

- GAS TURBINES
- STEAM TURBINES
- HRSGS
- GENERATORS
- CONTROLS
- AUXILIARIES



Issue 84 (2025)  
www.ccg-online.com



*Tenaska Virginia Generating Station*

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# PLAN FOR 2026: CCGT INDUSTRY EVENTS

## **PROENERGY Conference**

**January 26-28**

Arizona Grand Resort, Phoenix, Ariz. Details/registration at [www.proenergyser-vices.com](http://www.proenergyser-vices.com). Contact: Chris Evans, [cevens@proenergyser-vices.com](mailto:cevens@proenergyser-vices.com).

## **PSM Asset Managers Conference**

**January 26-28**

Wyndham Grande at Harbourside Place, Jupiter, Fla. Details/registration at [www.psm.com](http://www.psm.com). Contact: Michèle McDermott, [Michele.McDermott@us.psm.com](mailto:Michele.McDermott@us.psm.com).

## **Vogt Combined Cycle Seminar**

**February 11-12**

Omni Grove Park Inn, Asheville, NC. Contact: Jennifer Pasquariello, [jpasquariello@babcockpower.com](mailto:jpasquariello@babcockpower.com)

## **501F Users Group**

**February 15-20**

Hilton Norfolk – The Main, Norfolk, Va. Details/registration at <https://forum.501fusers.org/>. Contact: Jacki Bennis, [jacki@somp.co](mailto:jacki@somp.co).

## **501G Users Group**

**February 15-20**

Hilton Norfolk – The Main, Norfolk, Va. Details/registration at <https://forum.501gusers.org/>. Contact: Jacki Bennis, [jacki@somp.co](mailto:jacki@somp.co).

## **FT8 Users Group**

**March 17-19**

EPRI Main Campus and Marriott University Place, Charlotte, NC. Details/registration at [www.ft8users.com](http://www.ft8users.com). Contact: Ashley Potts, [ft8@ft8users.com](mailto:ft8@ft8users.com).

## **FT4 Users Group**

**March 17-19**

EPRI Main Campus and Marriott Univer-

sity Place, Charlotte, NC. Details/registration at [www.ft4users.com](http://www.ft4users.com). Contact: Ashley Potts, [ft4@ft4users.com](mailto:ft4@ft4users.com).

## **WTUI (LM2500, LM6000, LMS100)**

**April 7-10**

Long Beach, Ca. Details/registration at [www.wtui.com](http://www.wtui.com). Contact: Charlene Raaker, [craaker@wtui.com](mailto:craaker@wtui.com).

## **7F Users Group**

**May 18-22**

Woodlands Waterway Marriott, Houston, Tex. Details/registration at [www.powerusers.org](http://www.powerusers.org). Contact: SV Events, [planning.team@sv-events.net](mailto:planning.team@sv-events.net).

## **European HRSG Forum**

**May 19-21**

Monash University, Prato, Italy. Details/registration at [www.europeanhrsgforum.com](http://www.europeanhrsgforum.com). Contact: Rachel Washington, [rachel@meccaconcepts.com.au](mailto:rachel@meccaconcepts.com.au).

## **Legacy Turbine Users Group**

**(Frames 7E, 6B, 5)**

**June 22-25**

The OMNI Hotel, Oklahoma City, Okla. Details/registration at [www.powerusers.org](http://www.powerusers.org). Contact: SV Events, [planning.team@sv-events.net](mailto:planning.team@sv-events.net).

## **Alstom Owners Group**

**Mid-July**

TBD, Houston, Tex. Details/registration at [www.aogusers.com](http://www.aogusers.com). Contact: Ashley Potts, [ashley@aogusers.com](mailto:ashley@aogusers.com).

## **HRSG Forum**

**July 20-23**

Woodlands Waterway Marriott, Houston, Tex. Details/registration at [www.powerusers.org](http://www.powerusers.org). Contact: SV Events, [planning.team@sv-events.net](mailto:planning.team@sv-events.net).

## **HA Users Group**

**August 3-6**

Location TBD. Details/registration at [www.powerusers.org](http://www.powerusers.org). Contact: SV Events, [planning.team@sv-events.net](mailto:planning.team@sv-events.net).

## **Power Users Combined Annual Conferences (CCUG, GUG, PPCUG, STUG, and LCPG)**

**August 24-27**

Marriott Rivercenter on the River Walk, San Antonio, Tex. Details/registration at [www.powerusers.org](http://www.powerusers.org). Contact: SV Events, [planning.team@sv-events.net](mailto:planning.team@sv-events.net).

## **Combustion Turbine Operations**

**Technical Forum (CTOTF)**

**August 30-September 3**

Grand Hyatt River Walk. San Antonio, Tex. Details/registration at [www.ctotf.org](http://www.ctotf.org). Contact: Christine Doyle, [chrisdoyle@ctotf.org](mailto:chrisdoyle@ctotf.org).

## **CCGT/HRSG Forum: América Latina**

**September 22-24**

Blue Tree Premium Morumbi, São Paulo, Brasil. Details/registration at [www.hrsgamericalatina.com](http://www.hrsgamericalatina.com). Contact: Bianca Carreira, [bianca@hrsgamericalatina.com](mailto:bianca@hrsgamericalatina.com).

## **Wärtsilä Users Group**

**October 12-15**

Crowne Plaza French Quarter, New Orleans, La. Details/registration at [www.powerusers.org](http://www.powerusers.org). Contact: Jacki Bennis, [jacki@somp.co](mailto:jacki@somp.co).

## **Australasian Boiler and HRSG Forum**

**Late November**

Brisbane, Australia. Details/registration at [www.abhug.com](http://www.abhug.com). Contact: Rachel Washington, [rachel@meccaconcepts.com.au](mailto:rachel@meccaconcepts.com.au).



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**COMBINED CYCLE Journal** is published by PSI Media Inc, a Pearl Street company. Editorial offices are at 7628 Belmondo Lane, Las Vegas, Nev 89128. Office manager: Robert G Schwieger Jr.

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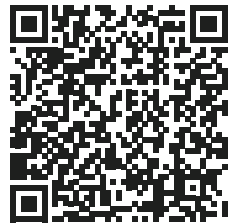
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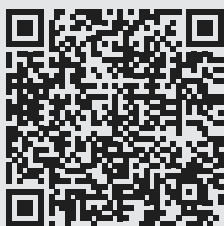
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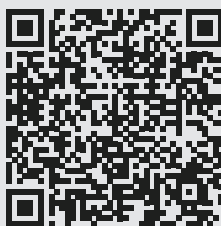
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## Three Rivers Energy Center

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Operated by CAMS

## WattBridge Fleet

Owned and operated by PROENERGY

## Woodland Generation Station, Unit 2

Owned and operated by Modesto Irrigation District (MID)

## Aurora Generation

Owned by LS Power  
Operated by IHI Power Services

## Bhikki Halmore CAPP

Owned by Halmore Power Generation Company  
Operated by GE Vernova O&M

## Central Eléctrica Pesquería (CEP)

Owned and operated by Techgen

## Cottage Grove Power

Owned by Panamint Capital  
Operated by IHI Power Services

## Dogwood Energy Facility

Owned by City of Independence, Evergy, Kansas City Board of Public Utilities, Kansas Municipal Energy Agency, Kansas Power Pool, and Missouri Electric Commission  
Operated by NAES Corp

## Edgewood Energy LLC

Owned by Milepost Power Holdings  
Operated by NAES Corp

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

Owned by EVM Energía del Valle de



México Generador SAPI de CV  
Operated by NAES Corp

## Exira Station

Owned by Western Minnesota Municipal Power Agency  
Operated by Missouri River Energy Services

## Fairview Energy Center

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

## Ferndale Generating Station

Owned by Puget Sound Energy  
Operated by NAES Corp

## Hill Top Energy Center

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## Hunterstown Generating Station

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## Long Ridge Energy Generation

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Operated by Burbank Water and Power

## Manchester Street Station

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Operated by IHI Power Services Corp

## Mankato Energy Center

Owned and operated by Onward Energy

## Mariposa Energy Project

Owned by Diamond Generating Corp  
Operated by DGC Operations LLC

## Marcus Hook Energy Center

Owned by JERA Americas and Electricity Generating Public Company Ltd  
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## Milton B. Lee Peaking Plants

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## Nebras Power IPP4/Jordan

Owned by AES Corp, Mitsui, and Nebras Power  
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## New Athens Generating Plant

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Operated by NAES Corp

## Ravenswood Generating Station

Owned by RISE  
Operated by IHI Power Services

## REO Cogeneration Plant

Owned and operated by Lansing Board of Water & Light

## Rio Nogales Power Plant

Owned and operated by CPS Energy

## River Road Generating Plant

Owned by Clark Public Utilities  
Operated by GE Vernova O&M

## Rockford Generation

Owned by LS Power  
Operated by IHI Power Services

## Salem Harbor Station

Owned by Castleton Commodities International  
Operated by NAES Corp

## Sand Hill Energy Center

Owned by City of Austin  
Operated by Austin Energy

## Sentinel Energy Center

Owned by Diamond Generating Corp  
Operated by DGC Operations LLC

## SUGEN Mega Power Project

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## Towantic Energy Center

Owned by Competitive Power Ventures  
Operated by NAES Corp

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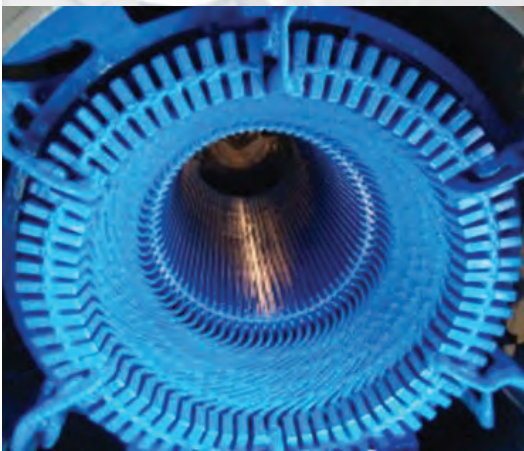
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# Eight Bells: Bob Schwieger, End of Watch

With heavy hearts, we announce the passing of CCJ founder, known to most as “Bob”



Robert G. “Bob” Schwieger, born April 30, 1943, in the Bronx, NY, passed away unexpectedly in Las Vegas, NV, on August 6, 2025, at the age of 82. For those of us fortunate enough to be dazzled by his rare combination of engineering knowledge, wordsmithing skills, steadfast ideals, and yet, somehow, carefree personality—count yourself among the privileged.

What made Bob, “The Bob,” began long before he dedicated more than fifty years to the global power generation industry, where his vision and voice became synonymous with technical excellence, practical knowledge-sharing, unwavering journalistic integrity, innovation, and, perhaps most of all, community building.

## Makings of “The Bob”

Born and raised in the Parkchester section of the Bronx to parents August and Josephine, Bob displayed an extraordinary cu-

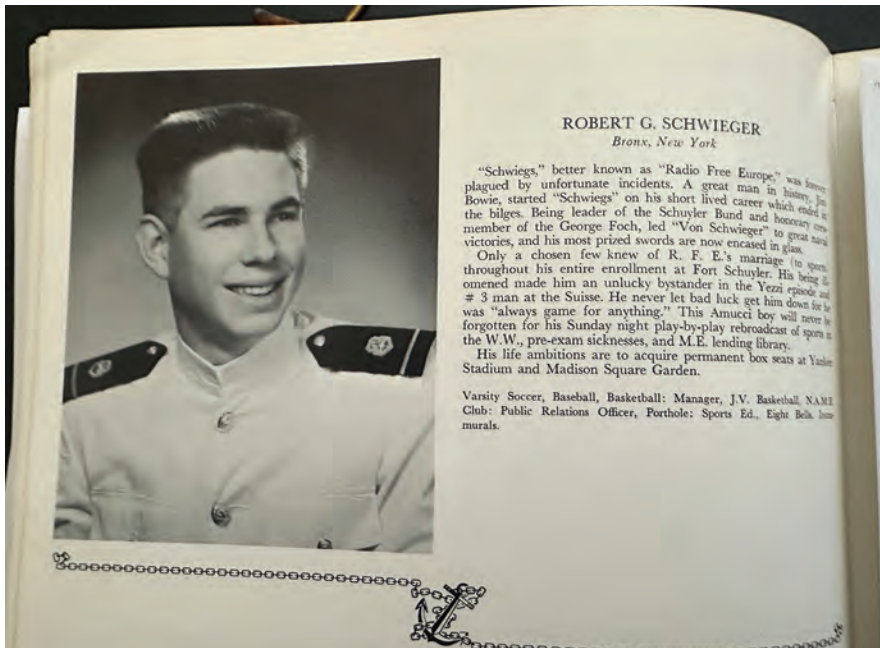
riosity for all areas of learning. His strong work ethic emerged early, beginning with his first job as a meat delivery boy at the age of 10. As a teenager (maybe even before!), he discovered a deep passion for journalism, rising through the ranks to serve as editor-in-chief of The Clinton News, the distinguished newspaper of DeWitt-Clinton High School. His aptitude for math and science eventually guided him toward a career as a marine engineer.

After graduating from SUNY Maritime (Fort Schuyler) in 1964, the newly minted boiler engineer—known to classmates as “Radio Free Europe”—embarked on a merchant ship adventure, laying the first long-distance telephone cable across the Pacific, from Hawaii to Japan, via Midway, Wake, and Guam.

Life at sea, however, was not for this city boy. Ashore, he spent a few years at the U.S. Atomic Energy Commission as a safety inspector before marrying his wife Jessica and

joining the design team at Westinghouse’s Advanced Reactors Division in Pittsburgh.

In 1969, he was summoned back to his first love, journalism, beginning a distinguished 33-year career at McGraw-Hill. There, he rose from Assistant Editor of Power Magazine to Vice President and Editorial Director of McGraw-Hill’s global energy magazines, conferences, and technical publications. His leadership shaped more than 15 respected journals—Power, Electrical World, Electric Power International, Global Energy Business—as well as numerous international conferences, industry workshops, awards programs, and specialized publications.





## Reflections on a Most Esteemed Colleague

Bob was an innovator and a pioneer, notes Jason Makansi of Pearl Street, who worked for, then with, Bob for 44 years. "While the user community certainly understood and embraced his uncanny ability to create community, users may not appreciate what it was like to have him as a boss, instead of a peer. Simply put, he was the best boss you could ask for."

He and his team constantly started up new editorial products, often collaborating with other McGraw-Hill publications, engineering societies, and industry trade groups. He encouraged his editors to work at home long before the term "telecommuting" entered the lexicon. He initiated an on-line digital news service for the power industry when the concept of an "e-zine" was a gleam in the eyes of the digital revolutionaries. Some may even remember printing Electric Power NewsLink out to read it in the late 1990s!

Bob was a brilliant manager of employees. He didn't suffer fools, but once you proved yourself and gained his trust, he would go to bat for you in every way possible, support your pursuit of new ideas and products and ways of improving how things got done. If you had personal issues to deal with, he figured out how to work with you.

He got the very best out of people and he didn't have to go to management school, read the Harvard Business Review, or make sure you had "the right credentials" to do it. It came naturally. He was always willing to insert himself between you and the ump.

Life at sea may not have agreed with him but he knew how to look ahead

at that 90 deg bend in the creek (often with rapids) coming up and making sure the boat turn was smooth.

Teams, community, relationships, empowerment, initiative, equity, entrepreneurial...these are words the corporate world bandies about like so many nickels and pennies collecting in your change drawer. But "The Bob" knew how to put those concepts into practice. Around my house with my spouse and two daughters, or with extended family, co-workers, clients, and partners who were fortunate enough to meet him, that's how we referred to him: The Bob. Because there is only one. Even if you met him just once, you never forget him.

Though Bob was larger than life, he never forgot his roots or the people around him. I was fortunate enough to have visited him in Las Vegas in June. Among my parting words to him were, "Bob, I just wanted to thank you in person for all that you've done for me and my career," and he quickly replied, "not nearly as much as you've done for mine." That's the kind of guy The Bob is. But in truth we should all thank him for what he contributed to our careers and our industry over close to six decades. Like a beloved baseball broadcaster, he was truly the voice of the power industry and that voice will stay in my head for the rest of my days like a favorite song or melody.

Guys like The Bob perhaps leave an especially indelible mark in today's times. Because while he may have been larger than life, he never, as we liked to say down in the southern town where I grew up, "got too big for his britches."



## The CCJ Years

In 2003, Bob returned to his "deckplates" roots and founded the Combined Cycle Journal (CCJ), dedicated to advancing knowledge in powerplant technology, operations, maintenance, and best practices at gas-turbine sites. Together with his son Scott, Bob built CCJ into the unquestioned leading resource for gas-turbine and combined-cycle professionals. Their mission—transferring expertise among engineers, operators, and plant managers to improve safety, efficiency, and performance—remains unparalleled in the industry.

Longtime friend Dr. Robert Mayfield, plant manager at Westmoreland Generating Station, said it best: "Bob will always be admired not only for his professional expertise but also for his warmth, wit, and generosity. Many will remember him as a mentor, a truth-seeker, and a friend who made everyone feel seen and heard. His conversations were as rich in humor as they were in insight, and his ability to inspire others left a lasting legacy in both industry and personal circles."

## Fare Thee Well, Good Man

Bob is survived by his wife, Jessica, and sons Robert, Clark, and Scott. He will also be deeply missed by the worldwide community of colleagues and friends whose lives he touched.

Thanks and blessings to our extended family—the user group community and the many supporters of CCJ over the past two decades. This includes, but is not limited to, all the Power Users Groups, the HRSG Forum, 501F, 501G, 501D-D5A, Western Turbine, AOG, CTOTF, and countless others across the power industry who believe in our mission. As longtime partners at WTUI expressed: "Bob truly made the industry better with his involvement. He was a true friend and will be sorely missed."

Bob never wanted flowers or a formal funeral. Not his style. What mattered to him was knowing there are people ready to step forward, guiding the next generation of power professionals by sharing best practices, asking questions, and fostering growth across the industry. Mission accomplished.

Rest in peace, Bob. You're the best dad, basketball coach, hiking buddy, and boss anyone could ask for. **Best Of the Best...**



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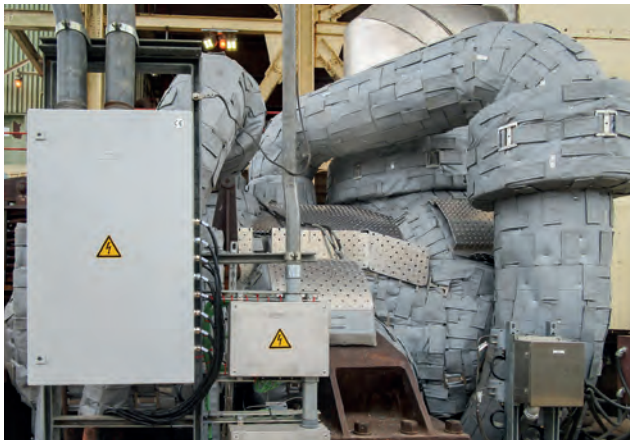
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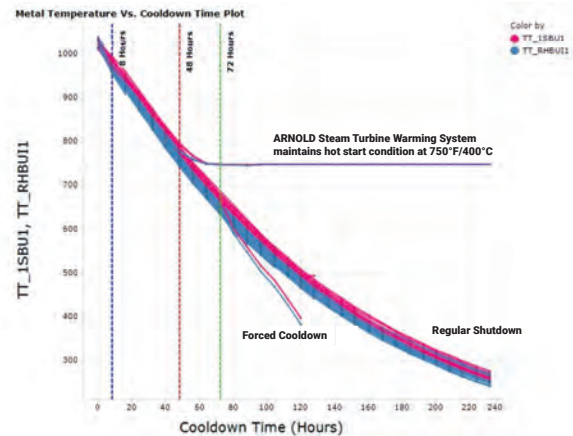




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**C**Owner/operators of 501F and 501G gas turbines co-located at Loews Ventana Canyon Resort in Tucson, Ariz, for their 2025 conferences this past February.

Sunday's program featured social events for all attendees. The agenda for Monday—including a safety roundtable, vendor presentations (a/k/a Vendorama), reception, and vendor fair—also brought together the 501F and 501G Users Groups. The organizations met independently on Tuesday through Friday for technical presentations by users, services providers, and OEMs.

