions.

As of February 15, presenting sponsors include: Baseload Power, Camfil Power Systems, GasTops, Groome Industrial Service Group, HPI Energy Services, Liburdi Turbine Services, Mee Industries, National Electric Coil, Sulzer Turbo Services, Woodward.

HPI will be hosting a deep dive into gas turbine rotor dynamics on day one. To close out the event, Mitsubishi Power Aero will conduct a Q&A session with the end users, piping in a number of SMEs virtually to support customer needs.

Vendor exhibitors, in addition to those listed above, at the March 18 vendor fair are: Advanced Turbine Support, AGTServices, Freudenberg Filtration Technologies, Global Turbine Support, Heiberger Solutions, Precision Iceblast Corp, Schock Manufacturing, Van Hydraulics, and WEG Electric Machinery.

Thanks to the generosity of EPRI, end user registration is free of charge, so sign up today.

CalPeak Power LLC

Owned by Middle River Power
Operated by NAES Corp

242 MW, four simple-cycle peaking plants (Border, Enterprise, Panoche, and Vaca Dixon), each consisting of one FT8-2 TwinPac generating unit operating on natural gas, located in San Diego, Calif

Plant manager: Ramiro Gonzalez

Midway Peaking LLC

Owned by Middle River Power
Operated by NAES Corp

120 MW, simple-cycle peaking plant consisting of two FT8-3 SwiftPac generating units operating on natural gas, located in Firebaugh, Calif

Plant manager: Ramiro Gonzalez

Monitor calibration-gas levels in real time to reduce regulatory risk

Challenge. The CalPeak Power and Midway plants are remotely operated, manned during normal working hours, and unmanned on nights and weekends. The six generating units are dispersed throughout California, with a spread of 544 miles. Some units are located in very rural areas.

CEMS calibrations are conducted daily, regardless of work schedules. Equipment issues affecting calibrations can go undetected until "it's too late," resulting in an environmental notice of violation and/or forced outage. Incidents can include the following:

- Failure of regulator valves.
- Pressure gage issues.
- Plant staff closing cylinder valves to prevent gas from escaping because of an unidentified leak.

Solution. Middle River Power (MRP) engaged WestAir Gas and Equipment, Fontana, Calif, to install a Pulsa real-time gas and tank level monitoring system. It uses sensors that are attached to the high side of the gas regulator (Fig 1) and a cellular service to communicate externally and transmit data (Fig 2). Internally it connects via Bluetooth® or WiFi to each individual pressure sensor to collect data at intervals of every few minutes.

The system also offers a cellphone app through which users can scan the sensor QR code and access status information. Plus, the application monitors connectivity health and sends notifications if a sensor is not reading data or becomes disconnected.

Pulsa is powered by solar energy (Fig 3) and features a battery life of 40 days (when fully charged) before depletion. Alternative power-supply configurations can be implemented as needed.

Pulsa's sensor/software technology allows staff to remotely measure consumption of calibration gas in real time, providing numerous advantages, such as these:

- Remote monitoring of system readiness
- Continual pressure monitoring.
- Alarm notification based on cylinder pressure.
- Alarm notification for rapid discharge (leak identification).
- Automatic ordering and supplier notification based on calculated remaining capacity of cylinders.
- Preventive planning and reaction—especially considering that sites are not staffed 24/7. In the past, MRP has experienced issues with leaks developing during weekends when there was no one onsite. They were discovered only when someone returned or when gas was required for a run but couldn't be delivered.

Results. The project easily met expectations—or surpassed them. The 24/7 monitoring presence provides peace of mind both when sites are manned as well as in the remote management of unmanned sites.

The safety net protects against incidents that could result in potentially large, unplanned expenses, such as these:

- Fines related to any potential notices of violation or correction. Prior to adopting the Pulsa technology, MRP had an incident that led to the filing of a Breakdown Report to the Air District. A bottle had drained over the weekend, leaving the unit without gas during operation. Since installing Pulsa, none of the company's generating units has encountered a similar situation.

  However, there have been low-pressure alarms, but they are programmed to trigger in advance, giving staff ample time to correct the cause. Personnel are currently monitoring the low-pressure alarms and may adjust their settings as needed to better suit requirements.
- Lost revenue from plant downtime attributed to failed calibrations caused by leaks or other issues.

Project participants:
Plant personnel

1. Calibration-gas consumption is measured in real time by sensors mounted on the tank as shown

2. Communications link transmits data captured externally

3. Pulsa runs on solar power

Schuyler Vaughn McElrath

Oct 14, 1958 — Jan 19, 2025

If you never had responsibility for operating and/or maintaining a GE E-, F-, or H-Frame gas turbine you might not have met Schuyler McElrath, who left us in mid-January at the age of 66. He was a fuel-system expert, always available to help users keep their engines starting and running reliably on oil. He was by far and away the industry's most visible fuel-system problem solver, having acquired his considerable knowledge and honed his skills over nearly 25 years with GE.

He brought that unique background to JASC two decades ago as an independent contractor after meeting founder Harvey Jansen. The two men had a special synergy: Schuyler understood well the fuel-system issues tormenting gas-turbine owner/operators while Harv and his team at JASC provided the creative genius to engineer the needed flow-control solutions based in large part on the company's work developing space-age components for the aviation industry. Both men had a passion for the mission they embraced and together they made good things happen.

The editors remember Schuyler as a very private man who focused on work, faith, family (wife Sylvia and two daughters), and fishing. We chatted with him at virtually every industry meeting for users of GE turbines over the last two decades. On-going discussions were not of a personal nature, but rather about technical issues associated with the use of liquid fuels and their solutions. He shared much of this work with CCJ's audience in print and online.

Schuyler's considerable health/physical challenges were not even a footnote. One can only imagine the immense effort it took for him to navigate meetings and industrial facilities via motorized scooter, juggle schedules to accommodate his many operations and hospital visits, get to and from places he believed he had to be to see customers in person—including the Middle East only a couple of months ago—etc. Never a thought of throwing in the towel, never a whimper. Always a smile. He was a very special person.