The technical meeting got underway after breakfast Monday with welcomes by the user-group chairs to the 106 registered owner/operators, acknowledgment of the 501F group's 25th anniversary, steering-committee members, and conference sponsors.

Chairman Ivan Kush, who was key in nurturing the 501F group back to full strength after the "virtual" years, announced that long-time board member Brian Berkstresser of Liberty Utilities would assume leadership duties going forward. A review of the user website by Chad Boschert (AptCrowd) and conference instructions preceded the annual safety roundtable, which sets the tone for the event.

Half-hour vendor presentations began in mid-morning, arranged in seven sessions, with five presentations conducted in parallel during each session.

A busy first day ended with a vendor fair and reception from 4 pm until 7:30, giving owner/operators the opportunity to peruse the products and services offered by over 80 companies with interest in the 501F and 501G fleets.

**Agenda highlights** for the F frame's portion of the 2025 joint meeting are summarized below. The program, developed and moderated by the steering committee, focuses on the operation, maintenance, inspection, troubleshooting, repair, and optimization of equipment in generating plants powered by 501F, 701F, and SGT6-5000 gas turbines made by Siemens Energy, Westinghouse, and Mitsubishi Power.

**Tuesday:** Outage execution roundtable and user presentations, Siemens Energy's presentation to users, and Mitsubishi Power's presentation to users.

**Wednesday:** Steam turbine, auxiliaries, and generator roundtables and user presentations, and PSM's presentation to users.

**Thursday:** Auxiliaries, combustor, and compressor roundtables and user presentations.

**Friday:** HGP and rotor roundtables and user presentations.

### USER-ONLY SESSIONS

The opening session centered on safety, communication, and workforce readiness across major field service providers, echoing the growing concerns of gas and steam turbine end users regardless of make or model. Users recounted several lifting and rigging incidents during recent outages, noting limited visibility and inconsistent sharing of safety lessons between sites. Many expressed concern that corrective actions are not being broadly communicated or applied across projects.

Attendees also discussed workforce experience and training gaps, citing more

### 501F OFFICERS AND BOARD OF DIRECTORS

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Brian Berkstresser, *senior director of generation operations, Liberty Utilities*

**Vice Chair**  
Ivan Kush, *principal CT and controls engineer, Cogentrix Energy Power Management*

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frequent use of less experienced field personnel and fewer veteran supervisors. Some crews reportedly lacked familiarity with standard safety practices and documentation requirements, leading to near-miss events. Participants emphasized the need to verify engineering approvals in writing and maintain clear communication throughout complex outage activities.

Conversation turned to risk management and outage planning, with users calling for stronger involvement in the OEM's Rapid Risk Assessments and clearer documenta-

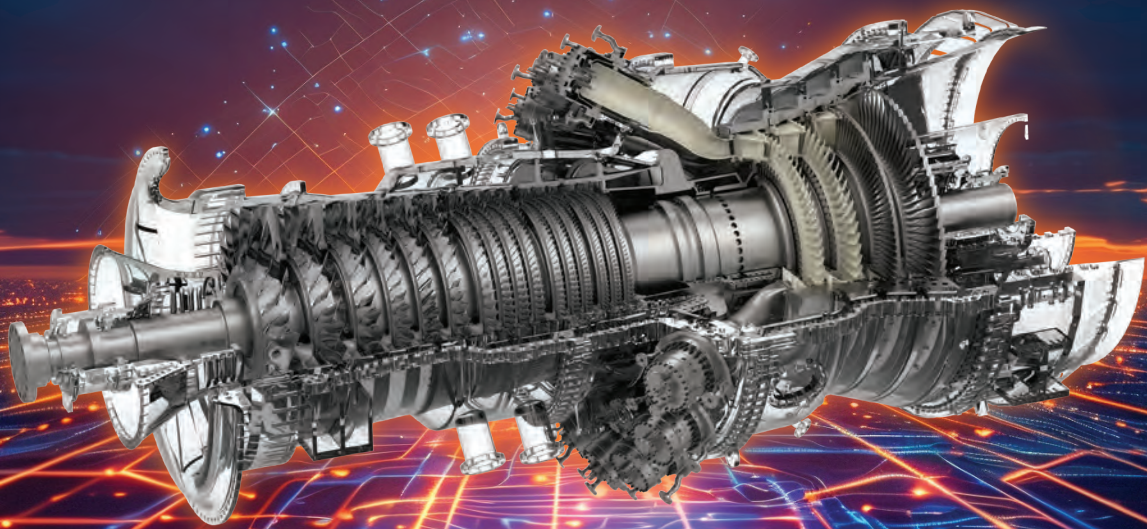


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**Purge credit upgrade reduces start-up time** and HRSG thermal stress while improving package durability through new logic and valve modifications

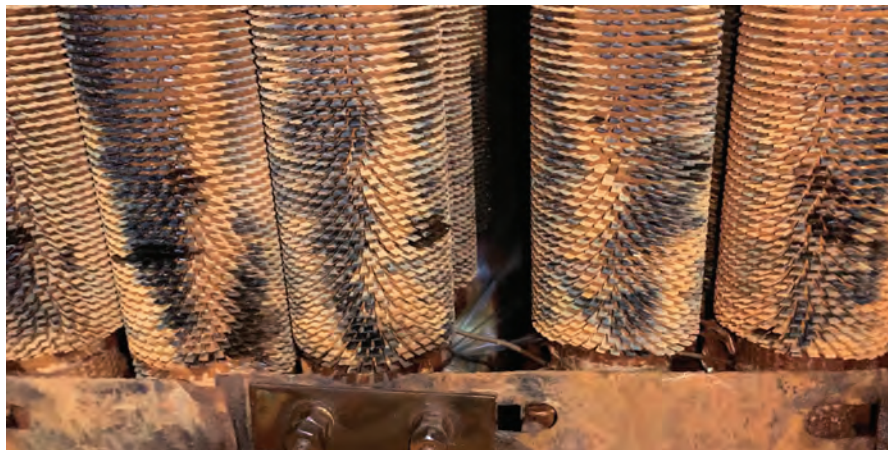
tion of engineering decisions made on site. The group urged more consistent processes, better feedback loops, and greater accountability in how OEMs share safety and procedural information across their fleets.

The session also explored the emerging role of artificial intelligence tools in plant operations and reliability analysis. Several users described pilot use of Microsoft Co-Pilot to mine years of outage and reliability data, identify regional trends, and even auto-generate management presentations within minutes. Others demonstrated internal AI setups that search company servers for equipment data while maintaining fire-wall protection. While participants agreed that these tools offer powerful diagnostic and benchmarking capabilities, they emphasized the continued need for human oversight, cybersecurity safeguards, and validation of AI-derived insights before operational adoption.

The following presentation summaries provide a concise look at key technical discussions shared during the 2025 501F Users Group Conference in preparation for the upcoming meeting. The full presentations—available to registered users through the 501F discussion forums ([forum.501Fusers.org](http://forum.501Fusers.org))—offer significantly greater technical detail, data, and field experience. Readers are encouraged to review the source materials for comprehensive insights into the engineering solutions and operational lessons exchanged by fellow end users.

#### **Teardrop egress device for confined space**

Modifications that removed the mechanical overspeed system and revamped insulation around the exhaust teardrop have complicated safe access and exit on a 501D5. The



**Repeated tube leaks traced to weld fatigue** and flow-induced vibration, prompting monitoring, cleaning, and anti-vibration support installation



**Heater cables installed** along mapped grid to ensure uniform heat distribution before applying insulation screens and cladding

team evaluated a 3M DBI-SALA Rollgliss R550 Rescue and Descent Device for confined-space egress.

Trained personnel operate the unit using the hand wheel, with option to convert to electric. The rope resists tangling and stores easily, and hardware accommodates multiple mounting locations. Two site rescue staff supported the exercise. The goal is to install permanent brackets or eyes to enable quick, repeatable setup and removal, improving safety and reducing time for tear-drop entry and exit.

#### **FD3 CCGT upgrades**

Site upgraded its two combustion turbines from 501FC to FD3 to increase output and improve heat rate. The upgrade program

required environmental permitting and multiple system studies, plus an H2 generator addition for one GT. Objectives include 198 MW at ISO, shaft-limited 215 MW, and an average 300 BTU/GT heat-rate improvement. Benefits are attributed to compressor sealing, stage-4 hardware with disc-4 change, exhaust-cylinder change, and optimized IGV settings with a 2% exhaust-flow rise at unchanged exhaust temperature.

Purge credit reduces start time, improves start-package durability, and mitigates HRSG tube thermal stress; additional modifications include a fuel-gas block-and-bleed valve, air-block system, and logic updates. GT ACO corrects exhaust-temperature control for off-reference ambient conditions. The DAIS evenly cools turbine elements



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post-shutdown using compressed air piped to disc cavities 2, 3, and 4. DAIS scope includes Siemens-supplied components, two 1000-CFM compressors, and two 1000-gallon surge tanks on a common header serving both turbines.

### HRSG impacts after GT upgrade

A 330 MW 1 x 1 plant with reported HRSG impacts after upgrading its 501FD2 with a hybrid rotor and thermal performance upgrade.

Following the 2022 turbine upgrade, maximum CT output reached 224.92 MW at minus 13°C with evaporative cooling, but HRSG issues emerged in 2023–2024. Repeated leaks occurred on an LP feedwater heater, with toe-weld cracks at the bottom header and heavy fin deposits.

Chemistry results were normal. Lab analysis identified high cycle fatigue, likely from flow-induced vibration. Field testing showed tube natural frequencies near 5 Hz, peak vibration over 10 in/s, and mid-span motion of 0.5 in peak-to-peak. Initial mitigations included winter derates, keeping overall vibration below 6 in/s peak, avoiding PAG and duct

burners below 0°C, targeted ice-blast cleaning, and shimming or repairing anti-vibration braces.

In October 2024, the team completed deeper cleaning and installed new lower mid-span supports. Results show overall vibration below 0.8 in/s peak across conditions, no derates, and no subsequent tube leaks. Long-term actions include comprehensive cleaning during major outages and reweld options at the lower header to reduce stress concentrations.

### Control system replacement considerations

An end user shared practical lessons from multiple control retrofits and upgrades, focusing on specifications, reliability and life-cycle planning for 501F assets and a diverse GT fleet serving a major metropolitan area.

Past projects span MkV to Ovation,

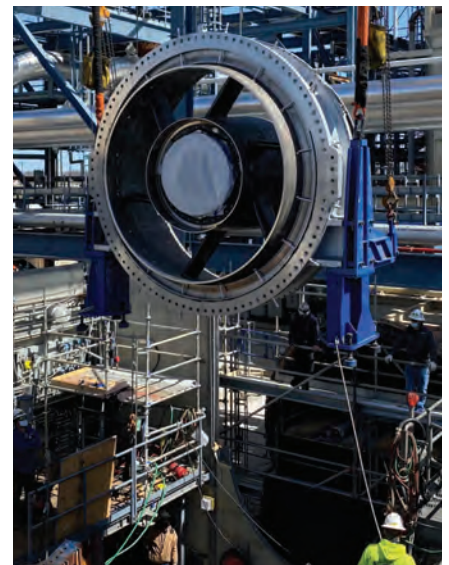
ABB to MkVIe, MHC to Foxboro, MkVI to Triconex, and later Triconex to MkVIe, illustrating that technology choices evolve and documentation must keep pace. A written, standardized control specification is stressed. Time and materials contracts are discouraged. Owners should leverage large awards for spares pricing, require training on factory-approved software, and secure service and support agreements.

Technical expectations include proven turbine or CCGT experience, human factors requirements, redundancy and room for expansion. The program calls for RFI hardening at excitation systems, load rejection survivability, sequence of events recorders, and HART I/O to future-proof instrumentation. Keep communication links but hard-wire cross trips. Retag and re-ferrule every touched circuit.

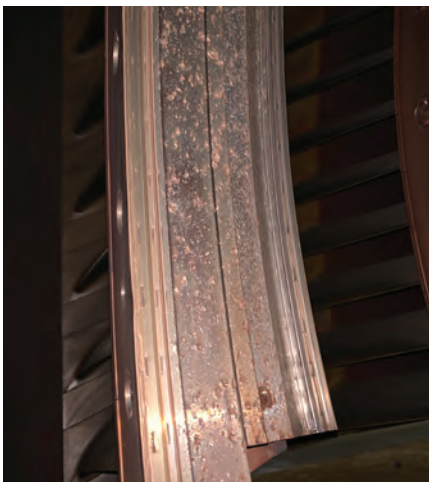
Other program elements include using



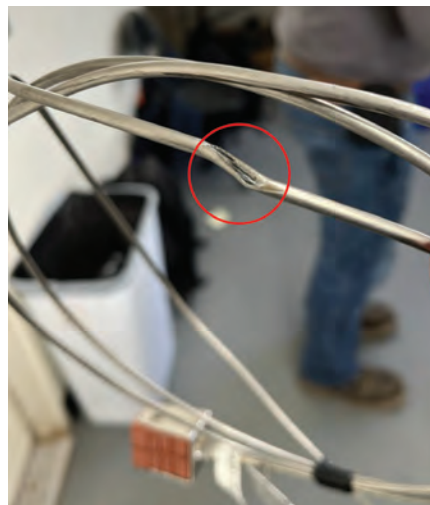
**Ducting installed to send heated air** from turbine enclosure to inlet, preventing icing at bell mouth and IGVs



**Single-piece exhaust section** lowered into place using swing set hangers to improve alignment and ease of installation



**Foreign object damage observed** on rotor discs from liberated diaphragm set screw, prompting replacement and corrective rework during major inspection



**Failed flashback thermocouples** revealed combustion instability and excessive heat exposure



**R3 blades exhibited creep damage** and liberation, traced to elevated temperatures during low-load operation





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EPRI resources, eliminating vendor obfuscation, stocking spare hardware by cabinet and I/O type, and managing obsolescence through proactive drawing creation and updates. Many of these points can be mandated in the specification or used as bid evaluation criteria. *Must read slide deck.*

### Bushing inspection and isolation findings

Review of generator bushing conditions, focusing on suspected first-fault locations around the manway, neutral and ISO leads, and a B-phase interface that transitions from the air side to the H2-side isolator.

Field notes identify several inspection nodes: neutral leads, ISO leads, and manway access for internal confirmation. The most credible issue presents on B-phase at the air to H2 isolator, where insulation and sealing integrity are scrutinized. Technicians document hardware condition, cleanliness, and lead routing to rule out abrasion or contact at supports. Temporary actions prioritize safety and containment, including controlled depressurization, isolating the suspect section, and verifying hydrogen purity and pressure stability before further work. Post-stabilization checks include visual inspections, torque verification on terminations, and seal assessment at the isolator interface.

Planned corrective maintenance scopes replacement or refurbishment of the affected bushing components, inspection of neutral and ISO lead insulation, and rework of gaskets or barriers at the air to H2 boundary. Return-to-service criteria include successful pressure hold, leak verification, and stable temperature indications on all three phases during ramp. The site will trend alarms, hydrogen parameters, and any condition-monitor data to confirm that vibration, thermal cycling, or aging insulation are not driving recurrence.

### Steam turbine insulation improvement

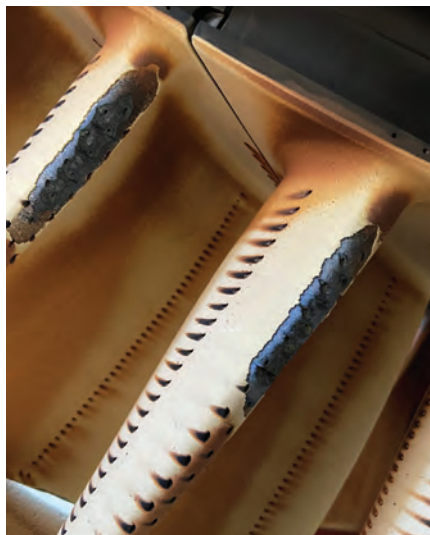
For those exploring a replacement of “original style” ST insulation with an upgraded, in this case, Arnold insulation system on a BB machine, check these well-organized slides out.

The scope begins with safe removal controls, including scaffolding, a temporary enclosure, air filtration and compliant disposal of legacy materials. These steps protect adjacent equipment and maintain housekeeping while exposing surfaces for inspection and prep. Preparatory work includes heater mapping to define the grid and termination points before new components are staged. This ensures cable routing, spacing and coverage align with thermal requirements and access limitations.

Installation proceeds in layers. Crews first install heater cables and an insulation screen to manage heat distribution and mechanical protection. Subsequent phases add precut pads and cladding, tying into the mapped heater grid and sealing interfaces



**Thermal barrier coating spallation** traced to iron contamination, leading to coating failure, base metal exposure, and vane degradation



**R1 blades on high-cycling peaking units** exhibited leading-edge distress despite clear cooling circuits

to minimize convection paths. The sequence supports repeatable quality, improves fit around complex geometries and standardizes future maintenance touch points.

The end user emphasizes a structured approach, from containment and removal through heater mapping and staged installation, to deliver consistent insulation performance on the BB platform. The staged method also clarifies future outage planning by breaking the work into predictable work packets: removal, mapping, cable and screen installation, then pads and cladding.

### CCGT inlet and exhaust upgrades

The project covers two reliability improvements increasing in commonality in aging F-class CCGTs: an inlet-air heating system to mitigate icing and a Single Piece Exhaust (SPEX) retrofit with new supports and expansion joint.

The inlet heating system extracts warm air from the compressor discharge or combustor shell and injects it into the inlet airstream immediately downstream of the silencer. Targeted protection areas include the bellmouth, inlet guide vanes, and struts, where ice formation can restrict flow or damage hardware. The routing runs from the



**Threading and machining restored proper** air separator fit after fretting damage, ensuring correct compression and long-term rotor integrity



**R2 blade damage prompted inclusion** of spare components in project budget and proactive preparation for future parts fallout

turbine enclosure to the air inlet, enabling on-unit heat use without external heaters. The objective is consistent winter availability and reduced IGV icing events during cold, humid conditions.

On the exhaust side, the site implemented a SPEX arrangement with a swing-set hanger, upper and lower assemblies, to simplify alignment and support. An upgraded expansion joint was also installed following a failure of the original EJ. New joint and hanger system aims to control movement, maintain sealing at the turbine-to-stack interface, and reduce maintenance driven by thermal cycling.

Together, the inlet heating and SPEX upgrades address weather-related risk at the front end and mechanical integrity at the back end of the GT train, improving reliability across changing ambient conditions.

### M501F3 compressor diaphragm set screw retention enhancement

Comprehensive presentation reviews field evidence and mitigations for liberated compressor diaphragm seal-box set screws on M501F3 units, tied to Service Bulletin GTB-21014 for Rows 1-4. A 2023 major uncovered foreign object damage on the seal-box ID





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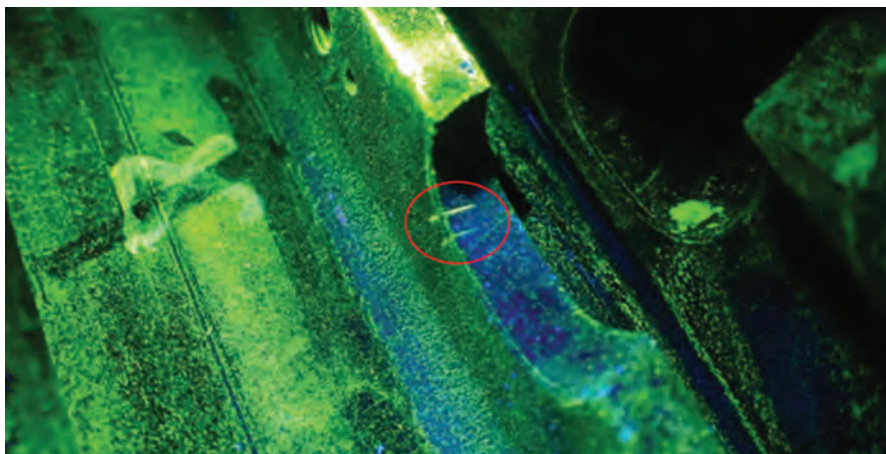
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**Turbine disk scallop cracking** observed during overhauls, identified by OEM as scrap criteria during comprehensive rotor inspections

and rotor discs, traced to a missing R3 set screw that never reached the blade path and escaped standard borescope routes. The unit received a new diaphragm, rotor repairs, and GTB-21014 implementation during the outage.

In 2024, a sister unit experienced liberated R2 and R3 set screws at 68k fired hours, with R2 especially concerning near the compressor spindle nuts. Limited parts forced blend repairs to diaphragms and disc cavities and deferred bulletin work to align with a GT upgrade. The end user strongly recommends proactive GTB-21014 installation across R1-R4 and targeted inspections of seal-box regions beyond conventional borescope paths. This is a must-read for any owner/operator with units affected by this service bulletin.

### FlameSheet™ implementation and improvements

In two follow-up presentations from the 2024 meeting on early FlameSheet experience on a 2x1 CCGT with two W501FD2s and a KN steam turbine, the end users initially reported controls, performance, and hardware challenges following install on both CTs in 2023. Scope included 16 new combustors, modified gas-stage valves, expanded instrumentation, OCR controller upgrades, new modes and alarms, and Autotune 3.0.

Initial commissioning focused on BOP tuning, acceleration to FSNL, and revised hold points. Early operation featured CT1 flashbacks, high baseload NOx, failed flashback thermocouples, and suspected compressor-discharge air shortfall. Extensive diagnostics, additional instrumentation, and tuning trades between dynamics and emissions followed.

Working in concert with PSM, corrective actions in 2024 rebalanced airflow via S13 orifice reduction, meter-plate changes shifting flow from pilot to main, plug welding transition-piece cooling holes, and liner-trip modifications. By mid-2024, CT1 achieved sub-8 ppm baseload NOx, acceptable dynamics, improved power and heat rate, and

turnaround near 50–65 MW.

More progress on the way. At the upcoming conference, expect an update on 2025 work including borescope results, EXB commissioning to enable sub-45 MW operation, and IBH system optimization.

### W501F R3 blade creep event

In late 2020 and early 2021, two units experienced abnormal vibration traced to R3 blade creep and liberation, with R3 creep features also found on one unit during a scheduled outage. OEM testing showed that at part load with LLCO enabled, exhaust temperatures were higher than expected; adjusting the OTC curve lowered LLCO temperatures and closed the immediate event.

To quantify thermal exposure, the end user and EPRI used an updated digital twin reflecting compressor bypass bleed to estimate stage temperatures before and after the OTC change. Results indicate the control change reduced estimated firing and gas-path temperatures by up to 30C at part load, while full-load service temperatures remain more than 100C higher than at 20–30% load.

Given creep's sensitivity to temperature and time, the team recommends adding a borescope inspection at 20,000–28,000 hours rather than running to a 33,000-hour HGPI, noting that a 5% absolute temperature increase can accelerate creep roughly tenfold.

### R1 vane issues

A 501FC+ in CCGT operation reports first-stage vane distress traced to iron contamination of the thermal barrier coating. Spring 2024 borescope inspection flagged four R1 vanes as high risk to the Spring 2025 HGP; a modified combustion inspection followed, replacing fourteen vanes. Offsite analysis concluded that iron contamination degraded the TBC, leading to cracking and base-metal damage on several vanes.

OEM spec sets an iron limit below 0.01 ppm. Site sampling identified probable

sources: inlet-chiller water at 0.61 ppm iron, which can enter via coil leaks; NOx steam at 0.01 ppm; and water-wash fluid at 0.02 ppm, a modest contributor given short duration.

Recommended actions focus on eliminating chiller-coil leaks, further qualifying NOx-steam quality, and tightening water-wash controls. The event reinforces rigorous chemistry monitoring and rapid follow-up inspections when borescope findings indicate early coating breakdown on hot-gas-path airfoils.

### R1 blade distress

W501FD1 peaking units, averaging ~150 starts/yr, continue to see recurrent first-stage blade distress. During its Fall 2022 torque-tube rotor replacement on one unit, the plant installed new R1 blades, the only non-OEM HGP parts on that machine.

By October 2024, the set had accumulated 318 starts and 2800 hours (up from 163 starts and 1082 hours the prior year) at a 900-start HGPI interval. Teardown showed clean cooling passages and no abnormal rust, yet leading-edge distress was present on nearly every blade; only one blade was unaffected prompting an RCA.

The site has historically cycled through multiple R1 designs and now plans an output-increase program with ULN combustors and a TPU/full-rotor upgrade beginning September 2025, targeting durable high-start operation with dual-fuel DLN and water injection. Details to come at February conference after initial cold-weather operations.

### Air-separator fretting and replacement

End user details W501F air-separator fretting history, inspection triggers, and a successful repair path informed by fleet experience and a 2018 OEM service bulletin covering FD1-FD3 units. Early cases include one case in 2016, where fretting led to scrap, and another in 2020, where fretting was discovered during a GT upgrade, prompting rotor shipment to Sulzer.

Disassembly revealed uniform radial fretting around 360 degrees, with measurements indicating the air separator was compressed about 0.007 in more than expected. The OEM recommendation was replacement, but the end user pursued repair, requesting WFMT and FPT of the gooseneck, fretted surface and ligaments, then machining and polishing the wheel, machining the separator, building up with a 0.015 in nickel-based HVOF coating, and final machining to optimize crush. Post-repair checks found no indications before or after the work, and air-separator compression was restored to 0.033 in.

The unit has operated successfully since early 2021, with the next outage planned for late 2027. Contact information was provided for follow-up.

### W501F rotor exchange/replacement timing and considerations



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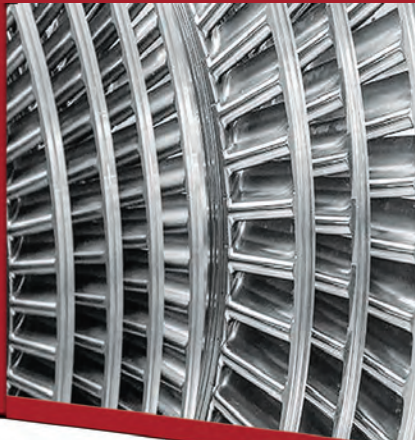
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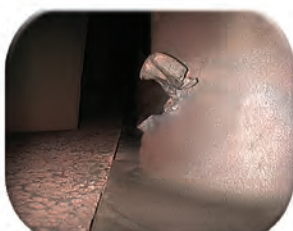
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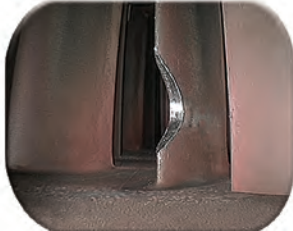
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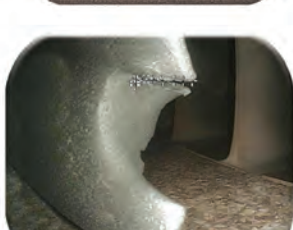
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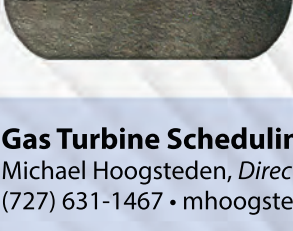
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OEM guidance links comprehensive rotor inspections (CRIs) to even-numbered majors (or 12 years) but gives no limits for turning-gear hours or rotor EOL.

The units have high turning-gear exposure: at first majors, one unit logged ~45k fired hours, 1,170 starts, 41k TG hours; the other ~59k fired hours, 1,628 starts, 55k TG hours. Both units show turbine-disc scallop cracking risk, which would trigger rotor scrap at CRI.

CRIs are quoted at ~30 days with no findings, while rotor exchanges can shorten outages if the seed rotor includes compressor blading. After pedigree checks and HS balance review, the site chose an early rotor swap on a unit with ~83k hours and will CRI/refurbish that rotor for next major of the sister unit, stressing parts planning, supply-chain timing, and R4 root-spring installation to protect the R4 disk.

### 501FD1-FD4 rotor replacement and mHGPI

Peaking site outlines why Unit 2 shifted from a planned HGPI to a rotor replacement in 2024, and how that decision drives work on Units 1 and 3 in 2025 and 2026. The 2000-vintage peaking site faced known compressor damage and torque-tube failures near the 900-start interval. Comparing options, fleet engineers found a seeded-rotor swap could compress outage duration to about 30 days with parts on hand, versus uncertain timing of a torque tube failure or roughly 60 days to replace the tube without addressing compressor issues.

Execution details stress vendor selection and shop capability, coupled with fallout planning and budgeting for R1 vanes and blades, R2 ring segments, and a fraction of R2 blades, and a technical recommendation to revert from VGP to standard parts at the next HGPI. Blade-height mismatches required tipping and rework, highlighting the need for clearances verification, prebuilt blade rings, and spare bearings. Compressor modifications to support hot restarts included trimming R1 and R16 and addressing a service bulletin on seal rub risk. After installation, elevated blade-path spreads around 2000-2400 rpm were tuned out, with the unit returning to service in October 2024.

Building on lessons learned, the requirements for work on the next rotor will include refined blade measurement, handling, and reinstallation procedures to improve accuracy and balance efficiency. The same high-speed balance process will be followed, but with tighter control over sequence labeling and position tracking for R1/R2. The shop will again identify and reinstall the longest blades in each row before tip measurement. Additional focus will be placed on careful blade packaging, alignment verification after shipment, and re-establishing consistent tip clearances.

## OEM SESSIONS

Extended presentation sessions by Siemens Energy, Mitsubishi Power, and Power Systems Manufacturing open valuable lines of communication between the end users on the front lines and various product line managers at HQ with the goal of addressing existing issues as well as pending and future solutions. Some of the key topics applicable to all of the major players follow:

- Supply-chain reliability issues, particularly delays in obtaining basic instrumentation from preferred suppliers and sub-suppliers
- Tracking and visibility of sub-supplier lead times
- Desire for updates on hardware, coatings, and component life improvements supporting fleets surpassing 40,000 EBH
- Engineering guidance for plants transitioning from baseload to cyclic operation and recommendation for inspection, modification, and monitoring recommendations across GTs, STs, and generators

**Siemens Energy** hosted an abbreviated session, squeezing in a lot of content and discussion into two hours. For those looking for a deeper dive into their suite of 501F upgrades and solutions, then consider blocking off an additional week midyear to attend the OEM's LGT conference in Orlando. Enquiring end users wanted to know:

- Locations and frequency of cracking observed in compressor, combustor, and turbine cases
- T-3000 I/O card availability and planned obsolescence
- T-3000 upgrade benefits from 8.x to 9.2
- Monitoring sub-supplier performance and component availability.
- Fleet experience and design improvements enabling operation beyond 40,000 EBH

**Mitsubishi Power** covered a slew of topics in broad strokes over the course of their four-hour session, focusing on their own M501F and cross-fleet solutions with the W501F. Keeping outage durations within schedule is always a big talking point at user groups, and the OEM was proud to report the opening of its new Houston workshop to support critical, time-sensitive outage activities in North America. Users kept discussion going with a wide variety of topics, many of which were planned for further analysis at MPA customer webinars:

- Rotor end-of-life philosophy for both M501F and W501F machines
- Fleet experience with compressor hook-fit wear on M501F units
- R1-R4 compressor diaphragm seal-box screw liberation
- Turbine-disc scallop cracking
- Update on 9-ppm combustor rollout to the broader M501F fleet
- Rotor LTE for steamers reaching 200k hours

- Spare-parts availability for Diasys Netmation control system components

**PSM**, coming off the heels of its annual asset manager meeting, was already in mid-season form delivering a robust session focused on maximizing 501F output, flexibility, and durability. Their session goals were to highlight current and future 501F projects and gather user feedback on emerging technologies and impacts on operations and maintenance.

The agenda progressed from current status through validation and future outlook, with audience prompts around the roadmap beyond GTOP7, additive manufacturing (AM), FlameSheet vs DLN/ULN, materials advances, and how AutoTune/FlexSuite interact with GTOP packages.

A central theme was continuous upgrade cadence across GTOP6 Light, GTOP6, GTOP7, FlameTOP7, and "Next Gen," targeting power increases and heat-rate improvements at a 24k-hour interval, plus sub-30% turndown (lower with ExB). The flexibility stack included IBH for roughly +10% additional turndown range, wet compression for power boost, FlameSheet for fuel flexibility, and ExB for further turndown—tied together by digital logic in GTOP7/FlameTOP7 to optimize emissions and operating modes. A field example showed IBH+ExB enabling <9-ppm NOx/CO at minimum load in hot-day conditions.

FlameSheet Gen V was presented as a drop-in combustor delivering sub-9-ppm NOx with <40% turndown and HRSG-friendly exhaust temperatures. The system bolts directly to the CDC, uses existing fuel headers, and works with common plant control systems with new scheduling/logic. Under the hood: a "combustor-within-a-combustor" with two aerodynamic stages, four gas circuits, trapped-vortex stabilization, and high premixer exit velocities to accommodate reactive fuels like hydrogen, all at low pressure drop for heat-rate benefit.

Validation highlights included AM modular hardware: 13 sets installed as of September 2024, >145k operating hours and ~2200 fired starts across the fleet, with leaders exceeding 31k operating hours and 483 starts since early 2020. The roadmap charted more than 15 years of 501F upgrades, aiming for sub-30% turndown and lower in 2025.

Bottom line: PSM's 501F path concentrates on flexible turndown, fuel flexibility (including H2 readiness), emissions control at minimum load, and validated lifecycle gains via AM and integrated digital controls, all packaged to fit existing plant interfaces.

## VENDORAMA

With supply-chain challenges a persistent issue in the CCGT industry, end users are faced with the growing need to find alternative solutions to keep their units humming. This unique segment at the annual 501F



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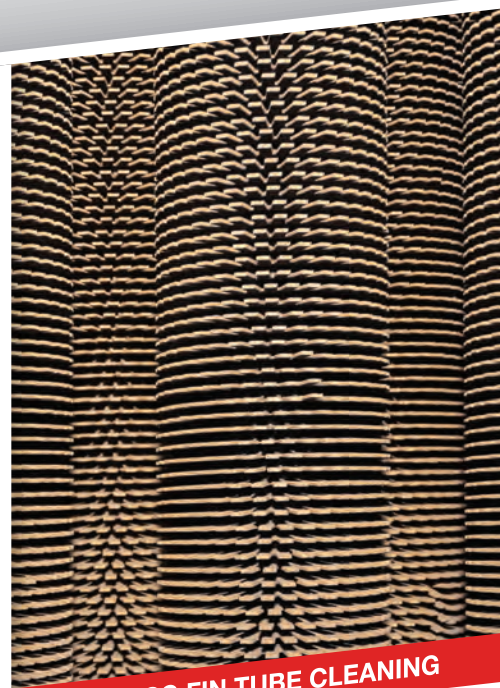
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and 501G Users Groups conferences offers a rapid-fire, must-attend day for owner/operators to gain a direct view of the latest third-party equipment and service offerings before the evening vendor fair.

The Vendorama day on Monday features concise, vendor-led technical presentations that are vetted by the steering committee to ensure substance and relevance, rather than pure promotion. With parallel tracks of several presentations, there's always a learning experience to be had. Below are brief recaps from presentations in 2025 where slide decks are available to registered attendees via the users-group website.

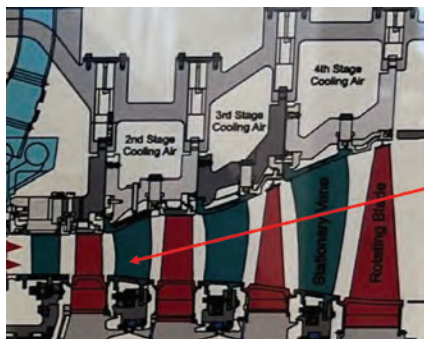
## Gas Turbines

### Heat rate improving insulation for GTs

*Arnold Group*

Pierre Ansmann presented a high-performance insulation system for gas turbines designed to reduce heat loss, improve plant efficiency, and extend component life across W501, M501, and M701 frames. The 3D single-layer insulation system replaces conventional multi-layer or pin-mounted designs that often suffer from sagging, hot spots, and material degradation after a few cycles. Each blanket is individually shaped and calculated for consistent surface temperature, maintaining a maximum of 15°C above ambient across the turbine casing.

The system features interlocking 45° interfaces between blankets to accommodate thermal expansion without creating gaps, eliminating hot spots that can damage nearby components. A stainless-steel sub-structure fixed by stud welding provides permanent support and safer access for



**Entrust Solutions.** R2 vane TBC spallation and oxidation attributed to coating durability and cooling design deficiencies, consistent with fleetwide design issues

maintenance, while high-temp Velcro fasteners allow selective removal during outages without disturbing adjacent sections. This approach enables up to 60–80% of insulation to remain installed, saving one to three days in outage reassembly time.

Field installations show significant gains in enclosure temperature uniformity and measurable heat rate improvement. Comparative testing demonstrates up to a three-fold reduction in heat loss versus standard systems, along with surface temperature reductions exceeding 40%. The result is a robust, maintenance-efficient insulation solution that supports long-term reliability and performance.

### Gas turbine cooling and wet compression

*Mee Industries*

Slides review the design, reliability, and maintenance considerations of high-pressure fogging and wet compression systems for gas turbines. The technology provides

22 to 28 MW of additional power output at a cost below \$50 per kW/hr, achieved through fine atomization and controlled droplet size to maximize evaporative cooling efficiency.

Approximately 90% of MeeFog droplets measure under 20 microns, promoting faster evaporation and minimizing compressor erosion compared to OEM nozzles, which typically produce droplets 3.4 times larger in mass.

The system integrates multiple protective and diagnostic features, including continuous water-quality monitoring through conductivity meters that trigger alarms and automatic shutdowns when conductivity exceeds turbine safety limits. Additional safeguards include drain activation interlocks to prevent large water droplets from entering the compressor.

Recent installations feature direct-drive pump designs and variable frequency drives in climate-controlled or NEMA 4-rated enclosures for improved control and reliability. Over 22,000 operating hours of field data demonstrate stable performance with no reported erosion issues. The presentation emphasizes precise droplet control, automated protection systems, and modular upgrades as key factors sustaining long-term operational reliability in fogging and wet compression applications.

### Better filtration pays for itself

*EMW Filtratechnik*

The presentation examines how advanced (H)EPA-grade gas turbine filters improve



**MeeFog.** Direct-drive pump improves on legacy plunger designs, offering simplified maintenance, higher efficiency, and improved reliability

**Arnold Group.** Thoughtfully designed insulation blankets enable partial removal, allowing 60–80% to remain installed during outages, cutting reinstallation time





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compressor cleanliness, maintain output, and reduce fuel consumption. EMW demonstrates that upgrading from F-class or E10 filtration to higher-efficiency E12 filters significantly reduces fouling and extends maintenance intervals, even in high-humidity or dust-laden environments. Testing follows ISO 29461 and ISO 29463 standards, measuring pressure drop, efficiency, and dust-holding capacity under both dry and moist conditions.

Field comparisons after 5,000 operating hours show that E12 filters maintain cleaner compressor surfaces, reducing the need for on- and offline washing. Lower pressure loss and stabilized compressor efficiency translate directly to better heat rate and availability. EMW concludes that E12 filtration delivers measurable financial return through sustained performance and reduced degradation across the turbine's lifecycle.



**HP Leak Detection.** Installed flange leak detection system uses pressure-activated flags to pinpoint flange leaks during operation, improving safety and minimizing downtime

## Root cause analysis process and case studies

### Entrust Solutions Group

This presentation outlines Entrust's structured, data-driven approach to root cause analysis (RCA) for turbine and generator failures, applying the Kepner-Tregoe method to distinguish probable mechanical, metallurgical, and operational contributors. The process integrates field inspection, finite element analysis, life assessment, and metallurgical evaluation to verify failure mechanisms and guide corrective actions.

A 501FD3 air separator failure case study attributes damage to fatigue cracking and liberation of the hammerhead section, initiated by fretting and compounded by thermal and centrifugal stress. A second case involving R2 vane burn-through links coating spallation and oxidation to a design deficiency in thermal barrier coating selection and vane cooling. Together, the examples illustrate how disciplined RCA supports fleet reliability, OEM negotiation, and preventive maintenance strategy.

### Fyrewash® F2 detergent development and field performance

#### Rochem Technical Services

Steve Egelhoff began with three important points: Faster rinsing, improved fouling removal, and no dangerous-goods label. He then went on to outline a reformulation of Fyrewash® F2, its water-based gas-turbine compressor detergent. The prior formulation used terpinolene as a grease cutter, however, transport rules later classified it as "very toxic to aquatic life." The new formulation eliminates terpinolene, using a plant-derived grease cutter with a proprietary non-ionic surfactant/co-solvent blend.