Our education began back in 2005 or early 2006. Given the complexity of the issues facing owner/operators of frame machines with respect to fuel systems, he told us in that first sit-down, "the solutions are amazingly simple." The primary cause of liquid-fuel-system failures, he said, is check valves that stick open, stay closed, or remain somewhere in between after the gas turbine runs for long periods on natural gas.

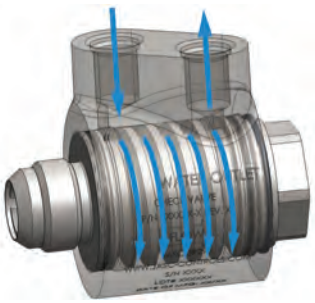
Specifically, the high temperatures around combustion cans "cook" the fuel inside the valves, promoting the buildup of a hard residue which inhibits valve operation. JASC solved this problem by designing a liquid-fuel check valve that resides within an external water jacket.

The editors were asked by Harv to proof-test the idea on a visit to JASC's shop. He put a valve in an oven at 500F and turned on the cooling circuit. Then he opened the oven door and, with a grin like that on the proverbial Cheshire cat, asked us to touch the valve. Having been schooled in the safety-first mentality of power users, that took a leap of faith.

First commercial use of the water-cooled check valve was at an East Coast refinery with two oil/gas-fired Frame 6 machines. From commissioning through the first six years of operation with standard check valves only two of 50 fuel transfers were successful. Water-cooled check valves were installed and over the next two years the success rate for transfers from gas to oil and vice versa was 100%. Longest run on gas was three weeks.

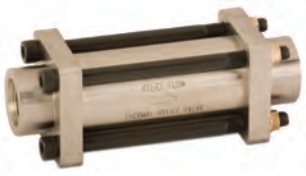
That success encouraged the development of JASC's product line for the electric power industry, today including the water-cooled three-way purge valve which combines the company's liquid-fuel and purge-air valves in one unit. Several JASC products, installed in hundreds of gas-turbine fuel systems worldwide, are shown nearby. CCJ

Water-cooled three-way purge valve



Water-cooled liquid-fuel check valve

Liquid-fuel check valve



Thermal relief valve

Purge-air check valve

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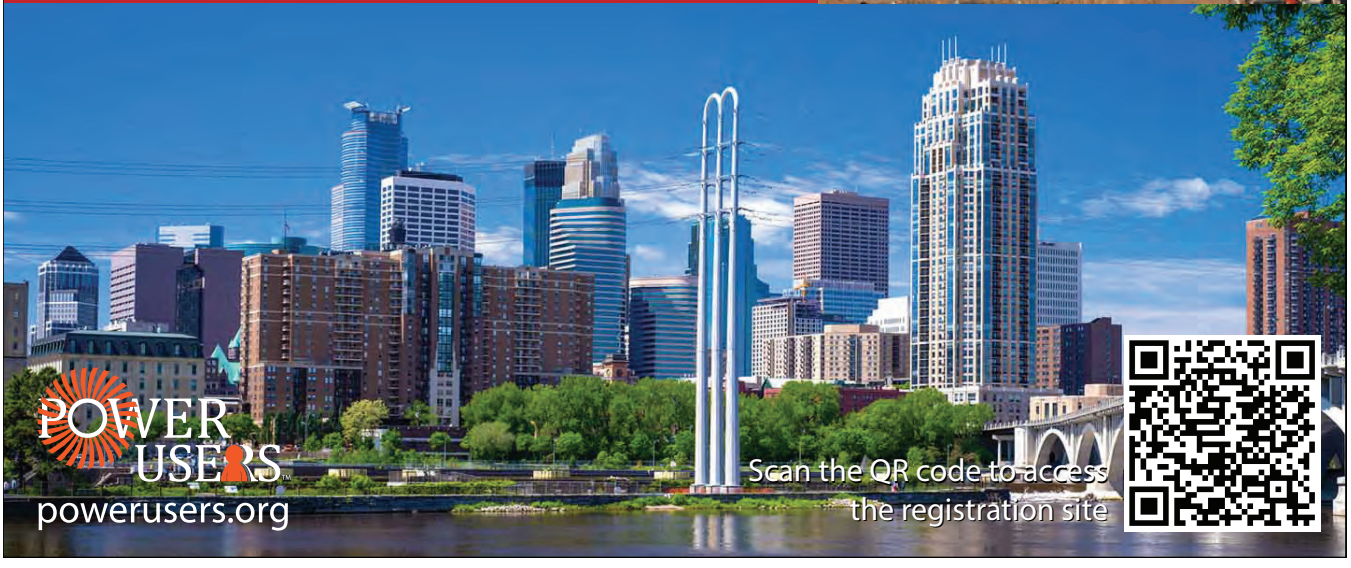

PROENERGY CONFERENCE 24

Fueling the future: Unlocking opportunities for flexible aeroderivative gas turbines

ProEnergy's growing presence on the aeroderivative gas turbine stage is undeniable, owning and operating 2.4GW of peaking capacity, along with complete overhaul services for LM6000 and LM2500 engines, and turnkey powerplant development.

Customers and industry leaders from around the globe filled the seats at its third annual conference, PEC2024, in November. The exciting future for the company only gets more interesting with the announcement of its new majority stakeholder, Energy Capital Partners, positive field results of the first PE6000 gas turbines, and explosive electricity demand growth, to name a few.

The conference has its roots in training owner/operators, featuring a shortened version of the four-day, on-site, intensive training programs offered for the LM6000 and LM2500. One full day of familiarization guided by ProEnergy SMEs, generator partner BRUSH, and emissions control partners EnergyLink International and Environex provided a great opportunity to learn and share best practices for LM technology.

Beyond the opportunity for technical training, PEC provides a compelling look at the future of the global energy industry, highlighting the critical need for adaptation and innovation in response to evolving market demands. As you read this report, it's clear to see the immense challenges and opportunities facing the generation sector as it navigates rising electricity demand, grid modernization, and the transition to cleaner energy. Insights on balancing innovation with reliability, the growing role of gas turbines, and the impact of data-driven strategies in power generation from varying perspectives are on display and strike a common chord.

Embracing disruption

The general session kicked off, as is custom, with resident raconteur, Carlos Picon, as thought-provoking and dazzling as ever addressing the rapidly evolving energy landscape and the challenges and opportunities that lie ahead. His message was clear: the world is facing an unprecedented demand for power, and the industry must adapt to ensure a reliable, efficient, and sustainable future.

Picon began by highlighting the rising global demand for electricity, particularly in 2024 and 2025, driven by factors such as economic development, heatwaves, and industrial expansion across regions like Asia and Africa. Although renewable energy sources—such as solar, wind, and hydropower—now supply 30% of the world's electricity, they still face significant scalability and reliability challenges.

Hydropower, for instance, has suffered from declining output, with a 5% drop this year and a 20% drop the year before. Meanwhile, while renewable energy is making progress, thermal power remains essential for maintaining grid stability, ensuring that businesses and households receive uninterrupted electricity. The transition to cleaner energy is happening, but it requires careful planning and infrastructure improvements to prevent disruptions.

One of the most pressing challenges is the growing energy demand from data centers. By 2026, their power consumption is expected to match that of entire nations, creating strain on existing infrastructure. Some of the world's largest technology companies have even had to lower their growth projections for 2025 and 2026, not because of financial constraints, but because they lack the power needed to support new data centers.

Beyond data centers, if you can imagine anything beyond data centers, the power transmission infrastructure itself is lagging, particularly in high-demand areas. Picon pointed to California's rising wholesale electricity prices, warning that inflexible power grids and regulatory inefficiencies will continue to burden consumers unless urgent action is taken.

Picon drew historical parallels to illustrate the importance of disruption and bold leadership. He referenced the Wright brothers, who faced immense technical and societal challenges but ultimately revolutionized aviation. Similarly, the energy industry must embrace innovation to ensure long-term progress.

More recently, Kodak's failure to adapt to the digital camera revolution proved costly and led to the company's decline. In contrast, SpaceX's ability to disrupt the aerospace industry through reusable rockets serves as an example of how companies can embrace change and thrive. Picon warned that energy companies that resist innovation risk being left behind, much like legacy businesses that failed to adapt to market disruptions.

ProEnergy, he emphasized, has undergone a remarkable transformation—evolving from a small service provider to a key player in independent energy solutions. The company continues to expand its global operations, with new facilities opening in Arizona, Argentina, and Europe. These expansions are part of a broader effort to enhance grid reliability, efficiency, and affordability.

Picon urged attendees to challenge their assumptions, engage in open discussions, and embrace collaboration. He stressed the power of storytelling and shared knowledge, reminding the audience that progress happens when people listen, learn, and innovate together.

What say EPRI?

Reinforcing Picon's outlook was Bobby Noble, the ERPI gas turbine R&D program director, who spoke on the evolving energy landscape, emphasizing the need for a balanced approach between clean energy transitions, reliability, and surging global power demand.

Noble drew on his vast experience with global power generators, all dealing with their own sets of challenges. The rapid increase in electricity demand, driven by urbanization, industrial growth, and the expansion of energy-intensive digital infrastructure like data centers. While clean energy solutions continue to gain traction, he warned that the grid cannot solely rely on intermittent renewables without adequate dispatchable power—resources capable of producing electricity on demand. Without these, the risk of blackouts and system failures grows.

Despite the push for decarbonization,

gas turbines remain indispensable for maintaining grid stability, particularly in high-demand scenarios. He pointed to their efficiency, scalability, and role in hybrid models integrating hydrogen and low-carbon fuels. While battery storage has a role, it cannot yet replace dispatchable power sources in managing long-term fluctuations.

Noble cautioned against aggressive retirements of fossil fuel plants without viable replacements, warning of potential energy shortages. While global policies are accelerating the shift to clean energy, permitting delays and regulatory complexities are slowing new power developments. He stressed the need for pragmatic regulations that balance decarbonization with grid reliability.

A key concern in is the projected exponential rise in electricity consumption from data centers, with forecasts predicting a 4-5x increase in demand over the next decade. Major tech companies are already adjusting expansion plans due to energy constraints, underscoring the urgency of securing reliable power sources.

Noble concluded by urging industry leaders to invest in clean energy research, strengthen international collaboration, advocate for balanced regulations, and prepare for rising energy demands. He emphasized that energy transition decisions made today will shape the reliability and sustainability of future power grids.

Here comes the sun (and gas)

Chris Jimenez delivered an insightful glimpse into the challenges faced by members served by Arizona G&T Cooperatives, where he functions as executive director. He detailed the cooperatives' efforts to modernize infrastructure, integrate renewable energy, and build trust with its members in the face of evolving energy demands and market challenges.

Arizona G&T Cooperatives play a vital role in supplying electricity to both rural and urban areas, adapting to shifting energy needs with a growing focus on sustainability. Investments in infrastructure have expanded access to reliable power, ensuring that remote communities are not left behind in the transition to cleaner energy. However, regulatory hurdles, market fluctuations, and rising energy demand—driven by urban expansion and agriculture—require strategic planning and investment.

While renewables like solar and wind are gaining traction, natural gas remains an essential stabilizing force in Arizona's energy mix. Jimenez emphasized its role as a bridge technology, providing backup power when renewable sources fluctuate. Community support for hybrid energy systems, combining natural gas and solar, has driven AZG&T to invest in 258-MW of LM6000-powered generation that will maintain grid stability during peak demand.

Recognizing the challenges of intermittent renewables, the cooperative has expanded investments in solar and wind while prioritizing energy storage solutions. A recent $55 million government grant is helping fund new battery storage projects to enhance grid efficiency and reliability.

Community engagement remains central to AZG&T's strategy by fostering transparency through surveys, town halls, and education initiatives. Informing members about energy costs, infrastructure investments, and sustainability efforts, the cooperative strengthens trust and support for its initiatives. By maintaining investment in both natural gas and renewables, AZG&T aims to create a resilient energy future capable of meeting the Grand Canyon State's growing power needs.

Back to the future

Mark Axford, a very well-seasoned expert with 58 years' experience in the gas turbine industry and full of new material, delivered a presentation on the state of gas turbines, the increasing demand for electricity, and the evolving landscape of energy policy and technology, beginning his presentation with the proclamation, "I love gas turbines."