Reported benefits include quicker rinsing from higher polarity and faster foam breakdown, smaller bubbles for longer blade contact, stable emulsions with demin water, minimal odor, and compliance with major OEM specs.

Field testing demonstrates consistent power recovery across multiple turbine types: 4–6 MW in 7FA and 7HA units, over 5 MW in SGT6-8000H models, and full conductivity recovery in under 90 minutes.

## GT air filtration solutions

### Faist Filters

Faist presents advanced static and pulse filtration systems for gas turbine air intakes, designed to maximize compressor protection and performance. Its double-cylinder pulse cartridge filter increases surface area by 7%, reduces pressure drop by 13%, and cuts transport costs by 50%. Hydrophobic synthetic media meeting ISO 29461-2 delivers high dirt-holding capacity, durability, and resistance to water and soluble contaminants.

## Flange gas leak detection to maximize safety at reduced cost

### HP Leak Detection

Learn about a patented flange leak detection system that identifies active fuel and compressor leaks during operation using visual flag indicators that trigger at approximately 6 psi. It eliminates unsafe manual leak checks, shortens troubleshooting time, and prevents costly outages.

## Solutions for legacy turbine torque converter issues

### Voith US

Presentation reviews service experience and replacement options for Voith torque converters used in turbine starting systems. Field data from 2023–2024 indicate fewer catastrophic failures as operators adhere more closely to maintenance schedules and perform alignment checks more regularly. Standard overhauls and overrunning clutch replacements remain common, while actuator adjustments and coupling wear show slight increases.

Bevel gearbox issues continue to rise, prompting attention to oil level and quality



**TRS Services.** Shop assembly allows TBR roundness and flatness verification, precise vane and seal installation, and delivery of outage-ready assemblies



# Smarter catalysts: two in one Better emissions compliance

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### **2026 HRSG Budget Planning Tips:**

- Compare OEM Data to current data trends
- Compare Inspection reports and fouling trends
- Compare plant performance to contract requirements to ensure meeting the demand of the contract
- Contact your PIC Regional Manager to discuss how we can assist in these areas through our **HRSG DEEP CLEANING™**

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**Nord-Lock Group.** Final installation of Nord-Lock's four-way joint solution—Superbolt MJTs, hydraulic tensioners, and internal seal system ensuring uniform sealing integrity

and inclusion of gearboxes in torque converter maintenance programs. Flexible element couplings and solenoid valves are identified as critical spares. Voith confirms availability of replacement units and components for all 501F and 501G torque converters, including solutions for obsolete starting equipment.

### Comprehensive approach to blade ring repair and assembly

#### TRS Services

TRS Services discussed a structured approach to repairing and assembling 501F and 501G turbine blade rings (TBRs) to reduce outage delays and improve fit-up accuracy. Field cases show that TBRs often exhibit radial out-of-roundness and axial distortion after engine service, affecting vane alignment and interstage seal housing fit.

Using precision jacking fixtures, TRS restores roundness from 0.117 to 0.037 in. total indicator runout and flatness from 0.085 to 0.022 in. Repairs include dimensional restoration, downstream deflection correction, and braze preform applications for vane and seal surfaces. Performing TBR centralization and assembly in a controlled shop environment ensures alignment accuracy, minimizes on-site labor, and shortens outage duration.

### Four-way-joint and coupling-bolt solutions

#### Nord-Lock Group

Company provides engineered solutions addressing persistent leakage and maintenance issues at turbine four-way joints and coupling interfaces. The four-way joint design combines a variety of custom solutions to correct cylinder misalignment and achieve uniform tensioning. The system integrates an internal sealing assembly



**Advanced Turbine Support.** L-0 diaphragm fillet weld cracking linked to condensate erosion and poor drainage, emphasizing need for improved inspection and repair oversight

with adjustable retainers that prevent air escape and accommodate thermal expansion during operation.

For coupling interfaces, the EzFit mechanical expansion bolt replaces traditional fitted bolts that are prone to galling and removal difficulties. EzFit allows installation and removal with hand tools while maintaining high torque transmission and precise shaft alignment.

Field cases show installations completed in under three hours, significantly reducing outage duration and machining time. Together, these technologies improve sealing reliability, alignment precision, and maintenance efficiency for the 501F and 501G fleets.

## Steam Turbines

### Steam turbine major contingency planning

#### Advanced Turbine Support

In a lively vendor session led by Bryan Grant, attendees were urged to treat steam-turbine major-outage contingency planning as a structured, 18-month process. The goal: lock down scope, suppliers, spares, people and specialty tooling early enough to avoid delaying the outage critical path.

Start 18 months out. Grant recommended beginning with scope development, budget approvals and RFQ packages; supplier vetting and parts quote lead times often dictate schedule realism. Aim to release POs roughly a year ahead to secure shop and field capacity.

Build scope from history and TILs. Use outage, operations and fleet history to frame risk; then review OEM technical information letters (TILs), confirm open/closed status, and bring in independent technical expertise. Don't rely solely on OEM guidance; leverage user groups and subject-matter experts to stress-test "what-if" scenarios.

Identify critical spares. Priority components include diaphragms (with L-0 fillet-weld issues), rotors, HP/IP front-end

blades, L-0 mid-span sleeves, stationary packing and heads, valves, bearings, and oil-system hardware.

Plan roughly 90 days for RFQ through PO, which covers shop support, repair resources and contracts. Then hold 60-day gates for scope finalization and maintenance/operations review to keep alignment.

Control manufacturing and repair risks. Top shop-floor defect drivers called out: drawing-revision errors, insufficient CNC-program verification, operator qualification gaps, missed operations in the manufacturing process plan, documentation and gauge errors, and material-selection mistakes. Treat finger-dovetail and cover installs as high-risk steps; verify fit before reaming and inspect before closing.

### Steam turbine warming system for CCGT flexibility

#### Arnold Group

If dispatch appeal and reduced startup costs are what you desire, then Norm Gagnon urged users to consider this three-pronged approach—steam-turbine warming, HRSG warming, and steam-valve service—aimed



**Arnold Group.** Downcomer pipe heaters successfully maintained HP drum pressure and temperature, proving effective for warm standby and startup readiness





# Mechanical & Welding

(Pictured) Crew at Plant McDonough 50% Hydrogen Blend Project Spring 2025

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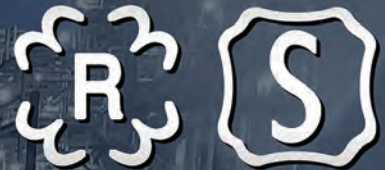
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Andrew P.

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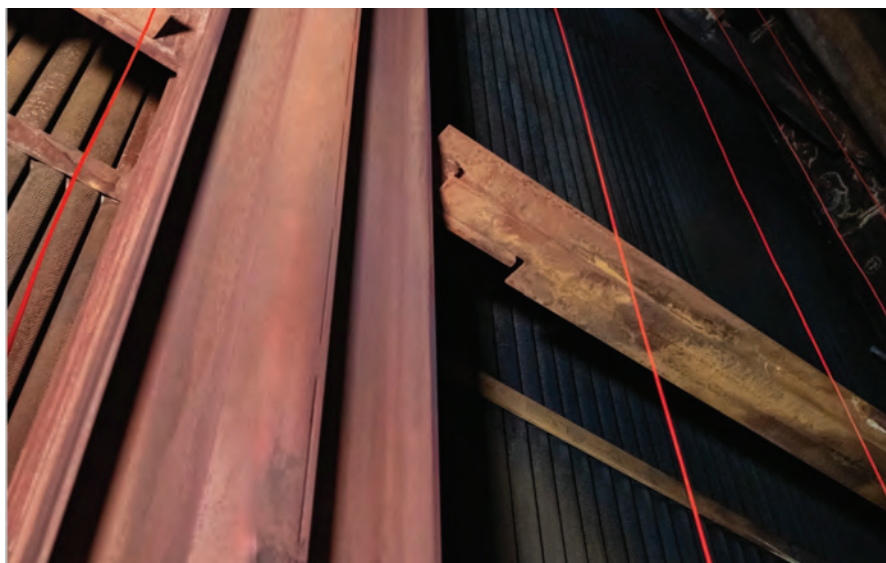
Holewatch & Firewatch

Field Service Safety





**National Electric Coil.** AEROPAC II generators can experience stator winding failures near the core exit from endwinding looseness, harmonics, and insulation degradation



**Groome Industrial.** Detonation cord curtain creates controlled shockwaves to dislodge fouling deep within HRSG tube bundles without scaffolding or mechanical tube movement

at improving starting reliability, emissions performance, and cycling life for your CCGT units.

A D11 steam-turbine warming case study reports total plant cycle time cut from 266 to 149 minutes, ~25% HP-rotor LCF reduction, and hot-start temperature hold for ~60 hours using insulation alone; casing differentials dropped up to 95% with active warming. Key takeaways include up to 75% startup-time reduction and ~50 kW parasitic to maintain temperature at shutdown.

An evolving HRSG warming concept, verified in an EPRI project, uses custom heating panels and PLC control to maintain ~200°F in HP drum downcomer piping with ~300 kW power; test demonstrated maintaining ~20 psig drum pressure for hours and reduced thermal shocks compared to sister unit.

Steam-valve service from Arnold Group utilizes its vast expertise in onsite machining and valve-parts partnerships to create opportunities for heat-rate gains from leak repairs and testing.

## Generators

### Generator fleet maintenance and rewind practices

#### *National Electric Coil*

Howard Moudy briefed attendees on maturing 501F/G generator fleets. With most units at or beyond 30-year design life he reiterated persistent focus areas: air-cooled generator issues, cyclic-operation damage, GVPI failure modes, and model-specific known issues.

For AEROPAC I units, common pain points include partial discharge (PD),

end-winding looseness/resonance, phasing and flex-link failures, and rotor pole-to-pole risks. NEC's response centers on pole-to-pole crossover upgrades (in-situ or rotor-out) and stator rewinds using optimized coil designs, upgraded OCP, improved coil-to-slot interfaces, and verified detuning via bump tests.

AEROPAC II (GVPI) machines show PD, end-winding looseness/harmonics, slot movement, and end-winding failures near the core exit; diagnostics emphasize bump tests, EMI/PD monitoring, and borescope inspections. Solutions range from pole-to-pole hardware replacements (connectors, shrouds, radial blocks) to selective stator rewinds, sometimes converting GVPI to conventional systems.

NEC's closing message: know your unit's known issues, monitor them methodically, and plan proactive fixes to avoid forced outages.

### Online non-destructive PD testing

#### *Doble Engineering*

This presentation reviews Doble's approach to online, non-destructive partial discharge (PD) testing for assessing the condition of medium- and high-voltage cable systems. PD activity serves as an early indicator of insulation degradation, allowing operators to identify developing faults without taking equipment offline. Doble's method applies capacitive or inductive sensors on energized cables to capture high-frequency discharge signals for laboratory analysis.

The proprietary time-frequency mapping software separates PD sources from noise and distinguishes between internal, surface, and corona discharges. Case studies in utility and industrial settings demonstrate how early PD detection supports maintenance prioritization, reduces unplanned outages, and verifies installation quality across complex power networks.

### Comprehensive rotating machine health assessment through PD and EMI diagnostics

#### *Doble Engineering*

The presentation explains how combining partial discharge (PD) and electromagnetic interference (EMI) analysis provides a more complete understanding of generator and motor insulation health. EMI testing detects high-frequency activity from 50 kHz to 100 MHz without requiring permanent sensors, allowing early identification of loose connections, damaged joints, or diode failures. PD testing characterizes localized insulation breakdowns, including void, slot, and end-winding discharges.

Case studies on 115-MVA and 105-MVA air-cooled generators show that integrating PD and EMI diagnostics can detect both electrical degradation and mechanical issues such as contamination and busbar joint defects. The approach improves root-cause analysis, enabling operators to plan target-





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**HRST.** Square duct liner failure from thermal fatigue and distortion 9 (left). Threaded stud failure caused by vibration and inadequate weld integrity (right)

ed maintenance, reduce unplanned outages, and extend the operational life of rotating machinery

#### **Protective relay life cycle planning for power stations**

*Shermco Industries*

Slide deck reviews best practices for upgrading obsolete protective relays in generator and auxiliary switchgear systems. Modern digital relays enhance reliability, provide event recording, and integrate with DCS platforms for remote monitoring. Aligning relay replacements with breaker refurbishment and PRC-005 testing reduces costs by up to 50% while improving protection and arc-flash mitigation.

#### **HRSGs**

##### **KinetiClean™ HRSG tube cleaning technology**

*Groome Industrial Service Group*

Growing demand for peak output and efficiency places HRSG cleaning in the spotlight, offering one of the most attractive ROIs in CCGT plant optimization regardless of cleanind method. The patented KinetiClean™ process removes fouling and deposits from HRSG finned tubes using a controlled three-step method. The system combines a kinetic shockwave generated by a detonation cord curtain, automated high-pressure air distribution, and in-house debris removal to achieve full-coverage cleaning without tube spreading, scaffolding, or manual handling.

Each curtain is engineered for the HRSG's size, fouling level, and fin configuration, ensuring deep penetration into tube bundles and removal of iron oxides, ammonia salts, and other contaminants. The detonation cord is cap-sensitive and handled only by licensed blasting professionals, ensuring safe, non-destructive operation.

Case studies demonstrate measurable performance gains: a derated Northeast

CCGT plant reduced backpressure by 2.4-in water column (WC), recovered 9 tons of debris, and restored baseload operation, while a Southeast site saw a 1.5-in WC drop in dP and a 2–4 MW output increase across two units.

KinetiClean improves heat transfer, lowers stack temperature, and restores gas turbine heat rate while minimizing outage duration. Independently reviewed by EPRI and approved by Siemens Energy, the method offers a reliable, repeatable, and safe approach to HRSG cleaning that supports efficiency recovery and sustained CCGT performance.

##### **How GT upgrades affect downstream equipment**

*Tetra Engineering Group*

Tetra Engineering examines how gas turbine and combined-cycle upgrades improve output, efficiency, and operational flexibility while affecting downstream systems. Typical gas turbine modifications—such as increased firing temperature, upgraded blading, and improved combustor design—can yield 3–5% higher peak power and lower heat rate. However, these upgrades alter exhaust temperature, flow, and composition, influencing HRSG steam production, casing vibration, and emission control performance.

Proper assessment requires digital modeling to evaluate system impacts, confirm safety valve and pressure ratings, and prevent fatigue in high-temperature components. Financial and regulatory planning remains critical to manage investment, supply chain constraints, and commissioning risk.

#### **BOP**

##### **The role of the owner's engineer in outage execution**

*Gulf Turbine Services (GTS)*

Joe Mitchell, a former end user and frequent attendee of the 501F Users Group, show-

cased how engineering oversight services enhance outage planning, execution, and quality assurance in GT-based powerplants. Acting as technical representatives for plant owners, GTS embeds SMEs within project teams to ensure compliance with specifications, maintain schedule discipline, and protect asset reliability.

The owner's engineer functions as an independent oversight layer, bridging plant management and contractors through technical validation, quality control, and risk mitigation. Services include monitoring progress against budget and schedule, verifying contractor workmanship, ensuring adherence to foreign material exclusion policies, and overseeing component testing and commissioning. GTS also emphasizes its staff augmentation model, which leverages experienced engineers, like Mitchell, to offset attrition-related knowledge gaps and provide niche technical skills during major outages.

Operational efficiency benefits stem from early involvement in pre-outage planning, structured quality control metrics, and lessons-learned integration across projects. This approach reduces change orders, improves schedule predictability, and ensures that both OEM and third-party work meets industry standards.

Access the slides to view case studies of oversight of F-class flange-to-flange upgrades, diverter damper overhauls, and major turbine inspections.

##### **Transition duct enhancement: A 3D-scanned approach**

*HRST Inc*

Slides detail a case study on improving the Siemens SGT6-5000F transition duct using LiDAR-based 3D scanning to address common liner and stud failures. The round-to-square duct, measuring roughly 13 ft in diameter and 14 ft in length, presents geometric challenges that have historically led to stud cracking, scallop bar detachment,





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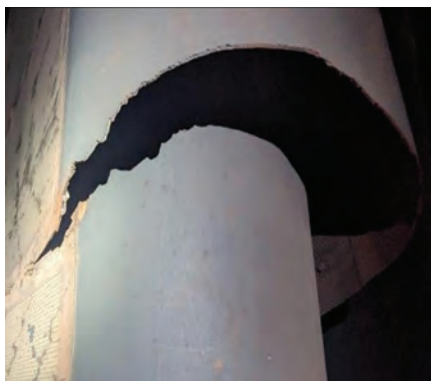
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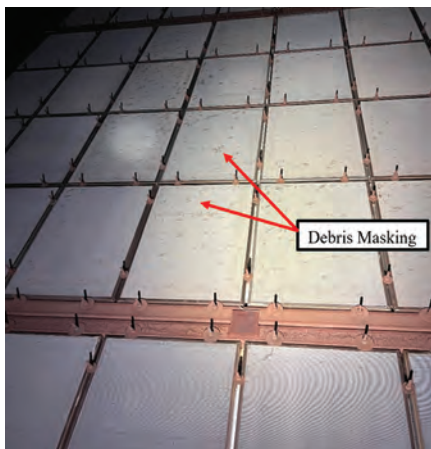


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**SVI Bremco.** Failed baffle nose resulted from thermal fatigue and inadequate weld design, leading to cracking and insulation exposure under high flow stress



**Environex.** Debris accumulation on the SCR catalyst surface masks active sites, restricting ammonia distribution and reducing overall NOx conversion efficiency



**Vector Systems.** Poor ammonia purity introduces contaminants that corrode AIG internals, form salts, and degrade SCR catalyst performance and longevity

and liner misalignment. Traditional field measurements and incomplete fabrication drawings made precision retrofits difficult.

To overcome these issues, HRST deployed LiDAR scanning to capture a detailed point-cloud dataset of the duct interior. Integrating this data with CAD tools enabled accurate modeling of stud locations, liner geometry, and sheet-metal cut patterns to ensure exact fit-up. The 3D overlay verified component interfaces before fabrication, minimizing rework and installation errors.

Installation procedures emphasized alignment of centerlines, shingled liner orientation for gas-flow optimization, and welded washer retention for structural integrity. The approach demonstrated how combining high-resolution scanning with disciplined installation practices can extend duct life, enhance reliability, and reduce turnaround times.

### CT exhaust silencer design approach

#### SVI BREMCO

Tucker York invites end users to read up on his engineering-based approach to CT exhaust silencer design, emphasizing material selection, structural integrity, and long-term reliability. The presentation covers parallel, bar, and cylindrical silencer types used in simple-cycle, bypass, and HRSG exhaust systems, each engineered to reduce turbine-generated noise and backpressure.

Design methodology incorporates finite element and computational fluid dynamics analysis to assess thermal fatigue, creep rupture, and vortex-induced vibration. Material choice—typically 409SS, 11Cr-Cb, 304SS, or 321SS—is guided by ASME II, Part D allowable stress limits for high-temperature service.

Fabrication guidance covered stitch and plug-weld techniques for perforated skins, protection of acoustical pillows/insulation, and common failure root causes with corrective practices.

### Extending catalyst life through proper system evaluation

#### Environex Inc

Andy Toback dove deep into strategies to extend the operating life of SCR and oxidation catalyst systems through detailed system evaluation, data analysis, and sample testing. Accessing his extensive slide deck is highly recommended after reading the Cliffs Notes version below.

Catalyst degradation is often accelerated by factors external to the catalyst itself, including exhaust temperature variability, uneven ammonia injection, seal leakage, and particulate buildup. Comprehensive inspections assess catalyst face fouling, side and floor seal integrity, bypass leakage, and ammonia injection grid condition to identify non-catalyst issues limiting performance.

Operational data analysis, typically spanning two to three years, includes load profiles, catalyst differential pressure, NOx inlet and outlet concentrations, ammonia slip, and vaporizer performance. Laboratory testing of catalyst samples across multiple temperatures and NH<sub>3</sub>-to-NOx ratios determines true activity levels and projects remaining service life based on the most demanding operating mode.

Field experience shows that a full-system approach (mechanical inspection, operational review, and analytical testing) extends catalyst service intervals, minimizes ammonia slip, and maintains emissions compliance at lower reagent consumption. Targeted corrective actions can realign catalyst performance with design expectations, helping operators preserve compliance margins, reduce operating cost, and avoid premature catalyst replacement in both combined-cycle and simple-cycle gas turbine applications.

### Oil, your hidden asset

#### CC Jensen

Presentation highlights the value of treating lubricating oil as a long-term asset rather than a consumable. Clean, properly maintained oil extends the life of critical rotating equipment, reduces downtime, and lowers total operating costs. Examples include a ball mill bearing system where optimized filtration and testing reduced oil changes from six times per year to once every three years, cutting oil use by 80% and extending bearing life by 50%.

Key testing methods are viscosity, total acid number, additive depletion, and particle count analysis to determine oil condition and remaining life. Advanced diagnostics, including FTIR, membrane patch colorimetry, and RULER tests, help detect varnish, oxidation, and additive loss before failure occurs.



# BCM

## Brush Condition Monitoring

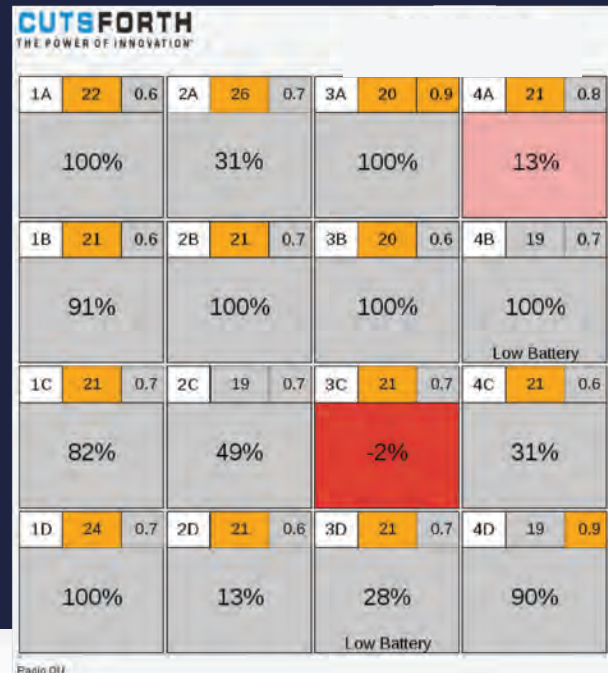
**BRUSH CONDITION MONITORING OFFERS AN EVEN BETTER WAY TO OPERATE YOUR GENERATOR'S BRUSH TYPE EXCITATION. AUTOMATED MEASUREMENTS AND BRUSH HEALTH ANALYTICS ARE DELIVERED TO THE CONTROL ROOM, ALLOWING MAINTENANCE TO BE PERFORMED BASED ON BRUSH CONDITION RATHER THAN A CALENDAR.**

### BENEFITS OF BCM:

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- Brush Vibration
- Temperature



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|      |    |     |      |    |     |             |    |     |             |    |     |
|------|----|-----|------|----|-----|-------------|----|-----|-------------|----|-----|
| 1A   | 22 | 0.6 | 2A   | 26 | 0.7 | 3A          | 20 | 0.9 | 4A          | 21 | 0.8 |
| 100% |    |     | 31%  |    |     | 100%        |    |     | 13%         |    |     |
| 1B   | 21 | 0.6 | 2B   | 21 | 0.7 | 3B          | 20 | 0.6 | 4B          | 19 | 0.7 |
| 91%  |    |     | 100% |    |     | 100%        |    |     | 100%        |    |     |
|      |    |     |      |    |     |             |    |     | Low Battery |    |     |
| 1C   | 21 | 0.7 | 2C   | 19 | 0.7 | 3C          | 21 | 0.7 | 4C          | 21 | 0.6 |
| 82%  |    |     | 49%  |    |     | -2%         |    |     | 31%         |    |     |
| 1D   | 24 | 0.7 | 2D   | 21 | 0.6 | 3D          | 21 | 0.7 | 4D          | 19 | 0.9 |
| 100% |    |     | 13%  |    |     | 28%         |    |     | 90%         |    |     |
|      |    |     |      |    |     | Low Battery |    |     |             |    |     |

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Effective maintenance combines continuous monitoring, inline and offline filtration, and moisture control. By maintaining cleanliness, dryness, and chemical stability, operators can increase bearing and gear life by factors of four to five and significantly improve equipment reliability across the power plant.

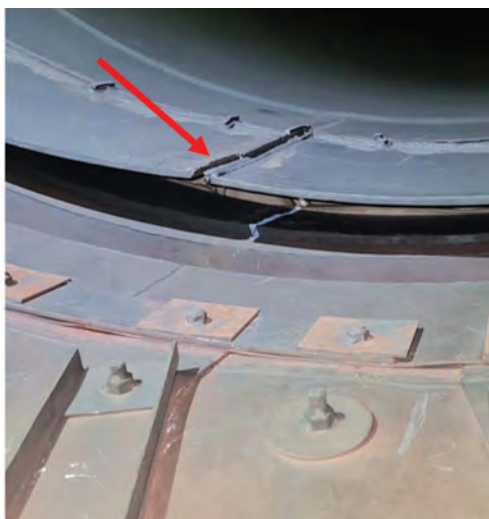
## **Improvements in freeze protection technology**

### *CIAC Systems*

Tim Mullen reviews advancements in electric freeze protection systems designed to maintain reliable operation of balance-of-plant piping and instrumentation in cold-weather CCGT facilities. CIAC's latest heating solutions use self-regulating heat trace technology with integrated monitoring and control to maintain uniform temperature across exposed surfaces. The system minimizes thermal stress, prevents ice for-

mation, and ensures consistent startup capability during subfreezing conditions.

Recent developments include improved insulation interfaces, real-time temperature feedback, and energy-efficient circuit design that reduces parasitic load. Field applications demonstrate enhanced performance compared to conventional trace systems, with faster response time and reduced maintenance requirements, supporting improved winter reliability for plant operators.



**IAFD.** Flow shield and EJ frame cracking caused by thermal growth and stress concentration at the flange base, leading to repeat weld repairs





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### Distribution effects on SCR system performance

#### *Vector Systems*

Vaughn Watson dives into how AIG tuning directly affects SCR performance and catalyst life. Uneven NH<sub>3</sub>-to-NO<sub>x</sub> ratios often stem from maldistribution, velocity stratification, and fouling in AIG lances, leading to elevated slip and inefficient NO<sub>x</sub> reduction. Precise tuning aligns NH<sub>3</sub> flow with measured NO<sub>x</sub> profiles, optimizing reaction uniformity and minimizing reagent use.

Case studies highlight these benefits. In one F-class CCGT retrofit, Vector's Katana AIG reduced ammonia consumption by up to 40% and stabilized NO<sub>x</sub> control without catalyst replacement. Another 501F site resolved poor performance in a new catalyst by rebalancing AIG flow after discovering excessive maldistribution caused by reduced system pressure drop. Together, the results demonstrate how AIG geometry, orifice precision, and in-situ tuning restore SCR performance, extend catalyst service life, and reduce total operating costs.

### CT outlet expansion joint and transition duct liner issues

#### *IAFD*

This presentation analyzes failure mechanisms and upgrade strategies for Siemens 501F/G outlet expansion joints and adjacent transition duct liner systems. Accelerated

wear in fabric joints is traced to startup vibration and operational flutter, all intensified by engine performance upgrades that increase exhaust energy. Original joint materials and frame geometries exhibit high stress at the base of the EJ flange, promoting cracking at weld interfaces.

IAFD recommends redesigned flanges that accommodate thermal growth and flexible, heavy-duty PTFE-based joint materials with improved insulation to resist fatigue and flutter. Thermographic inspections reveal consistent liner plate deterioration, misaligned overlaps, and insulation breakdown contributing to localized hot spots.

Corrective actions include increased stud density, proper baton channel installation, and re-lapping of liner plates to maintain gas-tight integrity. These targeted upgrades enhance structural flexibility, extend component life, and reduce recurrent welding and outage frequency in aging units.

### Proper prediction of turbine oil degradation to prevent varnish formation

#### *Shell Lubricant Solutions*

Slides provide a review of oil degradation mechanisms and predictive testing methods to prevent varnish formation in gas and steam turbine lubrication systems. Oxidation by-products such as acids, aldehydes, and ketones agglomerate into sludge and varnish, reducing bearing clearances, foul-

ing valves, and accelerating wear.

Key predictive tools include the RULER test to quantify antioxidant depletion, FTIR spectroscopy for oxidative species, TAN for acidity, and MPC for deposit potential. Routine trending of these parameters enables timely oil replacement or varnish filtration. Effective monitoring minimizes forced outages, extends fluid service life, and preserves turbine reliability.

### Expansion joint upgrades for legacy 501FD and 5000F units

#### *Frenzelit Inc*

Case studies were presented on recent field upgrades to exhaust expansion joints on legacy 501F units. Failures in original manifold sections are linked to moisture intrusion, vibration during low-load operation, and thermal cycling fatigue. The upgraded design introduces scalloped TEM flanges and reinforced flow shields to reduce stress concentration at weld joints. Enhanced soft goods protect against water ingress and startup pulsing, while redesigned hard parts maintain flexibility through repeated thermal cycles. Externally, spring-loaded insulation bands keep the manifold wrap tight during expansion and contraction, preventing radiant heat exposure on the lower joint. The improvements extend durability and minimize maintenance frequency for aging F-class equipment. [ccj](#)

# In-service tank inspections slash risk, cost, and downtime at GT sites

End users have long treated API 653 tank inspections as necessary pain from challenges associated with fuel handling, confined-space entry, outage coordination, and weeks of operational uncertainty. A recent Electric Power Research Institute (EPRI) Incubator Energy Labs demonstration with Tennessee Valley Authority (TVA) shows there's a safer, faster path: submersible, autonomous robots that perform phased-array UT while tanks stay online.

The system, developed by Square Robot (Westborough, Mass), was deployed on four TVA tanks across two sites to test coverage, data quality, and real-world logistics against traditional out-of-service (OOS) methods.

## WHY IT MATTERS

- **Eliminate OOS disruptions.** Robots inspect from inside the product, avoiding drain/clean/vent cycles that drive outage days and safety exposure. The platform uses proprietary navigation plus 256-element PAUT to image bottom plates, size corrosion on product and soil sides, measure coatings/linings, and track settlement patterns—with location accuracy to roughly six inches.
- **Shift inspections from “project” to “activity.”** Keeping tanks in service simplifies staffing, trucking, and back-up fuel planning, while preserving plant flexibility during peak or contingency periods.

## FUEL OIL TANK RESULTS

At TVA's Marshall Combustion Turbine site, three identical 62-ft tanks (~1,000,000 gal each) were inspected robotically in 3.5 days total—versus weeks to a month per tank for OOS. Coverage averaged ~60% of the bottoms, with ~100 GB of PAUT data per tank; by comparison, the previous OOS effort collected 28 single-point UT readings across a bottom, orders of magnitude less information.

Operational and safety impacts were equally material:

- ~6 tons of CO<sub>2</sub> avoided by not venting/drainage.
- ~850 confined-space hours eliminated, plus no need for dedicated personnel to supervise those entries.
- Zero fuel trucking: TVA estimated OOS would have required ~130 truck movements per tank, with potential loss of a half-day of plant operations if fuel was needed mid-inspection.

## FIREWATER TANK RESULTS

At the Magnolia CCGT site, the robot

tackled a 92-ft firewater tank—bolted floor, significant sediment, and flows observed up to 5,500 gpm. Compared to a prior robotic crawler (63-element spot UT) that could reach only a single plate due to bolt obstructions, the submersible robot delivered >10× the data, touching ~90+ plates, and achieved ~10% bottom coverage in ~3 days—while coordinating flow adjustments with plant staff (targeting ≤2,500 gpm during key passes).

For planning purposes, TVA estimated that a conventional OOS path here would have meant ~500 confined-space hours. API 653 reports were issued within 2-4 weeks; Marshall's fuel tanks received 20-year intervals, while Magnolia's firewater tank, given lower coverage and minimum thickness, received a 5.47-year extension.

## PROGRAM-LEVEL TAKEAWAYS

TVA's technology scout characterized the shift succinctly: inspections proceeded while operations continued, changing how the utility thinks about tank programs going forward.

From the lab vantage point, the demonstration confirms that in-service robotics can reduce safety exposure, improve data density, and enable smarter interval decisions—without tying up people and equipment in lengthy tank outages. Project notes highlight potential six-figure cost savings, reallocation of project-management hours, and the ability to prioritize scarce outage windows for higher-value work.

Square Robot reports over 300 tanks inspected across eight countries, with 190k confined-space hours eliminated and 600k lb emissions contained.

## WHAT TO LOOK FOR, HOW TO REACT

- **Asset mix.** Firewater vs fuel oil will drive coverage expectations, hydraulics coordi-



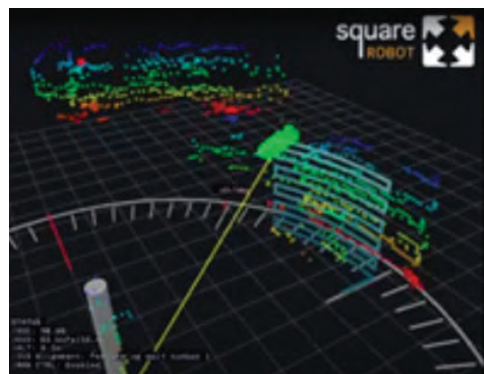
**1. Crawler inspects storage tanks in-service,** using PAUT to map corrosion while eliminating confined-space entry and downtime

nation, and interval outcomes; Magnolia's lower coverage still yielded a meaningful extension.

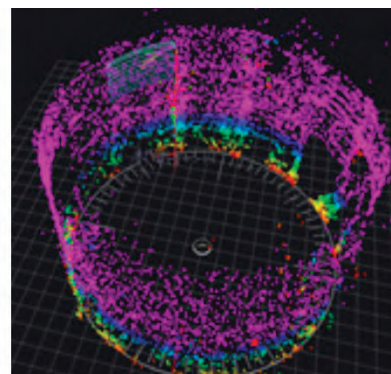
- **Data density.** Moving from “dozens of spot UTs” to hundreds of gigabytes of PAUT creates richer corrosion mapping and settlement insights, useful for RBI models and capital planning.
- **Safety accounting.** Quantify avoided entries up front; TVA's experience shows the scale—hundreds of hours—is non-trivial for staffing and contractor budgeting.
- **Fuel logistics.** If your OOS plan includes significant transfer/hauling, model the operational risk case; TVA's estimate of ~130 trucks/tank underscores schedule and HSE exposure otherwise.

## BOTTOM LINE

For owner/operators, submersible robotic inspections convert a high-risk, high-disruption task into a short, in-service activity that yields better data, safer work, and more predictable schedules. TVA's results provide a credible blueprint: compress inspection timelines from weeks to days, eliminate large blocks of confined-space work and trucking, and make interval calls on evidence not guesswork. [CCJ](#)

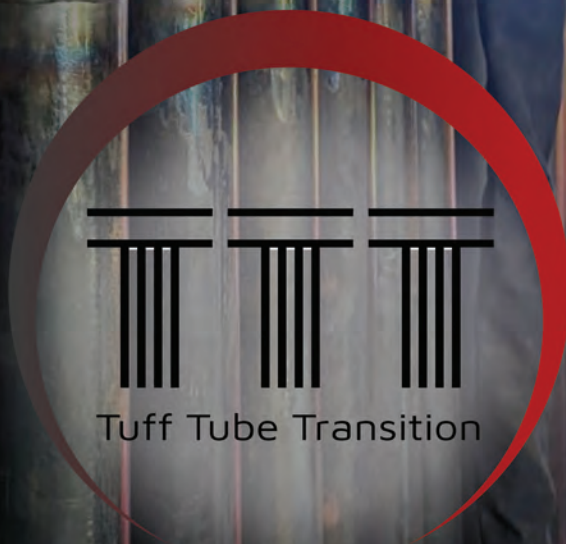


**2. PAUT quantifies shell thickness** while differentiating internal and external corrosion and defects including corrosion-under-insulation (CUI)





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# CCGT seminar offers practical HRSG training, case studies, tools

**H**eld in Asheville, NC, in January 2025, the Vogt Power Combined Cycle Seminar delivered concentrated HRSG fundamentals, inspection how-tos, and deep technical case studies. End users compared notes with peers, and Babcock Power's business units were on hand with design, construction, field, and product expertise. The content below highlights what attendees learned and why you should consider attending in February.

Session blocks moved from HRSG basics to inspection priorities, then into retrofit and rerate case studies, and ended with end-user experience. This progression helped less experienced staff build a base while giving veteran engineers and O&M leads detailed examples they can plan to implement. The emphasis throughout was on actionable steps, clear decision criteria, and most importantly, code compliance.

**HRSG 101.** The fundamentals session led by Greg Rueff traced how cycling and faster starts have reshaped HRSG design and operation, culminating in present-day requirements for high ramp rates,  $\geq 60\%$  combined-cycle efficiency in prior generations, and today's focus on flexibility. Materials guidance noted broader adoption of Grade 92 for heating surfaces as ASME lowered allowable stresses for Grade 91, while many plants still use Grade 91 in high-energy piping. Hydrogen blending and extreme load following were identified as ongoing realities operators must plan for.

**Inspection.** Much to learn from Jake Holvey, field services director, in his photo-rich presentation which organized field observations into six categories: safety, aging, corrosion, thermal growth, overheating and water chemistry. Examples included neglected anchoring systems and broken repair welds tied to module movement, rein-

forcing the value of tracking growth and slot travel instead of "set and forget." The structure offered inspectors a simple checklist to frame outage scope and near-term mitigations.

**GT24 HRSG front-end replacement.** Vignesh Bala, VP of HRSG Services, provided a detailed look at a high-cycling 1x1 CCGT coupled with a two-pressure, once-through HRSG with horizontal reheater bundles. Site experienced persistent tube-to-header joint leaks and startup challenges. Root-cause analysis identified four primary issues and the corresponding fixes:

- **Material system and dissimilar welds.** Original Grade 22 inlet headers plus stainless tubes and outlets created thermal mismatch. The redesign moved the reheater to Grade 91, with thermal analysis verifying predicted startup metal temperature around 1180F, below ASME's 1200F limit for the service.
- **External supports imposing stress.** Pipe supports on main reheat and superheat headers were influencing harp stress. The fix added new guides, safe ends and axial restraints, and reworked hangers.
- **Drainage that could not clear condensate.** Basement routing, expansion loops and side-exit drains prevented proper removal of water at starts and shutdowns. The redesign re-worked drains and added condensate detection.
- **Unmanaged thermal growth.** Differences between tube and header materials aggravated expansion; the redesign pre-tensioned supports to harness growth rather than fight it.

Bala stressed that inspection data, leak maps and empirical behavior should trigger retrofit timing rather than relying solely on theoretical life-cycle studies.

**GT upgrade drives HRSG rerate.** A utility in the western USA upgraded a

2x1 F-class CCGT, targeting fast capacity for summer reliability. Thermal modeling showed a 58-MW gain, but terminal pressures exceeded relief limits, even 1x1 unfired, requiring a formal HRSG rerate. Mechanical review, updated to ASME 2021/B31.1-2020, leveraged higher allowable stresses, driving selective reinforcement rather than wholesale replacement.

Scope included added drum cyclones and reworked chevrons, larger attemperator capacity, and replacing RH harps with P91/P92 to meet new MAWP and constructability needs. The team pre-aligned with the AI and state; shop 1.5x MAWP hydro, 80% MAWP field hydro, and 100% NDE ensured compliance.