He reflected on the evolution of these beloved machines, noting that what was once considered a large turbine, such as the GE Model 7B, has now been eclipsed by much more powerful and efficient models. The demand for electricity, particularly from data centers and AI computing, has surged beyond expectations. In early 2023, regulators significantly underestimated electricity consumption, leading to power shortages in key markets. Texas, in particular, is experiencing rapid growth, with an additional 40,000 megawatts of power needed over the next five years—an annual increase of 8%, a rate not seen since the 1980s energy boom.

To meet this growing demand, some coal plants that were previously slated for closure have been brought back online. At the same time, orders for gas turbines have risen sharply, with a 25% increase in 2024 compared to the previous year. However, long lead times for new turbines—ranging from 12 to 18 months—have created additional supply constraints. As a result, developers of new data centers are now being told to "bring your own electricity," signaling a shift in responsibility for securing power generation.

The industry is also undergoing structural changes. General Electric has split into three separate entities: GE Vernova, which focuses on energy and power, GE Aerospace, which specializes in aviation technology, and GE HealthCare. Meanwhile, companies like Siemens Energy and Mitsubishi Power are expanding their turbine production to keep up with demand. However, rising turbine costs and extended production timelines may deter some potential buyers.

Regulatory and policy shifts further complicate the energy landscape. The legal principle of Chevron Deference, which has granted federal agencies regulatory authority for the past 40 years, is under reconsideration. If overturned, it could significantly impact environmental and energy regulations.

Additionally, potential changes in U.S. energy policy—particularly when Trump-era policies are reinstated—could favor domestic gas production and fossil fuels over renewable incentives. At the same time, nuclear power is regaining traction, with Georgia Power recently bringing the first new nuclear plant online in 40 years. Microsoft has also announced plans to repurpose a retired nuclear reactor to power its data centers.

Despite the growth of renewable energy sources, gas turbines remain essential for maintaining grid stability. Battery storage, particularly in California and Texas, is expanding rapidly, with projections estimating a capacity of 20 gigawatts by 2026. However, battery storage alone cannot fully re-

End users from as far away as Thailand experienced firsthand ProEnergy's deep engineering expertise and growing capabilities. From left: Carlos Picon, Wattana Chunark and Kowit Kwamman of B Grimm Power Ltd, Bob Bosse, Grahame Martin, Bob Dodson, and Supachai Mernmuang of Nueng Meena Engineering

place gas turbines, as reliable, dispatchable power is still required to balance intermittent renewable energy output. Axford concluded by emphasizing that dispatchable power sources, such as gas turbines, are not just part of the energy transition—they *are* the energy transition.

Data-driven analysis

Strategic Power Systems (SPS) has been gathering LM engine data for nearly 40 years giving Tom Christensen plenty of ammunition to provide a comprehensive look into the evolving challenges and opportunities in the power generation industry. He emphasized the growing importance of data-driven decision-making in maintaining reliability, efficiency, and long-term sustainability in power production.

SPS has been instrumental in collecting and analyzing operational data from power plants across the U.S. and internationally. This vast database allows the company to track performance trends, identify maintenance needs, and provide actionable insights to plant operators. By leveraging analytics, SPS helps utilities optimize operations, extend asset lifespans, and reduce costly downtime.

One of the key themes of Christensen's talk was the increasing demands placed on existing power infrastructure. Over the past decade, power plants have been required to operate for longer hours due to rising electricity demand, delays in new power plant construction, and market fluctuations that encourage the maximization of existing assets. In many cases, annual operating hours per plant have increased by 20-50%, pushing many facilities beyond their original design limits.

This heightened utilization has also accelerated wear and tear on critical components, leading to an increase in forced outages and unplanned maintenance. Christensen identified several factors contributing to these disruptions, including aging infrastructure, regulatory uncertainty, supply chain issues, and extreme weather events. He particularly highlighted the growing frequency of transformer failures, turbine malfunctions, and control system breakdowns, which can take months to repair if replacement parts are not readily available.

Brotman plant superintendent Eric Kuper talks controls, remote operations, and fast starts

One of the most pressing concerns he raised was the rising cost and duration of forced outages. Traditionally, maintenance schedules were carefully planned to minimize downtime, but recent industry shifts have made it increasingly difficult to adhere to these schedules. As a result, many power plants are experiencing prolonged outages lasting from several days to months, significantly impacting grid reliability and operational costs.

Despite these challenges, Christensen pointed to predictive analytics and data transparency as key solutions for improving power plant performance. SPS's data-driven approach enables operators to anticipate failures before they occur, allowing for proactive maintenance that can prevent costly breakdowns. By analyzing historical trends, power plants can better plan for necessary repairs, reduce unexpected downtime, and allocate resources more effectively.

Looking ahead, the power industry faces a series of critical challenges, including the transition to renewable energy, regula-

tory changes, and workforce retention. Additionally, the industry must contend with a shrinking workforce of experienced operators and engineers, making data retention, training, and knowledge transfer more critical than ever.

Industry issues panels

No PEC is complete without engaging panel sessions with participants representing a wide swath of stakeholders and expertise the world over. Overarching topics included:

- Shifting dynamics in power generation and government regulation
- Mitigating risk and maintaining reliable plant operations with fewer resources
- Insurance essentials for LM users

Bright future, proceed with caution

Industry leaders, policymakers, and experts explored the complexities of the energy transition, addressing grid reliability, regulatory hurdles, affordability, and the evolving role of dispatchable power.

The discussion began with the growing politicization of energy policy, where public perception often diverges from industry realities. Panelists emphasized the need for rational, informed discussions rather than ideological debates. Public education remains crucial, as social and corporate pressures for renewable energy often clash with grid stability needs.

Dispatchable power sources such as gas, hydro, and nuclear remain essential for grid reliability, particularly as extreme weather events highlight the risks of over-reliance on renewables. The Texas grid failures underscored this challenge, and while battery storage is advancing, it alone cannot meet the demands of a renewable-heavy grid. Many panelists maintained that natural gas will remain critical for energy security, even amid decarbonization efforts.

Rising electricity demand, driven by data centers, AI, and electrification, is straining energy markets. Panelists expressed concerns over whether current policies and investments can sustain this growth, particularly with permitting and regulatory bottlenecks delaying much-needed power projects. The slow pace of regulatory adaptation, along with carbon taxes and emissions limits, further complicates long-term energy planning.