**After two solid days** of learning and networking, the takeaways for end users were plentiful, including the following:

- Use inspection categories to build outage scope and measure movement where modules grow
  - Trigger reheater or front-end replacements based on empirical leak behavior, then address materials, supports, drains and growth together
  - When a GT upgrade is planned, commission a thermal study early, involve the AI and state, and prepare a code-compliant rerate plan covering HRSG and BOP
- The 2026 seminar** returns to Asheville, February 11–12, at the Omni Grove Park Inn. Contact Jennifer Pasquariello, [jpasquariello@babcockpower.com](mailto:jpasquariello@babcockpower.com), to reserve your seat. Preliminary agenda includes the following topics:
- HRSG 101
  - Design for advanced-class GTs
  - State of market, tariffs, supply chain
  - Endcap repair and replacement
  - Top ten drivers of lost run time
  - Rerating your HRSG

CCJ



The Babcock Power executive team on hand covers all the bases from HRSG manufacturing to aftermarket solutions

# HRSG reliability and performance takes center stage at EHF2025



## SAVE THE DATES

EHF2026  
Prato, Italy  
May 19–21, 2026  
[www.europeanhrsgforum.com](http://www.europeanhrsgforum.com)

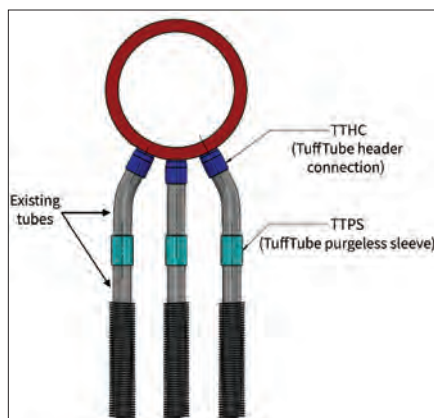
The eleventh annual European HRSG Forum (EHF2025), held May 13–15 in Prato, Italy, drew 95 participants from 20 countries. Co-chaired by Barry Dooley of Structural Integrity and Bob Anderson of Competitive Power Resources, EHF2025 continued its mission of advancing best practices and global knowledge-sharing in combined-cycle and HRSG operations.

The event, organized by Mecca Concepts (Australia), is supported by IAPWS and held in association with HRSG Forum (US), Australasian Boiler and HRSG Forum in Brisbane (ABHUG), and the recently-launched HRSG Forum América Latina in São Paulo, Brazil.

EHF2025 offered 23 technical presentations, including a workshop on cycle chemistry, and featured strong international representation across plant operators, OEMs, engineers, consultants, and vendors. Seventeen sponsors supported the event: Precision Iceblast Corp, NEM, Dekomte, Freudenberg Flow Technologies, TÜV Rheinland, New Composit, Advanced Valve Solutions, Tuff Tube Transition, TesTex, Quest Integrity, Metroscope, OMB, Pruss, Fuel Tech, Arnold Group, IMI, and Thermic Systems.

## Global priorities

A consistent theme across presentations: reliable, flexible operation of aging HRSGs remains a top concern for users worldwide.



1. TTT upgrade solution at Bouchain

Daily cycling, faster startups, and deeper turndowns are placing growing stress on pressure parts and internal components, especially in:

- Superheaters and reheaters (creep and fatigue failures).
- HP evaporators (flow-accelerated corrosion and under-deposit corrosion).

While pressure-part upgrades using modern materials are often proposed, many operators find these investments difficult to justify amid long-term plant uncertainty.

## Codes and compliance

The European Pressure Equipment Directive (PED) was highlighted, especially in Germany, where HRSGs must meet stricter design and compliance requirements beyond ASME code.

Alexander Bibow, TÜV Rheinland, addressed these differences in his presentation *New generation of H2-ready power plants in Germany*. He noted that ASME can be used as a product standard within the scope of PED, but ASME on its own is not fully in line with certain safety requirements of the PED 2014/68/EU. “Additional requirements are mandated and must be verified,” he said. He added that these details are not easily determined. He also referenced requirements of NFPA International to highlight overall complexity.

Bibow discussed allowable stresses, material certification, welding procedures, essential task analysis and safety requirements of PED, testing methods, and variations in inspection periods. His ultimate motivation was design developments for H2 applications.

He stressed that original ASME design philosophy focused on base-load power stations before the influx of load cycling and some operational issues including corrosion, erosion, and fatigue. This leads to current-day complications on welding and NDT approvals, risk analyses, and testing/operating instructions. He ended with discussions on inspection schedule variations.

H2 readiness analysis, he summarized, requires details in engineering, design and materials, explosion protection, operational safety, emissions awareness, organizational awareness, and corporate support.

## Tube failures

HRSG tube failures (HTFs) continue to dominate reliability discussions worldwide. Key takeaways from EHF2025 include:

- Only 8% of plants globally have a formal HTF reduction program in place.
- Successful reduction programs require top-down commitment and cross-functional involvement.
- New templates and benchmarking tools for tube failures, flow-accelerated corrosion (FAC) and cycle chemistry are available.

Root cause accuracy remains vital. Case studies emphasized the need for experienced metallurgists to avoid misdiagnosing the failure mechanisms. The correct determinations of fatigue, FAC, or under-deposit corrosion (UDC) are critical to prevent repeat events.

FAC again topped the list of tube failure mechanisms. Presenters detailed:

- The role of pH control in two-phase FAC.
- Importance of oxidizing power in preventing single-phase FAC
- The linkage between UDC and poor chemistry, often worsened by corrosion product transport.

Case studies included robotic waterside inspections that now allow access to upper headers for thickness readings. Efforts are underway to enable robotic internal deposit density measurement for HP evaporators.

## Tube repair/replacement

Innovative repair methods, such as tube sleeves, are gaining traction as cost-effective, short- to mid-term solutions to extend unit life.

Guillaume Grognet, EDF France, presented *Repair of inaccessible economizer: replacement of tube-to-header welds with reinforced sleeves*.

The project: Bouchain CCGT in Lille, France, a 604 MW plant with 9HA.01 and D650 steam turbine, commissioned in 2016. The HRSG is a CMI horizontal design with reheat.

This HRSG experienced several technical issues since commissioning, primarily: HP interstage attemperator replacement, desuperheater/attemperator thermal liner cracks, DMW weld bead machining, drum



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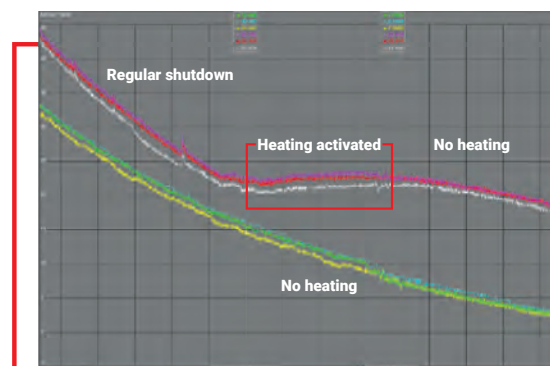
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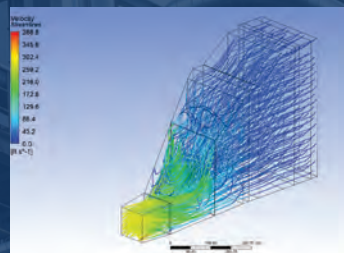
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manhole leaks, LP economizer fouling, HRSG inlet expansion joint failure, among others.

Grognet focused on the HP 4-1 economizer upgrade, a project undertaken after several tube leaks and forced outages. Root cause analysis showed that thermal fatigue lifetime had been reached after only seven years of operation.

With the site down for unrelated extended maintenance, a window of opportunity presented itself for HRSG work, and Tuff Tube Transition (TTT) was selected for repairs on short order (Fig 1). Grognet walked through the steps of working alongside TTT's Marcus Hutchinson for planning and implementation, stressing a compressed lead time, to complete over 200 upgraded, purgeless tube-to-header weld connections (TTHC).

After dealing with the ins and outs of accessing the bundle, a temporary hanging system was installed to lift the harp safely without modifying the original supports.

Installation steps featured a dummy header for welder qualification (Fig 2), sequenced tube cutting one-third at a time to control stresses, TTHC fit-up and welding, followed by 100% PT and a hydrotest.

Post-work, EDF added tube temperature sensors and set a follow-up inspection plan to validate the fatigue relief. The reinforced sleeves provide a fast, engineered path to reduce local stresses, avoid a long replacement lead, and stabilize an economizer subjected to high cycling.

For a more detailed report, see <https://www.ccg-online.com/case-studies-on-hp-economizer-tube-leaks-at-bouchain-ccg/>

#### Tube/header inspection

Shawn Gowatski, TesTex (US), presented an HRSG inspection update focused on faster coverage and better access to problem areas using electromagnetic techniques and purpose-built tooling. Highlights for cycling fleets and short outages:

- Finned tubes. External scans through fins to find pitting and wall thinning on evaporator and economizer tubes (Fig 3). Typical productivity about 1,250 linear feet per shift, with defect sizing by calibration standards.
- Tube-to-header welds. CLAW locates cracking around the full 360 degrees of the weld. Current heads cover common HRSG tube sizes and can examine up to about 150 welds in a shift. Modified "mini"

heads and extension links improve reach in tight header nests.

- Internal Access Tool. Access via endcap removal or an 8-in header hole to push probes up individual tubes (Fig 3). Waveforms and video document localized FAC and pitting at multiple elevations. A crew can clear a header in 3 to 4 shifts when access is favorable.
- Case pattern. Internal inspections frequently show highest FAC near upper headers, with ranges from 20 to 65 percent wall loss on selected tubes. Video often correlates wall loss with deposit accumulations. Findings guide selective retube plans when full drum internals removal is not possible in a short outage.
- Development items. Ongoing work with EPRI includes methods to measure internal deposit thickness in HP evaporator tubes, downsized crawlers to detect tube-to-header weld cracking from inside small headers, and phased-array follow-up for the CLAW.

#### Fireside cleaning and plant performance

Gas-side fouling remains a primary performance issue for HRSGs. Two cleaning technologies received attention:

- Ice blasting.
- Pressure waves.

For HRSGs with badly fouled finned tubes, cleaning remains one of the fastest



2. TTHC welder training and qualification



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### Additional Technical Solutions

- Hot Spot Repair with Pumpable Insulation
- Casing and Insulation Repairs

return-on-investment solutions for recovering generating capacity loss due to gas-side pressure drop. New developments in pressure wave cleaning were discussed, including improved performance when used while deposits are still hot, before moisture absorption increases adhesion.

Markus Bürgin, Bang & Clean Technologies AG, focused on Swiss innovation and technology for gas-path cleaning, beginning with PressureWave+ mobile cleaning in 2001. He covered developments and ex-

perience in Italy, the Benelux region, and France.

A recent innovative development, he noted, is CloudEx, a stationary installation designed for keeping a boiler clean. (Fig 4).

Special application of HRSG deep cleaning was also highlighted by Bürgin for two projects in Italy. One installation was a syn-gas-fueled 166 MW gas turbine, horizontal flow HRSG and 115 MW steam turbine. The project purpose was reduced backpressure and increased plant efficiency. The other was a 262 MW gas turbine, horizontal flow HRSG and 122 MW steam turbine, with similar goals and positive results.

### Duct burners

A new short-flame-length, self-supporting duct burner design was presented as a retrofit option for older HRSGs and a design advancement for new builds.

Scott Baumann, Thermic Systems, introduced the new *Gemini tandem duct burner* design featuring compact flames (50 percent shorter) to eliminate flame impingement on

tubes and liners. These burners showed a 2.4 m flame length as opposed to the original 5.5 m length. Gemini burners and baffles had been installed on a unit and after 16 months run time there were no signs of side wall impingement (Fig 5).

Baumann discussed other innovations including an HRSG intelligent recirculation system to reduce dew point, innovations for rethinking dilution air thermal energy, optimizing ammonia vaporization, and examples of an induced-flow heat exchanger.

Bill Kitterman, SVI Bremco, offered two distinct projects for *HRSG duct burner replacement*.

One case was a Frame 5 modification from vertically fired to horizontally fired, including gas piping and controls.

He first showed the existing vertical system and existing piping system. Explaining access points, Kitterman then showed the horizontal arrangement during construction.

Next was a 7FA HRSG retrofit involving runner replacement (Fig 6) as well as small piping (ignitor, etc.). The unit had also suffered severe liner damage.

Scope included removing existing burner runners and header and modifying support sleeves.

New burners were then installed, piping was replaced, and new liners were secured (Fig 7).

The project was completed in 14 days (28



**3. Internal access tool deployed in header, modular carriage aligned to push RFET probes up individual tubes**



**4. Stationary cleaning system CloudEx™**

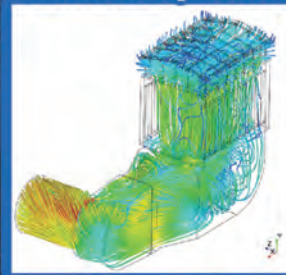


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shifts).

### Cycle chemistry

Barry Dooley presented global chemistry benchmarking results and the latest IAPWS guidance. New data show:

- 86% of plants lack effective corrosion product monitoring.
- 80% operate with substandard instrumentation.
- 78% do not monitor drum carryover.
- 73% do not question legacy chemistry practices.

A new IAPWS decay map and corrosion product monitoring procedure now allow operators to evaluate the effectiveness of chemistry during operation and shutdown.

For more on this, see <https://www.ccg-online.com/cycle-chemistry-corrosion-monitoring-in-flexible-and-fast-starting-plants/>

Updates on film-forming substances (FFS) noted some key status items:

- Documented reductions in corrosion product transport in water-touched circuits.
- Limited or questionable protection in steam circuits.
- Risk of under-deposit corrosion and “gunk” formation when pre-application steps are skipped.
- Reports of increased HP evaporator fouling and deposit load when FFS are misapplied.

Attendees also received updates on IAPWS Technical Guidance Documents (TGDs) for combined-cycle plants.

Kenneth Hutchinson, GE Vernova, presented *Water chemistry: GE Vernova's once-through HRSG vs. drum HRSG*. He first

walked through features of the two designs, noting the same arrangement but without the HP drum for the once-through unit.

This led to a detailed discussion comparing the HP steam purity of GEV's once-through and drum HRSGs during startup and continuous operation, and methods of controlling HP steam purity.

He offered a case study of various operating plants during the first decade of commercial operation. Details of startup and long-term operating reliability were reviewed.

His conclusions:

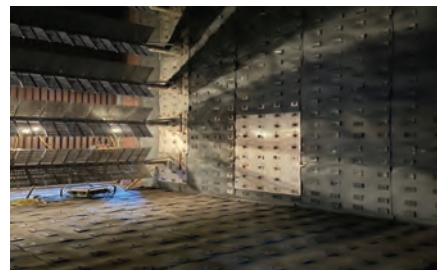
1. Steam purity – both drum and once-through HRSGs have comparable performance and consistently achieve degassed cation conductivity (DCC) values below 0.2 µS/cm.
2. Startup performance – DCC decay time during startup is within specifications for both HRSG types.



5. No sidewall impingement after 16 months, Gemini duct burners



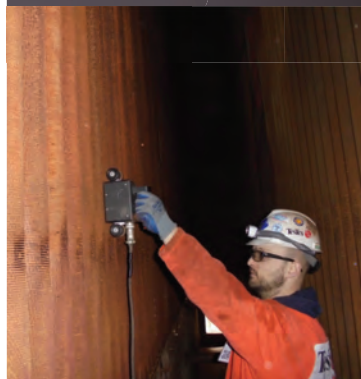
6. Failed duct burner



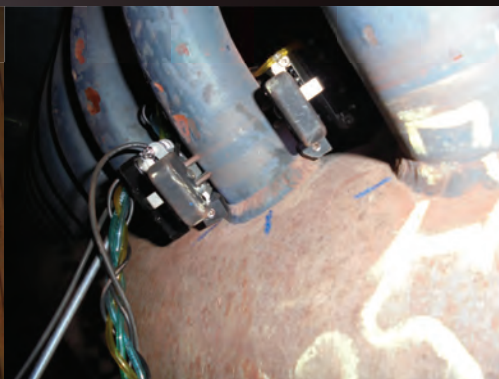
7. New duct burners, liners and access door



Keeping your HRSG in running order is your business.  
Finding better ways to inspect them so they stay in running order is ours.



Through Fin Tube  
Scanning for Wall Thinning



Tube to Header Weld  
Examination for Cracking



Internal Inspection,  
Collecting Tube Video  
& Measuring Wall Loss



Better Tools,  
Better Inspections,  
Better make it TesTex



3. Operational efficiency – The enhancements done on plants for limiting impurity ingress during operation and standstill maintain healthy chemistry for both start-up and long-term operations.

For more on this, see <https://www.ccgj-online.com/selecting-a-new-hrsg/>

### Transients, layup risks, and valves

Thermal transients continue to drive operational issues. The latest data, based on Bob Anderson's thermal transient surveys of 73 CCGT plants worldwide, shows:

- 85% of plants experience leaking spray water at attemperators.
- 92% use valve logic that encourages leaks.
- 37% report overspray, 30% allow manual control, and just 20% routinely inspect attemperators.
- Only 38 to 40% effectively drain the HPSH/RH during startup.

Two HRSG layup failure scenarios were

flagged for potential safety impact:

1. Leaking or open cold/hot reheat isolation valves, intermediate-pressure superheater (IPSH), or leaking high-pressure bypass pressure control valve on a non-operating HRSG during 2×1 operation can allow steam from the operating unit, IPSH, or HP drum to enter and flood the reheater. If undetected, this condition may lead to water hammer or even steam turbine water induction during restart. Installing an alarm to detect positive pressure in a non-operating reheater can provide critical early warning.
2. During hot layup, normal condensation in the high-pressure superheater (HPSH) can accumulate at the bottom of certain harps, forming a loop seal. This trapped water can migrate upward into hot headers and pipework, posing a risk during startup if not properly drained. A differential pressure alarm between the HPSH outlet and HP drum can help detect this condition and prevent damage.

Valve-specific sessions covered high-temperature gate, globe, and check valves, of main steam stops, bypass pressure control valve selection, and the benefits of combination stop/check valves.

Paolo Tomaini, OMB Valves, Italy, discussed *How to specify reliable gate, globe and check valves for 1050F and above (P91 and P92 steam lines)*.

He began with the impact of valve failures:

- Reduced heat rate due to steam leaking.
- Longer startup due to leaking or improper open/close functions.
- Increased maintenance requirements to monitor and repair.
- Forced shutdowns due to safety-related issues on pressure containment.
- Financial loss due to poor performance and reduced plant availability.

Tomaini covered key features and benefits of gate valves, globe valves, check valves (swing and tilting), material selection, and hard-facing issues which are becoming more prominent.

His conclusions included the importance of properly specifying valve features and designs, proper material selection, and reliance on suppliers with proven expertise.

### Penetration seals

Jake Waterhouse, Dekomte (UK), focused on how penetration seals and GT exhaust joints can be specified and installed for high-cycling service common at CCGT plants. The target is gas tightness, stable metal temperatures, and predictable life under frequent starts and load swings.

- Cycling classes were shown from base-load to very high cycling, with design validation using transient temperature data and analysis. Field experience indicates low fatigue usage when frames are kept at even temperature and internal flow shields calm the hot gas stream.
- Typical leaf flex seals struggle in cycling



8. Combination side wall penetration  
seal for cyclic duty



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duty. Foil layers can crease, crack, and leak, and the many small parts complicate maintenance near sensitive equipment.

- Replacement concept: formed multi-layer fabric with PTFE membranes, insulated frames, and internal flow shields. The package is aimed at reducing leakage, lowering casing temperature, and shortening outage time.
- For HRSG side wall penetrations, split steel collars and fabric bolsters allow replacement without post-weld heat treat-

ment. This supports fast installs during short cycling outages and simpler future maintenance (Fig 8).

In practice, cyclic service drives larger relative movements and thermal gradients at side wall nozzles. A combination approach was highlighted: renew casing insulation, cap and shield the liner around the nozzle, and use a staggered fabric penetration seal to limit gas circulation inside the seal cavity. Early surveys at a reference site showed low fabric and casing temperatures after one year of cycling.

Operator notes for cycling fleets:

- Trigger a retrofit plan when there are persistent gas leaks, paint discoloration or hot spots at penetrations, frequent repacking, or degraded insulation.
- During the outage, specify internal flow shields, confirm insulation details around the nozzle, and use bolted collars where feasible.
- After return to service, trend start counts and verify low frame and casing temperatures, then plan a mid-life inspection of fabric layers and pillows at about five years for high-cycling units.

### Drains

Sergio Gómez, Bahía de Bizkaia Electricidad (BBE), Spain, addressed *Problems and solutions in economizer drains*. BBE is an independent power plant operational since 2003, near Bilbao. This 800 MW plant fea-

tures two GE 9FA+3 type gas turbines and one D11 type steam turbine. The plant is now experiencing fewer operating hours and more starts annually.

The two HRSGs are Nooter/Eriksen design manufactured by Babcock Wilcox Española.

In a case study, water below the boiler was difficult to trace. The leak was in a drain tube of the HP economizer, in the area enclosed by the expansion bellow (Fig 9).

The solution is shown in Fig 10.

### Lifetime assessment

Tom Popov, Wien Energie, Austria, presented *Lifetime extension of combined heat and power plants by performing life assessments*.

He discussed a natural gas/oil fired Benson unit commissioned in 1992, with planned end of life in 2030. This plant is operated primarily during the cold season to supply Vienna's district heating.

Popov focused on plant operator experiences with lifetime assessments (LTA) to extend plant operating life. Program features included long-term employees with plant knowledge, careful review of plant documentation and history, and risk-based classification of plant subsystems based on plant availability and safety. These factors were used to set priorities for any required actions.

Lifetime assessment (LTA) was used to obtain "more profound knowledge of the



9. HP economizer drain tube leak





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condition of key components for which the already accessible information was not sufficient.”

“Some previous inspections,” he added, “did not provide a full picture of the conditions.”

The plant took a “practical rather than theoretical LTA approach,” he explained. Key elements included:

- Thorough non-destructive examination of the boiler.
  - Visual and remote visual inspections.
  - Wet fluorescent magnetic testing.
  - Replica examination.
  - Hardness testing.
  - Creep or fatigue calculations were not included.

- Consideration of historical operating and service data.

LTA execution was within a tight framework of five weeks.

Results showed that despite operational changes (decreasing operating hours), life-time extension beyond the initially planned end of life is possible. “Use of auxiliary steam will be used to keep the boiler under slight overpressure during standstill hours,” he stated.

### Rounding it out

Throughout this event, details and in-depth discussions on thermal transients and water chemistry issues were led by Bob Anderson and Barry Dooley.

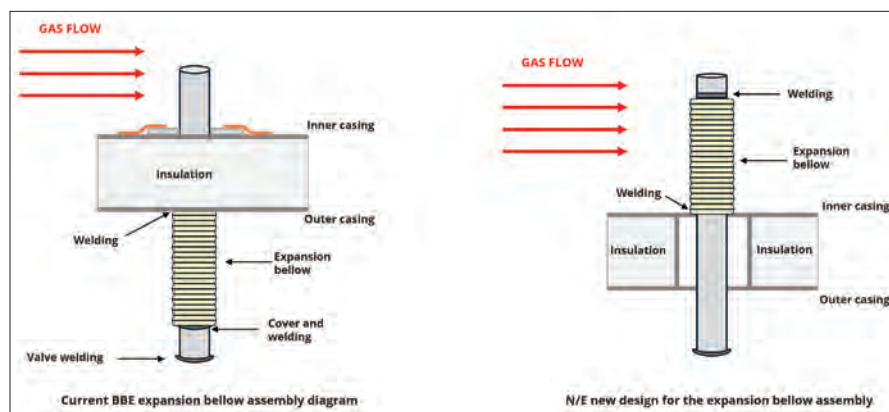
Specific presentations not named above are listed below:

- HRSG tube failure reduction program, Stan Rosinski, EPRI (US).
- Gas turbine SCR in a changing world, Karolyn Hagan, Cormetech (US).
- Re-life on main steam stop valve, Graham Murray, Altrad Babcock (UK).
- Specifying replacement bypass valves, Ory Selzer, IMI-CCI (US).
- Innovative bypass systems, Pascal Ebbeler, NEM Energy (Germany).
- Persta combined stop check valve, Khalid Achbari, Advanced Valve Solutions (The Netherlands).
- Importance of reheater isolation and avoiding HPSH loop seal formation during layup, Anderson.

To close out the successful technical sessions, a conference dinner, hosted by Precision Ice Blast, was held at Conservatorio San Niccolò in the heart of Prato, offering delegates a scenic venue for informal exchange.

### Looking ahead

The twelfth European HRSG Forum (EHF2026) will return to Prato, May 19–21, 2026. For information, contact Barry Dooley (bdooley@structint.com / bdooley@IAPWS.org) or Bob Anderson (anderson@competitivepower.us). Additional updates will be posted at [www.europeanhrsgforum.com](http://www.europeanhrsgforum.com). CCI



### 10. New expansion bellow design

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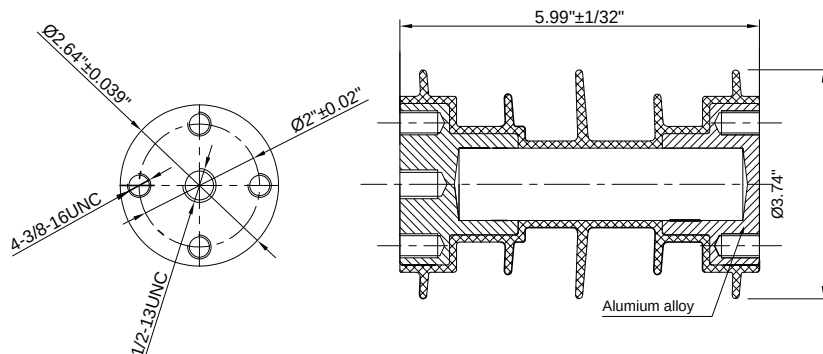


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| BIL rating.....                          | 95kV       |
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| Specified cantilever load.....           | 2000lbs    |
| Specified tensile load.....              | 9000 lbs   |
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| Torsion strength.....                    | 2900in-lbs |
| Min creepage distance.....               | 11.8inch   |
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# Target repeat chemistry mistakes to stop HRSG and steam-turbine damage



The International Association for the Properties of Water and Steam (IAPWS) opened its Power Cycle Chemistry (PCC) webinar series with Dr. Barry Dooley outlining how repeat cycle chemistry situations (RCCS) drive the majority of chemistry-influenced failures in fossil and combined-cycle/HRSG fleets. The message was direct: failures are patterned, measurable, and preventable when plants adopt current IAPWS Technical Guidance Documents (TGDs) instead of allowing RCCS to continue.

## RCCS in the field

RCCS are recurring gaps in monitoring, controls, and procedures. Typical examples include unknown or excessive corrosion-product transport, high HP evaporator deposits, carryover above action levels, insufficient on-line instrumentation and/or reliance on grab samples, outdated treatment philosophies and guidelines, and lack of shutdown protection. Evidence of failures/

damage indicates that plants operating with two or more RCCS are far more likely to suffer tube failures, FAC, and/or PTZ steam turbine damage.

## High-risk mechanisms

Under-deposit corrosion (hydrogen damage). When corrosion products accumulate in HRSG HP evaporators, contaminants (often chloride) concentrate beneath deposits and initiate hydrogen damage, producing brittle tube failures. Control requires measuring total feedwater iron, trending HP evaporator deposition, and scheduling cleaning before “reaction products” appear at the deposit base. The IAPWS Technical Guidance Documents TGD6-13 (Corrosion Products) and TGD7-16 (Internal Deposits) address all aspects of these corrosion mechanisms and thus prevent failure.

Flow-accelerated corrosion (FAC). Still the leading HRSG failure mechanism and a safety issue in fossil feedwater lines. It is necessary to differentiate single-phase from

two-phase FAC as they are controlled by different cycle chemistries. Apply AVT(O) or OT for single-phase locations, raise pH<sub>25</sub> (to ~9.6–9.8 as needed) for two-phase zones, and verify that the levels of total iron are in agreement with the IAPWS achievable guidance values (TGD6-13 (Corrosion Products)). Avoid reducing agents in HRSG service.

Steam-turbine PTZ pitting, SCC, and corrosion-fatigue. Failures initiate at pits formed during moist layups, not because of steady-state steam purity. Protect LP turbine sections with dehumidified air (DHA) applied before ~72 hours of shutdown. Instrument for steam purity, measure drum carryover, and avoid attemperation during contamination events. The IAPWS Guidance addresses all aspects of these corrosion mechanisms and thus prevent failure (TGD5-13 (Steam Purity) and TGD1-08 (Carryover)).

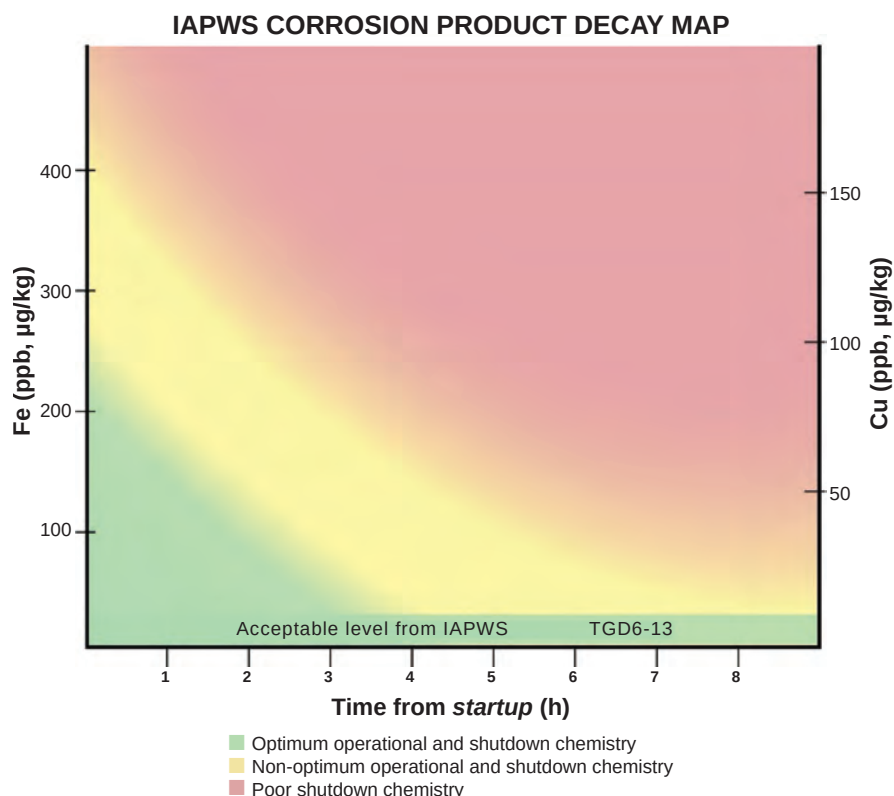
## New tools

*IAPWS Decay Map for startups.* For fast-start/frequently started units, plot the start-up iron-decay profile (using a proxy technique such as turbidity correlated to total Fe) and overlay the profile on the IAPWS Decay Map. Profiles in the “Green” area of the decay map indicate optimized operation and layup; profiles in the “red/yellow” area indicate high iron transport into boilers and possible elevated internal deposit levels which can initiate UDC (under-deposit corrosion). The white paper details procedures and use cases including ACC fleets and FFS verification.

*IAPWS Deposit Map for HP evaporators.* Remove lead-tube samples (initially within the first ~20,000 operating hours) and place measured deposit loading on the map to determine cleaning need. Red-zone results indicate an RCCS and elevated UDC risk. A strong warning for use of a film-forming substance (FFS) indicated that an FFS should not be applied with heavy deposits in the red area of the deposit map. The IAPWS FFS Guidance (TGD11-19) suggests that deposits are characterized before application of an FFS (Section 8 review).

## Immediate actions

■ Download and implement the relevant freely available IAPWS documents at [www.iapws.org](http://www.iapws.org): Corrosion Products, HRSG HP Evaporator Deposits, Steam Purity, Instrumentation, Volatile Treatments, PT/CT, Carryover, FFS and the



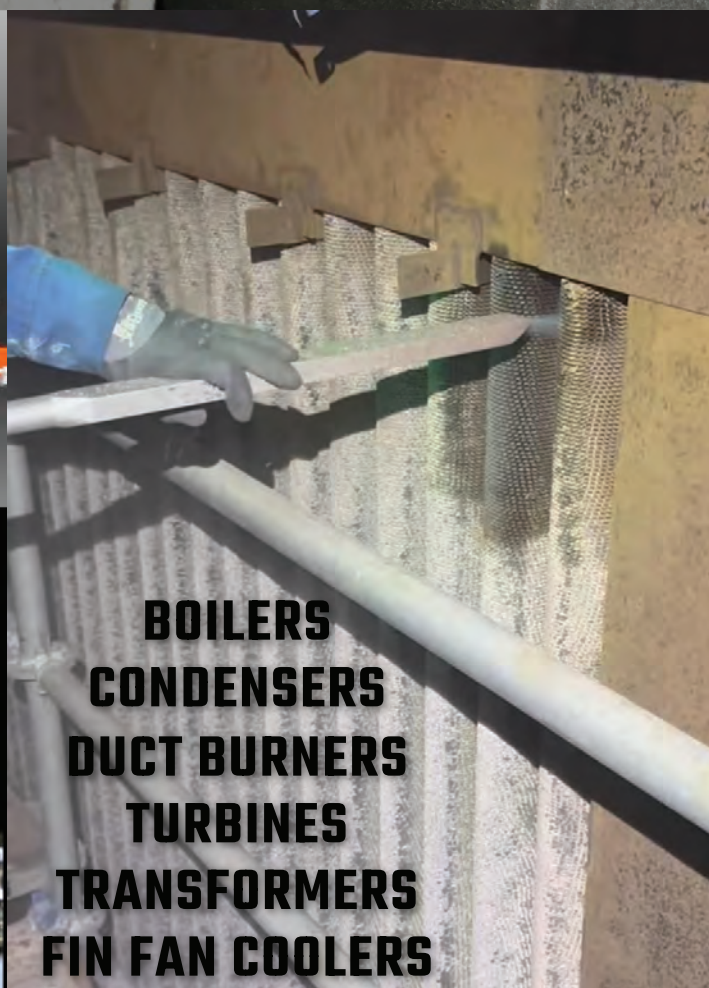
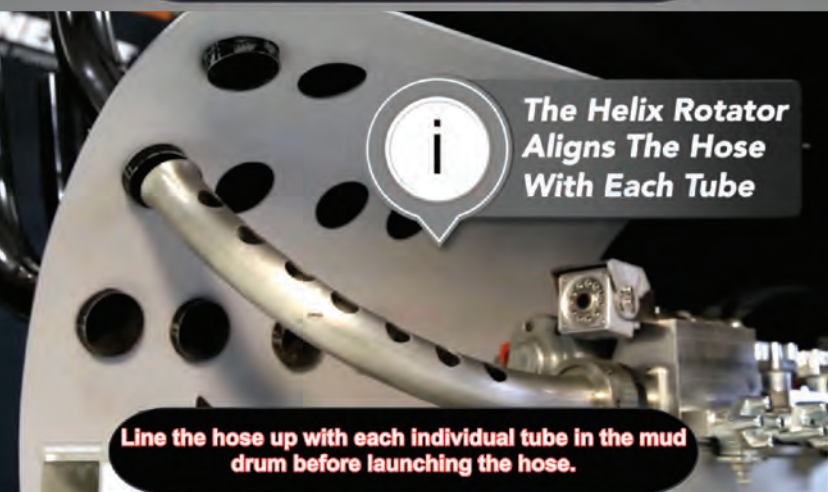
1. IAPWS Decay Map with startup iron-decay profile; green region indicates optimized operation and layup



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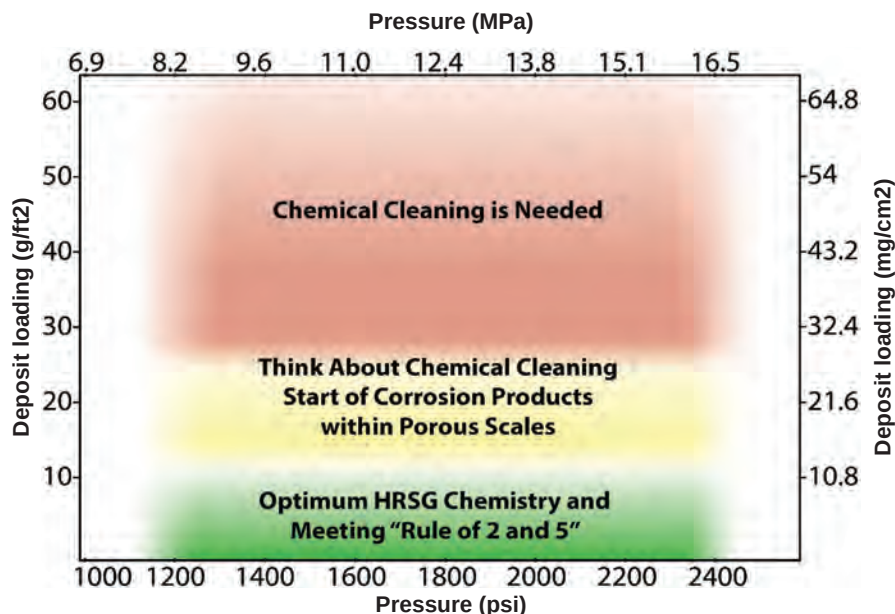


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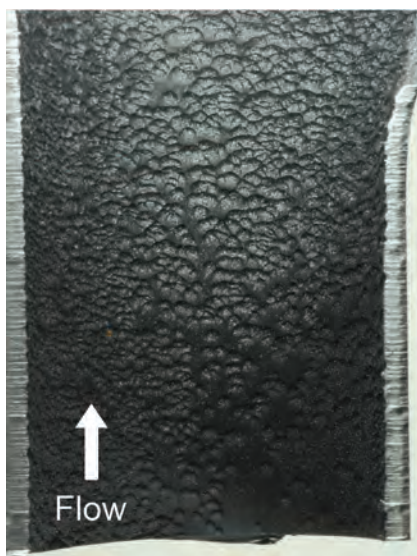
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## IAPWS DEPOSITION MAP FOR HRSG HP EVAPORATORS



2. IAPWS Deposit Map for HRSG HP evaporators; red-zone deposit loadings indicate RCCS and cleaning need



3. Single-phase FAC example (left) at HP economizer inlet showing chevron/horse-shoe attack in the flow direction. Shallow, dark "dimple" morphology indicates two-phase FAC attack in LP evaporator tubing (right)

## NUGGETS TO REMEMBER

With IAPWS PCC Chair David Addison moderating and Dooley presenting, the large global virtual audience drove a candid, robust information exchange. Highlights follow:

- **HP evaporator sampling for internal deposits.** First sample within ~20,000 hours; lead tube near outlet on horizontal-gas-path HRSGs. Interval thereafter depends on findings.
- **Iron measurement.** Always digest samples; spectrophotometer without digestion measures only a small fraction of total Fe. Millipore Filters don't provide sufficient accuracy. Establish proxy correlation (turbidity <-> Fe) and Decay Map.
- **OT oxygen levels.** No strict "upper limit" is required in once-through service; for all units a focus on achieving very low total Fe at economizer inlet is needed. Watch cation conductivity.
- **P drum pH anomalies.** Verify calibration, chemical identity, dose point, and mixing. Instrument issues and incorrect line-ups are common causes.
- **FAC control.** Don't rely on oxygen addition to solve two-phase FAC; increase pH and verify by iron trending. Identify the FAC type by surface morphology before addressing any chemistry changes.
- **FFS use.** Perform a Section 8 deposit review first (this is in FFS guidance document); avoid adding FFS to heavily deposited HP evaporators.
- **LP turbine layup.** Apply DHA before ~3 days of downtime; shutdown chemistry matters as much as operating chemistry.

January 2025 white paper on startup iron decay.

- Trend total Fe and use the Decay Map to tune startup and layup; improvements are when the profiles move into the green area with procedure and chemistry changes.
- Inspect deposits with the IAPWS Deposit Map, schedule cleaning on evidence, and verify results with post-clean Fe trending.
- Close instrumentation gaps (alarm-enabled, online) and set action/shutdown

levels aligned to IAPWS guidance.

- Eliminate reducing agents in HRSG service; raise pH for two-phase FAC zones; stop attenuation during contamination.
- Standardize DHA for LP turbine sections; treat shutdowns as critical chemistry events.

## Final word

The full webinar recording is posted on the IAPWS website. View to see example Decay Map overlays, deposit/reaction-product mi-

crographs, and FAC morphology side-by-side (Fig 3), useful visuals when educating station leadership and maintenance teams.

RCCS are measurable, repeatable, and correctable. Plants that adopt the TGDs, instrument to alarmed standards, verify with iron-decay and deposit maps, and protect turbines during shutdowns cut forced-outage risk while stabilizing heat-rate and component life. The discipline is the work. All the IAPWS guidance documents referenced are freely available at [www.iapws.org](http://www.iapws.org). [CCI](#)



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# SAVE THE DATE



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# Automated hydrogen purge cuts outage time, boosts safety

Hydrogen remains the cooling medium of choice for large turbine generators because of its superior heat-transfer efficiency and low windage losses. Yet that same efficiency creates a narrow safety margin. During outages or emergencies, operators must replace hydrogen with carbon dioxide and, if necessary, with air before personnel can enter the generator enclosure.