Landon Tessmer proudly points out one of the many distinguishing features of the ProEnergy package

Affordability was another major concern, with some panelists warning of a potential two-tier energy system where wealthier regions access cleaner, costlier power while others struggle with rising prices. Government subsidies and policy-driven market distortions were debated, with some advocating for more competitive, market-driven pricing structures.

Investment uncertainty also looms large, as inconsistent policy signals deter long-term commitments. The energy industry is increasingly diversifying, exploring hydrogen, carbon capture, and next-generation nuclear, but private investors remain cautious due to regulatory and market volatility.

Looking ahead, the panelists stressed the importance of a pragmatic, flexible energy transition. Hybrid models integrating renewables with traditional power sources appear to be the most viable path forward. While nuclear energy is gaining renewed interest, permitting and cost challenges remain. Carbon capture and hydrogen technologies are still in early development but hold promise for decarbonization.

The panel reinforced that energy policy must balance decarbonization with reliability, affordability, and economic feasibility. While regulatory and market challenges persist, technological advancements and adaptive strategies offer pathways to a more sustainable, resilient energy future. Industry collaboration will be key to ensuring energy remains secure, accessible, and cost-effective.

Doing more with less

A panel of end users shed light on the operational challenges facing the gas turbine industry, particularly as electricity demand rises, grid conditions evolve, and regulatory pressures mount. One major concern was the aging fleet of gas turbines, which requires extensive maintenance and modernization to remain viable.

Extreme weather events and recent grid disruptions have emphasized the need for fast-response dispatchable power, with gas turbines continuing to serve as a critical backup for intermittent renewable sources like wind and solar. However, extended runtime requirements and increased cycling have led to higher maintenance demands and unexpected failures, further straining operations. Additionally, global supply chain bottlenecks have made it difficult to access critical replacement parts and technical expertise, delaying necessary turbine maintenance.

The discussion also explored how the rapid integration of renewables has reshaped the role of gas turbines. With the increasing penetration of wind and solar power, gas turbine operators are experiencing reduced run hours and declining revenues, making it difficult to justify reinvestments in existing fleets.

Another critical issue addressed was the changing workforce in the gas turbine sector. Many senior operators and engineers have retired, leading to concerns about the loss of institutional knowledge within the industry. In response, companies are implementing mentoring programs and knowledge transfer initiatives to train the next generation of turbine operators.

However, attracting new talent remains a challenge, as fewer young professionals are entering the field. The panelists emphasized the need for greater outreach to engineering students and young professionals, highlighting the essential role of dispatchable energy in maintaining a stable power grid.

Brotman Generating Station is a key asset in Texas's energy infrastructure, offering reliable, fast-start power to support both current electricity needs and the ongoing shift toward renewable energy

Powering protection

The participation in information exchange by insurance companies at user groups and industry events has increased dramatically in the past few years and has been viewed positively by attendees and the editors of CCJ. Here, panelists from the world's largest providers explored risk management, underwriting challenges, and policy considerations in an evolving energy landscape. Experts emphasized the complexities of securing coverage, particularly as the industry shifts toward renewables.

Risk assessment remains central to underwriting, with insurers evaluating factors such as equipment failures, natural disasters, market volatility, and regulatory changes. Loss history significantly influences policy terms, while compliance challenges and fluctuating energy markets add further complexity. Renewable energy facilities present unique risks, including intermittent generation and evolving standards, requiring insurers to adapt their coverage strategies.

Proactive risk mitigation emerged as a key theme. Insurers are increasingly partnering with plant operators to implement safety protocols, predictive maintenance, and modernization efforts, reducing exposure and improving insurability. Some firms even offer specialized consulting to enhance operational resilience.

Technology is transforming insurance practices, with data analytics and AI improving risk assessment and policy precision. Real-time monitoring allows insurers to adjust coverage based on operational performance, leading to more tailored and cost-effective policies.

Regulatory shifts, geopolitical instability, and supply chain disruptions also impact insurance costs. Insurers must account for third-party vendor reliability, further complicating underwriting decisions. The panel unanimously agreed on the need for closer collaboration between insurers and plant operators, advocating for customized policies that address specific risks rather than reactive loss coverage.

Think outside the turbine

It's not all about the LM engines at PEC. Several expert-led sessions highlighted critical systems that support power plant operation and provide a robust learning environment for end users. With many sessions to choose from the editors focused on the following:

- SCR and CO catalyst systems design and optimization
- Filtration solutions for enhanced turbine performance
- Gas turbine synchronous condensing applications
- Optimizing generator life

Get your catalyst right

An educational selective catalytic reduction

(SCR) systems session, presented by Jeff Wirt of EnergyLink International and Dan Ott of Environex, dove deep into emissions control solutions. By sharing best practices in system design and maintenance, the experts conveyed an in-depth review of SCR and CO catalyst systems, covering their process, mechanical, controls, and acoustic design.

EnergyLink is a leading provider of air and noise emissions control solutions, gas turbine auxiliary systems, and turnkey buildings. Environex, an independent consulting firm, specializes in SCR and CO catalyst system design, performance optimization, and maintenance services. Together, these companies offer expertise in reducing emissions and improving system efficiencies for power generation.

The design and functionality of SCR systems were explored in detail. The process design ensures optimal gas flow, temperature distribution, and ammonia injection for effective NOx reduction. Mechanical design considerations focus on the durability of catalyst support structures, ensuring long-term performance. Control design integrates PLCs to enable precise emissions management, while acoustic design incorporates silencers, barriers, and insulation to reduce noise pollution.

A key aspect of the session was the discussion on catalyst performance and maintenance. The lifespan of a catalyst ranges from 1,000 to 40,000 hours, depending on system operation. Performance can be impacted by fouling, poisoning from contaminants such as sodium and sulfur, and sintering due to high temperatures. Regular maintenance, including catalyst cleaning, AIG tuning, and root cause analysis, is essential to mitigate these issues and sustain optimal performance.

Limitations and optimization of SCR systems. Ott emphasized that excessive ammonia injection does not necessarily enhance NOx reduction and can lead to ammonia slip. Proper flow distribution and catalyst selection are crucial for maximizing efficiency. Additionally, temperature and residence time play a significant role in NOx conversion, necessitating tailored designs for various gas turbines and industrial applications.

What's in your filters?

Bob Reinhardt of filter giant Donaldson explored how effective filtration enhances equipment protection, improves efficiency, and reduces maintenance requirements. The discussion revolved around key filtration classifications, the impact of various filter types, and strategies for maintaining optimal filtration performance.

Filtration is essential for safeguarding equipment from contamination, ensuring operational efficiency, and minimizing maintenance costs. Effective filtration protects turbines and compressors from harmful particles, including large debris, fine dust, salt, and chemical contaminants. By reducing the accumulation of these impurities, filtration enhances system efficiency, prolongs equipment life, and ensures reliable operation in diverse environments.

The company employs an Er-W-P classification system to assess filter performance. This system evaluates filtration based on three key metrics: particle removal efficiency (Er), water resistance (W), and pulse cleaning capability (P).

The efficiency rating measures how well a filter captures airborne particulates, helping operators balance performance with cost. The water-tightness rating is particularly relevant in humid or coastal locations, where moisture and salt can accelerate corrosion. Finally, the pulse cleaning rating is crucial for environments exposed to high dust, snow, or ice levels, as it determines the filter's ability to recover from heavy contamination.

The session also compared different filtration technologies. Standard F8/F9 filters are suitable for moderate contamination levels and require periodic maintenance. In contrast, high-efficiency particulate air (HEPA) E11/E12 filters offer superior performance by employing multi-layered media to trap even the finest particles. These advanced filters provide excellent protection in harsh environments, significantly reducing particulate penetration.

Filtration effectiveness varies based on environmental conditions. For example, in urban areas with an Air Quality Index (AQI) of 50, HEPA filters drastically reduce particulate accumulation compared to standard filters or no filtration at all. In more extreme conditions, such as wildfire-affected areas with an AQI of 150, high-efficiency filters become indispensable for preventing excessive debris from damaging equipment.

Proper maintenance is essential for sustaining filtration performance. Regular inspections, pre-filter replacements, and data-driven monitoring help prevent pressure drops and system inefficiencies. Ensuring that filters are clean and functioning optimally can extend equipment lifespan and reduce operational costs.

Empowering the grid

Morgan Hendry, SSS Clutch Company, presented on the role of gas turbine synchronous condensing applications in modern power grids with emphasis on how synchronous condensers contribute to grid stability, facilitate renewable energy integration, and provide ancillary services through advanced clutch systems.

A synchronous condenser is a specialized machine that connects to an electrical system to either absorb or supply reactive power (VARs), stabilizing voltage levels and restoring power factors. Equipped with an automatic voltage regulator (AVR), these machines adjust excitation levels based on grid conditions, ensuring consistent power quality.

Beyond voltage regulation, synchronous condensers contribute to system inertia and fault current availability—critical elements for maintaining grid stability as the transition to renewable energy reduces traditional sources of inertia.

Synchronous condensers play a vital role in modern energy infrastructure by stabilizing frequency, managing power factor corrections, and supporting voltage levels across transmission networks. They are particularly useful for industrial and urban areas, where power fluctuations can disrupt operations. Additionally, they provide valuable services to long transmission lines and integrate seamlessly with static capacitors. Their flexibility allows participation in ancillary service markets, offering an additional revenue stream for grid operators.

Retrofitting gas turbines with clutches enhances efficiency by reducing mechanical wear and optimizing power consumption during condensing mode. This ensures quick transitions from synchronous condensing to active power generation when needed, increasing system reliability while extending equipment lifespan.

Beyond their operational advantages, synchronous condensers help accelerate the transition to cleaner energy by improving transmission efficiency, providing dynamic reactive power to support renewables. Retrofitting older generators with modern clutch systems is a cost-effective approach, often delivering a return on investment within just a few years.

Don't forget the generator

The training session on generators, presented by BRUSH Power Generation, a subsidiary of Baker Hughes, provided an in-depth overview of generator technology, maintenance, and best practices for optimizing product life. The speakers emphasized the importance of maintenance, inspections, and operational best practices to extend the lifespan of these critical assets.

The session also addressed generator maintenance and life optimization, emphasizing that BRUSH generators are designed for a lifespan of approximately 30 years, provided they receive proper maintenance. Factors that significantly impact generator longevity include regular inspections, using the correct replacement parts, adhering to proper operational practices, and conducting routine health checks on automatic voltage regulators (AVRs) and protection systems. Contamination from dust, dirt, and moisture was highlighted as a major risk to generator performance, requiring preventative measures to ensure long-term reliability.

A structured maintenance schedule was presented to optimize generator life. Annual inspections or those conducted every

8,000 hours focus on minor checks, while more detailed Level 1 inspections (conducted every 25,000 hours) involve partial disassembly to assess components. Level 2 inspections, occurring every 50,000 hours, include a more thorough examination of bearings and end windings, while Level 3 inspections, performed every 100,000 hours, require full rotor removal and extensive stator testing. Adhering to these maintenance levels is essential for preventing costly failures and extending generator service life.

Poor maintenance and operational errors, such as back-energizing or mal-synchronization, can cause significant damage to the rotor, stator, and insulation systems. Additionally, loss of oil can result in bearing failures, while contamination can degrade insulation and lead to long-term performance issues. Paramount is the importance of proactive monitoring, ensuring spare parts are readily available, and following best practices to prevent these operational risks.

The road forward

State of the PE6000

Rob Andrews, CTO, provided attendees with some exciting news on the performance and continuing development of the PE6000 gas turbine. For those who don't know, ProEnergy unveiled the 48-MW PE6000 aeroderivative turbine one year prior at PEC2023. The engine is designed for dispatchable power applications to quickly close the gap between power supply and demand that often occurs during severe weather solar ramp-off, and days with low or limited production from renewables. Each PE6000 begins with a ProEnergy-overhauled engine core from GE's CF6-80C2, which is found in aircraft including the Boeing 747.

The PE6000 gas turbine has undergone extensive validation to assess its engineering integrity. This process included testing materials, vibration resistance, and overall subsystem performance, as well as comprehensive engine trials both in the field and on test stands.

Two units were put through rigorous operational testing, including hot starts, cold starts, and load rejection scenarios. One unit accumulated 2,300 hours and 400 starts, while another logged 1,000 hours and 150 starts. Following these tests, the first unit was torn down to examine potential failure modes or wear characteristics that might differentiate it from the LM6000.

The results confirmed that no unexpected issues emerged. Similarly, the second unit operated at WattBridge throughout the summer of 2024 before undergoing a teardown, further validating the turbine's reliability.

The structural integrity of critical components, such as the LPC inlet frame and LPC case, remained intact, with no indications of defects. Vibration levels and tolerances stayed within expected specifications, while starting reliability and overall performance met or even exceeded that of the rest of the WattBridge fleet.

Looking ahead, ProEnergy is advancing the PE6000's development. Compressor blade reverse engineering is already underway, with testing in progress. The next phase involves HPC blade manufacturing for all stages. Additionally, combustor hardware is currently in the testing phase, with validation scheduled for 2025. The program is also moving forward with manufacturing wheels, blades, and nozzles for the low-pressure turbine (LPT) section, as well as all accessory gearbox components and an improved power augmentation system.

With 10 fully developed PE6000 units and two feasibility units, the turbine is proving its reliability and performance, positioning itself for full-scale deployment in the near future.

Where the turbines meet the load

To close out the conference, attendees were treated to an O&M best practices plant tour of WattBridge's Brotman Generating Station, a 384-MW peaking power facility located in Brazoria County, Tex. Commissioned in May 2023, it is equipped with eight PROENERGY LM6000 gas-turbine packages, designed to provide fast-start, reduced-emission power during periods of peak electricity demand.

As you can imagine, countless lessons learned trickle down as dozens upon dozens of turbine packages are manufactured in Sedalia shop, shipped, constructed, commissioned, and operated. ProEnergy holds this continual improvement across the entire value chain as sacred. Guests were afforded the opportunity to see and hear about the evolution of the gas turbine package as design improvements and best practices have been implemented to enhance the operations and maintenance of the entire fleet. CCJ

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How to upgrade, replace under-performing circuit breakers

1. Generating plant features multiple 7EA simple-cycle peakers

GE's 7EA gas turbine is widely respected for its reliability, operational flexibility, and efficiency in simple-cycle, combined-cycle, and cogeneration systems, and mechanical-drive applications (Fig 1).

This frame has been upgraded and improved continuously since its introduction some three decades ago. Today, it is rated up to 90 MW in simple-cycle service. Combined cycles incorporating the 7EA (today often referred to as 7E.03 or simply 7E) can achieve an efficiency of more than 52%. With a focus on the future, the OEM says the machine is 100% hydrogen capable.

However, as Bruce Hack, a member of the management team at Crown Electric (CE) and National Breaker Services (NBS), pointed out at a recent industry meeting, "as is the case with any multi-component system, time has brought its weakest links near, or to, the end of their productive lives."

Two such sub-systems are (1) the main bus duct between the generator and the generator step-up transformer (GSU) and (2) the generator circuit breaker in the generator accessory cabinet (GAC) located in the middle of that run to protect equipment upstream and downstream (Fig 2). Industry experience indicates these breakers often were under-rated (and fraught with cooling issues) for the service duty encountered.

Hack told conference attendees that CE and NBS teamed up to provide a full turnkey removal and retrofill replacement of under-rated generator circuit breakers from GE (Magne-Blast) and PACS Industries. He said CE/NBS's Citadel 5000-amp (fully rated) product is self-cooled and certified by KEMA Arnhem.

A few words on terminology are important here. The term *cell* refers to the "cabinet" shown at the left in Fig 3; the *circuit breaker,* which is inserted into the cell, is at the right. *Retrofill* is the removal of the original cell, its "guts," and breaker, and their replacement—with a Citadel 5000 in this instance. *Retrofit* is used to describe replacement of the breaker only.

This is the way the retrofill process works: Upon contract execution, the plant shares with CE/NBS its available physical and electrical documentation (Fig 4). If CE/NBS does not already have these files in its library (from work at another plant), an outage for measurements is scheduled and Team CE/NBS visits the facility to take exact measurements and to verify the point-to-point wiring.

Critical measurements in hand, the CE/NBS design engineering team creates a retrofill kit package that perfectly overlays with (and can slide into) the space occupied by the original cell. These custom 5000-amp, 63-kA Citadel kits are sent to the site with everything from silver-plated copper to hardware to newly made bus boots.

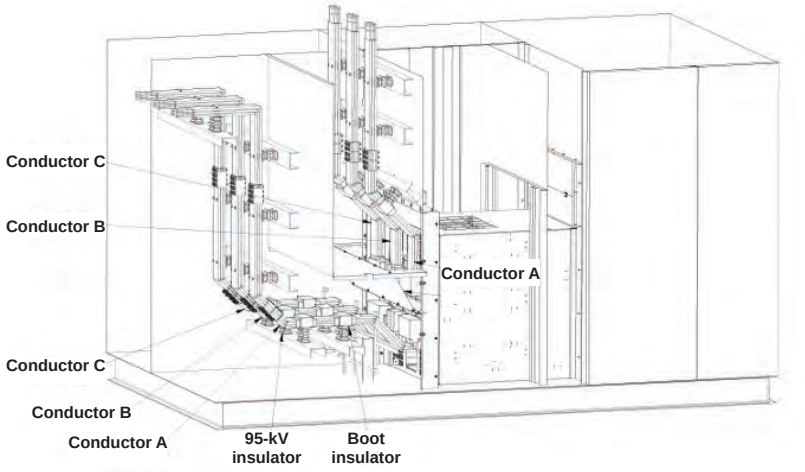
Gutting and prepping of the original cell typically takes a day and a half. The

2. Circular non-seg bus runs from the generator (extreme right) to the circuit breaker in the generator accessory cabinet at the center of the left-hand photo; it is shown entering the generator step-up transformer in the right-hand photo

3. Circuit breaker at right is inserted into the cell at left

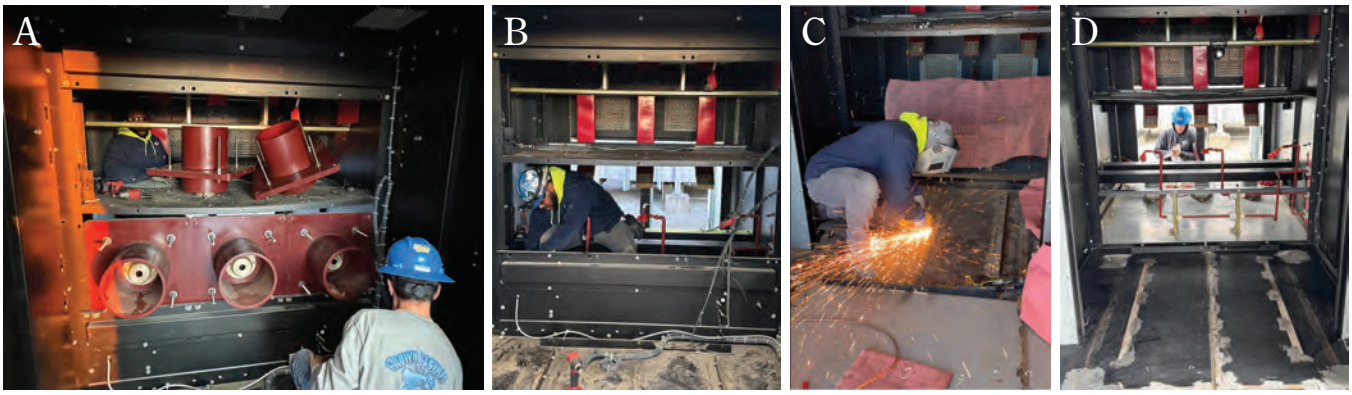
Options for GTs other than 7EA

National Breaker Services currently has three breaker options for gas-turbine owner/operators, with more on the way. One is rated 10,000 amps, the Citadel 5000 described in the text, and the Citadel 13.8-kV, 63 kA, 3000-5000 amps.



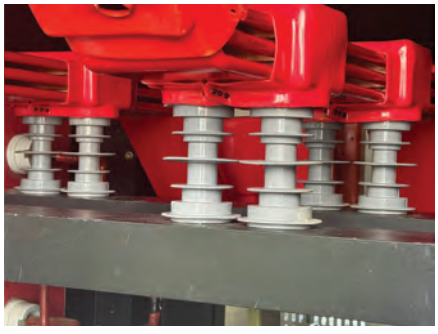
4. Guts of a retrofill project are housed in the enclosure

6. Cell fully prepped to receive the retro-fill-kit components



5. Some of the tasks required to gut and prep the original cell to accommodate the new Citadel breaker are shown in photos A-D

7. Glastic stand-offs used in many of the original cells were replaced with more durable Crown-sulators



8. With Crown-sulators in place, switchgear has better mechanical bracing and dewpoint-rated hi-pot withstand

original breaker is removed, of course, shutter assemblies too, and then the current transformers and their stationary primary disconnect bottles are taken out. The line load barrier is removed in whole or in part and modified during the installation phase as necessary (Fig 5).

The six pieces of copper that connected the original cell to the line/load bus work are removed and replaced with custom copper to span the new topology. Floors and sidewalls are made smooth and safe. The fully cleaned and prepped cell is now ready to receive its retrofill kit components (Fig 6).

Inexpensive glastic stand-offs used in many of the original cells were associated with tracking and failure in 7EA bus duct and GACs industry-wide (Fig 7). Hack noted that CE had pioneered the development of so-called Crown-sulators—a bolt hole-for-bolt hole replacement for 95- to 150-kV BIL standoffs—and standard in all of the company's retrofill kits.

He said they have better cantilever strength, creep, and BIL characteristics than porcelain and are dew-point rated. Hack went on to say that with Crown-sulators in place, switchgear has better mechanical bracing and dewpoint-rated hi-pot withstand (Fig 8).

Mounting of the new bus and line load barriers normally takes a long day to a day and a half.

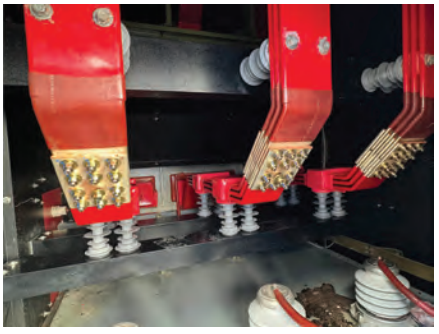
Cell installation is next. A 5000-amp, self-cooled Citadel cell is lifted into the space formerly occupied by the original cell in Fig 9. Once rigged into its precise location, the final bus connections are made and the line/load barrier is completed (Fig 10). Wiring is landed on the proper terminal-block points so control-room personnel can verify there is zero difference between the Citadel indications and those of the old circuit breaker (Fig 11).

Final installation step: The Citadel draw-out breaker is introduced to the GAC and its one-high enclosure (Fig 12).

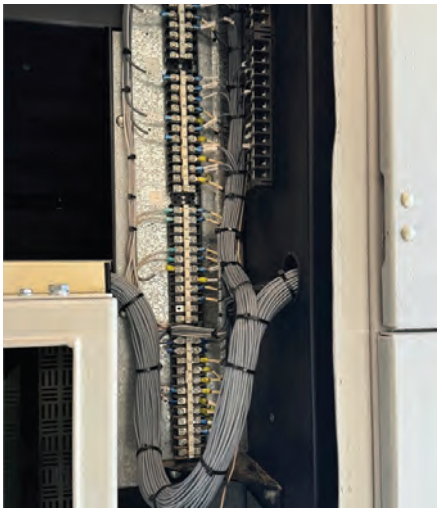
Completing the process. A full battery of tests (Fig 13), including operational checks, is performed by CE/NBS. After all tests are passed and documented, the cell's flashing is installed to complete the retrofill installation.

The entire retrofill process usually takes less than a week per position. Optional O&M training, offsite or onsite, is developed according to customer needs. CCJ

9. Citadel cell is lifted into the space formerly occupied by the original cell



10. Once rigged into its precise location, final bus connections are made



11. Proper wiring connections is a critical step in the retrofill process

12. Citadel draw-out breaker is introduced to the GAC and its one-high enclosure

13. Testing and operational checks confirm retrofill is ready for service

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