Each transition introduces risk when done manually. Differences in operator skill, changing plant layouts, or equipment condition can create delays and, in worst cases, unsafe sequencing.

A recent CCJ webinar, “Automating Hydrogen Purge to Maximize Power Plant Safety,” presented by E/One and J3 Engineering & Construction, described a system that eliminates much of this variability. For those looking for greater details, scanning the QR code will get you access to both the recording and slides.

The session, presented by Mark Williams and Jason Justice, outlined an operator-initiated purge system designed to execute an interlocked, validated sequence directly from the control room. The concept is simple but powerful: the same steps, the same checks, and the same confirmation of success every time, regardless of who is on shift.

## NOT FULLY AUTOMATIC

Williams emphasized that the purge begins only when the operator commands it. The human still decides whether to conduct

maintenance or an emergency purge. Once initiated, the system performs a controlled sequence that closes hydrogen supply valves, opens vents, admits CO<sub>2</sub>, and verifies purity and flow conditions. The goal is to preserve operator judgment while automating the mechanical execution, ensuring the purge happens quickly and safely even under pressure.

Operators can select among several modes: hydrogen-to-CO<sub>2</sub>, CO<sub>2</sub>-to-hydrogen, or a full emergency purge. Each mode uses logic permissive tied to generator pressure, seal-oil differential pressure, gas concentration readings, and turning-gear speed. These built-in safeguards prevent premature transitions that could lead to static discharge or incomplete gas removal.

## STANDARDIZING A BEST PRACTICE

Many generating stations still rely on legacy procedures that vary by technician. Inconsistent training, aging manifolds, and missing instrumentation often produce purge cycles lasting from six to sixteen hours.

Bottled CO<sub>2</sub> gas feed frequently freezes during the CO<sub>2</sub> purge process, vent analyzers fail to verify the amount of CO<sub>2</sub> that has flowed to the generator, and only a handful of staff know the full sequence. The system targets these deficiencies by creating a standardized approach that can be replicated across multiple plants.

The program’s priorities are straightforward:

- **Repeatability.** Every purge follows the same defined steps and timing.
- **Verification.** Continuous feedback from analyzers and flow transmitters confirms real gas movement.
- **Isolation.** Two motor-operated valves (MOVs) close the hydrogen line before venting pressure down and the admission of CO<sub>2</sub>.
- **Ergonomics.** Purges are executed safely from the control room, minimizing field exposure while keeping manual backup available.

## HARDWARE AND INTEGRATION

The automation package centers on three main elements: an upgraded gas-handling manifold, a non-powered CO<sub>2</sub> vaporizer, and software integration within the existing plant control system. The manifold includes MOV hydrogen shutoff valves with feed-

back, dedicated CO<sub>2</sub> supply and vent MOVs for top and bottom headers, and a pair of solenoids that direct analyzer samples from either header (Fig 1).

Dual explosion-proof analyzers measure hydrogen, carbon dioxide, and air concentrations with remote range-change capability. The operator can switch measurement ranges from the control room without accessing the analyzer cabinet. A differential-pressure transmitter verifies that the analyzer is sampling live flow rather than a stagnant pocket of gas. CO<sub>2</sub> flow meters and totalizers record the actual amount used, helping plants confirm the purge was completed.

Integration is designed for major distributed control systems such as GEV Mark VIe, Ovation, and Siemens T3000. This eliminates the need for an auxiliary PLC and allows purge records, alarms, and analyzer data to be stored in the plant historian for future audits.

## FROM BLANKET FLOW TO PRESSURE-PURGE

The system replaces the old “blanket purge” method, in which operators slowly bled gas through the generator to avoid freezing, with a pressure-purge cycle that is faster and more effective. The process involves several pressurization and venting steps:

1. Close hydrogen valves.
2. Vent the generator to approximately 10 psig.
3. Admit CO<sub>2</sub> to raise internal pressure to roughly 28 psig.
4. Vent again from the upper header to expel displaced hydrogen.
5. This sequence repeats three times; a fourth cycle can be initiated if the operator is not satisfied with the purge or if the analyzer readings show an incomplete purge.

Each step is timed and interlocked. The control system records case pressure, flow, purity, and analyzer DP readings. Operators can view both turbine-end and collector-end analyzer outputs reading from the top or bottom header pipes based on the gas that is being read to confirm full displacement before declaring completion.

## SOLVING THE CO<sub>2</sub> BOTTLENECK

The bottleneck in many purges is CO<sub>2</sub> delivery. When gas is drawn from the top of



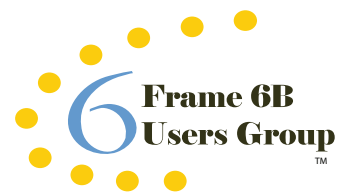
**1. Operator-initiated purge enhancements.** Remote range-change analyzers, MOV isolation, and interlocked sequencing replace variable manual steps with a verified process



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storage cylinders, the temperature drops, forming dry ice and choking flow. E/One's solution uses liquid-withdrawal cylinders or micro-bulk storage combined with a passive vaporizer that converts liquid CO<sub>2</sub> into gas using ambient heat. This approach provides stable flow of 6-7k standard cubic feet per hour at 50 to 65 psig without requiring electrical power.

Because the vaporizer is non-powered, it continues operating during a total station blackout. The only component that must remain energized is the flow totalizer, which can be tied to the plant's uninterruptible power supply. (Fig 2).

The design not only prevents dry-ice formation but also reduces CO<sub>2</sub> consumption by roughly thirty percent, saving cost and shortening purge time to as little as one to two hours.

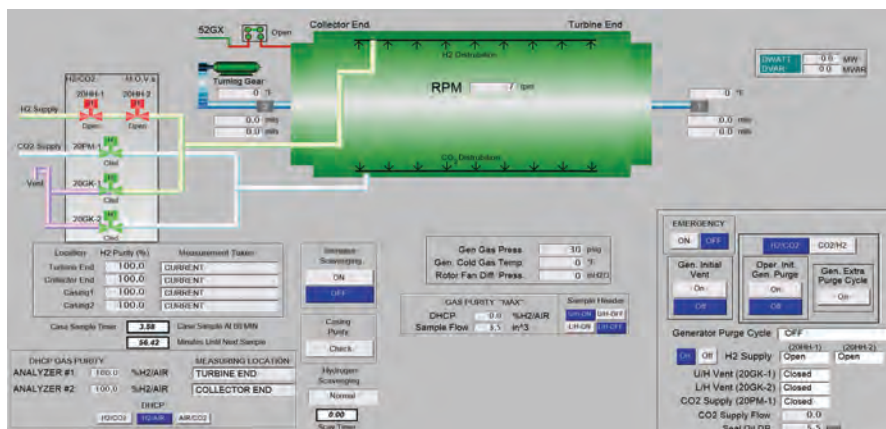
### IN THE CONTROL ROOM

Justice, a seasoned controls expert, walked the audience through a series of simulations for each purge modality. The operator interface consolidates all purge information onto a single screen. It displays hydrogen purity for both ends of the generator, MOV positions, analyzer-flow DP, seal-oil DP, generator case pressure, and CO<sub>2</sub> flow totals (Fig 3).

In maintenance mode, the logic pauses the sequence if seal-oil DP falls too low, allowing operators to correct oil-system conditions before continuing.

In emergency mode, the system prioritizes hydrogen removal and finishes by holding the generator pressure to about ten psig with CO<sub>2</sub> to maintain seal oil system integrity preventing seal oil back flow into the generator.

Manual valves remain in place for contingency. If an MOV fails or loses power, operators can complete the purge by hand. MOVs are designed to fail in position to prevent unintended motion during outages.



**3. 7FH2 tie-ins and HMI.** Dual hydrogen shutoff MOVs, upper and lower vent control, CO<sub>2</sub> supply MOV, and analyzer flow verification displayed on the control-room interface

### SAFETY LOGIC AND FAIL BEHAVIORS

Safety functions are embedded throughout the sequence. The control logic requires verified closure of both hydrogen isolation valves before any venting or CO<sub>2</sub> introduction. Analyzer ranges shift automatically to the appropriate gas pair, preventing operators from viewing misleading values.

Analyzer DP transmitter ensures that purity readings reflect actual flow across the analyzer cell. During an emergency purge timing safeguards guarantee that CO<sub>2</sub> flows for a minimum period with acceptable purity readings before the system ends the emergency purge.

In a total power loss, the vaporizer continues functioning, and the analyzers and





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MOVs can operate on UPS power long enough to complete a safe purge. Plants may also add conditional logic to initiate purging



## 2. Non-powered CO2 vaporization.

Liquid withdrawal and ambient vaporization prevent dry-ice formation for efficient purge cycles

automatically if seal-oil DP collapses during a blackout.

### IMPLEMENTATION STEPS

For facilities evaluating automation, the presenters recommended the following actions:

- Survey existing manifolds, hoses, and regulators, and replace outdated hardware
- Review P&IDs to identify tie-in points for hydrogen, CO2, vent lines, top header, and bottom header
- Determine generator case volume to calculate proper CO2 gas flow rates and volumes
- Verify analyzer condition and upgrade analyzers with remote range change capability
- Size an ambient vaporizer rated for local climate conditions
- Integrate the new sequence within the main DCS and historian rather than a separate controller
- Train operators on the purge HMI and conduct dry runs before field deployment

### THE BENEFITS

Plants that have implemented the operator-initiated purge report shorter purge durations, reduced CO2 consumption, and improved procedural consistency. The ability to conduct the entire operation from the control room eliminates the need to send staff into harms way during storms or equip-

ment emergencies.

Automation also allows logging and a verifiable record of each step, reinforcing the safety culture expected in modern combined-cycle and fossil-steam plants.

Hydrogen management is an area where discipline pays dividends. A repeatable purge process reduces both risk and uncertainty, providing operators with confidence that hydrogen has been completely removed before maintenance begins.

### WATCH AND SHARE WITH YOUR TEAM

The webinar recording and slide deck (QR code) explain each purge mode in detail and include demonstrations of analyzer range changes, seal-oil protections, and field installations. Operations, I&C, and safety departments are encouraged to review the recording together and discuss how similar improvements could be applied to their own generators.

Williams and Justice concluded that automation does not replace skilled people; it enables them to perform a critical safety task with consistency and confidence. [CCJ](#)



# **SCHOCK Retrofit Systems**

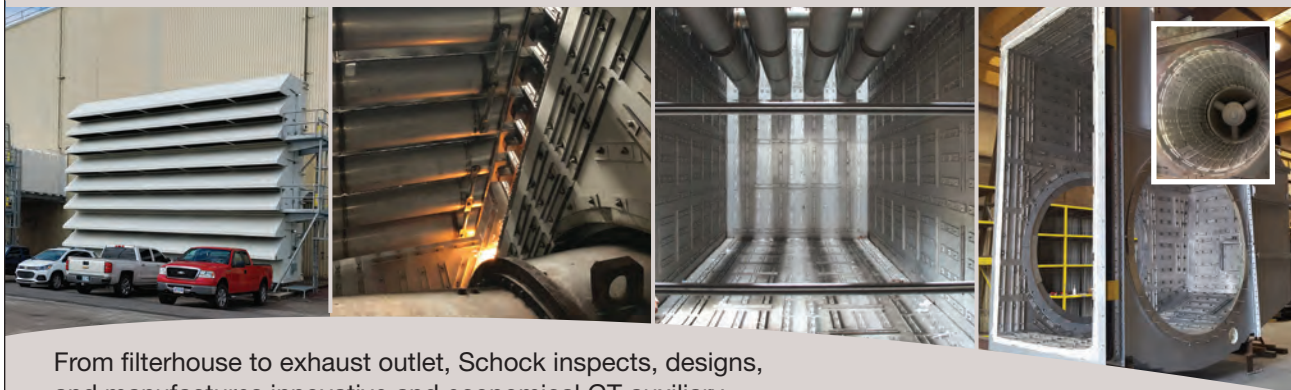
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# LOOKING BACK

at what your colleagues were telling CCJ  
subscribers five, 10, 15, and 20 years ago

## Five years ago



**7F Users Group**

The 7F Users Group and CCJ collaborated on the first virtual user-group meeting conducted as a result of the global pandemic. It was the launchpad for more than 20 online user meetings facilitated by CCJ during that challenging three-year period.



**COMBINED CYCLE USERS GROUP**

The Combined Cycle Users Group (CCUG), a core building block of the Power Users' network of O&M conferences and online forums serving owners and operators of gas turbines, addressed the following at its annual meeting: Damage to main-steam piping and hot-reheat valves, how to identify and mitigate compressor losses, compressor

cleaning alternatives, corrosion under insulation, causes of performance degradation, impacts of drain issues and how to deal with them, SCR and AIG tuning, experience with film-forming substances, and much more.

Results of a comprehensive training program dispelled the notion that coal-plant personnel can't be transformed into multi-skilled combined-cycle operators.

Turbine Logic, EPRI, and ENMAX Energy introduced a novel combustion-dynamics monitoring algorithm and case study to demonstrate the successful detection of a gas-turbine combustor fault which other-





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pH  
**7.2 - 7.5**

Specific Gravity  
**1.01**

Corrosion Inhibitor  
**Yes**

Total Alkali Metals  
After Dilution  
**< 0.5 ppm**



pH  
**8.0 - 8.5**

Specific Gravity  
**1.00**

Corrosion Inhibitor  
**No**

Total Alkali Metals  
After Dilution  
**< 4 ppm**

wise might have done extensive damage to both the combustor and hot-section components.

INTERNATIONAL  
ASSOCIATION  
FOR THE PROPERTIES  
OF WATER & STEAM **IAPWS**

The Power Cycle Chemistry working group of the International Association for the Properties of Water and Steam (IAPWS) announced publication of the following Technical Guidance Documents, available free of charge on the organization's website at [www.iapws.org](http://www.iapws.org):

- "Application of film-forming substances (FFS) in industrial steam generators."
- "Chemistry management in generator cooling water during operation and shut-down."
- "Application of FFS in fossil, combined cycle, and biomass powerplants."
- "Air in-leakage in steam/water cycles."

A combined-cycle conference specific to the needs of Saudi Arabian users was hosted by the Ali A Tamimi Co in Dhahran. The meeting was coordinated by Keck Group International LLC, headed by former GE executives Richard Keck and Bob Johnston.

Depending on your plant's power purchase agreement, adding peak-firing capability to

simple- and/or combined-cycle gas turbines can provide significant economic benefit—provided the peak-fire capability is used strategically at times of high demand to avoid unnecessary maintenance.

**10 years ago**



Western Turbine Users Inc, led by Riverside (Calif) Public Utilities' Generation Manager Chuck Casey, hosted its annual conference and vendor fair in Long Beach to commemorate 25 years of dedicated service to owners and operators of GE aeros (LM2500, LM5000, LM6000, and LMS100).

There was a special tribute to Jim Hinrichs, who retired as president of WTUI in 2008, having directed the organization for 17 years, some of those requiring full body armor in dealings with the OEM. Jim passed a few months before the celebratory meeting.

Among those contributing thousands of hours to assure the organization's success during its first quarter century (and earlier,

before incorporation): Wayne Kawamoto, Mike and Charlene Raaker, Jon Kimble, Mark Axford, Sal DellaVilla, Wayne Fergan, Jack and Gae Dow, Andrew Gundershaug, Brian Hulse, Jimmie Wooten, Frank Oldread, Dave Merritt, Bill Lewis, Steve Johnson, Ed Jackson, Alvin Boyd, Jim Bloomquist, John Baker, Jason King, Perry Leslie, Don Driskill, Bryan Atkisson, and so many others. Apologies to those not mentioned.

CTOTF™ celebrated four decades of service to the industry at its 2015 conference and trade show in Coeur d'Alene, Idaho. The formal affair was a fitting send-off for Wickey and Mike Elmo, who retired after managing the organization's meetings and administrative affairs for 20 years. Their Puritan work ethic, business sense, warmth, and generosity were constants in a prolonged period of disruptive industry change, contributing very significantly to the group's success.

The first 7FA.05 gas turbines began commercial operation at Xcel Energy's Cherokee Generating Station, Denver, which connects to 17 transmission lines. The combined cycle incorporating these two GTs made use of a grey-market D11 GE steam turbine owned by the utility. CCJ editors had the pleasure of visiting site during commissioning.

Allied Power Group's Aaron Frost, a well-re-

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spected metallurgical engineer and hot-parts repairs expert, tells attendees at CTOTF's fall 2015 meeting that commercial realities may complicate 7EA first-stage repair techniques. He warned that some repair shops may be under pricing pressure, potentially affecting repair quality, and electing to fix components multiple times rather than educate the owner and operators on previous (and often substandard) repair methods. Caveat emptor!

Wind effects on the thermal performance of air-cooled condensers and fan reliability draw increased attention worldwide, prompting testing and analysis of alternative wind-screen designs.

High-voltage electrical emerged as a top interest area among gas-turbine users. One reason: The reliability and availability of the basic engine had improved to the point where other plant equipment—such as bus duct—was at least as likely to cause an outage.

Steam-turbine warming blankets grow in popularity as operating experience proves their ability to enable faster starts, and eliminate cold starts altogether, by preventing rotor-stress and differential-expansion issues. ARNOLD Group leads the industry with its products.

GE completes its acquisition of Alstom's power and grid businesses.

Babcock & Wilcox Co publishes the 42nd edition of "Steam/Its Generation and Use," considered by many the world's most authoritative reference on boilers, dating back to 1875. Structural changes to the electric-power industry likely mean there will not be a 43rd edition, at least in the near term. CCJ Consulting Editor Steve Stultz was the editor of both the 41st and 42nd editions and provided guidance on the production of the most recent book, weighing in at eight pounds (3.6 kilos).

## 15 years ago

Clyde Maughan, renowned authority on electric generators, penned his first article for CCJ, "Input from monitoring, inspections, tests critical for maintenance planning," launching an information service specific to the needs of gas-turbine owner/operators that continues to this day (see "Club 99 welcomes Clyde Maughan" elsewhere in this issue).

Capital Power installed the first STIG-equipped LM6000 at EF Oxnard. Designated the LM6000-PC CDP, the machine's HTP first-stage nozzle area, shafts, and coupling

adapter are different from standard Model PC components. The modified engine can replace workhorse LM5000 STIG 120 engines as they are retired.



NV Energy and CTOTF™ conducted a special workshop to help guide the electric power industry in identifying the challenges and unknowns associated with integrating renewables into the generation mix. CTOTF Chair Bob Kirn, then a senior manager at TVA, called for a national forum of stakeholders to address the impacts of "must take" renewables on electric-system operations. Speakers and panelists were among the industry's thought leaders.

The city of Toledo's (Ohio) Bay View combined-cycle cogeneration facility integrated state-of-the-art landfill-, digester-, and natural-gas fuel systems to provide the city waste-management services while producing up to 10 MW of electricity.

The 7F Users Group, led by Chairman Richard Clark of SCE Energy (now with GEV)





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and Sam Graham of Tenaska Virginia Generating Station (now its plant manager) developed what was believed at that time the organization's "best 7F meeting ever." Hot compressor topics included tip cracking of R0 and R1 blades, R0 dovetail cracking, clashing; cracking of piccolo pipes for the inlet-bleed-heat system; erosion attributed to the wash system; pinning of rocking stator vanes; loose shims; blade health monitoring; plus, plus, plus.

The vendor community contributed its expertise on modeling for troubleshooting HRSGs, collector-ring fires, water cooling to improve the reliability of fuel valves, optimization of GT operation, uncooled flame scanners, varnish solutions, PAG alternative to mineral oils, control-valve repairs, etc.



In the months following the 7F Users Group, the framework for Power Users Group was developed as a support system for 7F gas turbine users and quickly grew into a broader network addressing the needs of the entire power generation community.

Over time, the group expanded to include steam turbines, combined-cycle equipment, generators, and more. Today, Power Users supports eleven user groups and hosts industry-leading forums and conferences that promote collaboration, knowledge sharing, and operational excellence across technolo-

gies and fleets.

NV Energy's generation department, led by Kevin Geraghty, and CCJ's editorial staff, collaborated on the launch of the Air-Cooled Condenser Users Group and conducted the new organization's first conference at the utility's headquarters, focusing on steam-cycle chemistry and corrosion, performance issues, design, O&M, fans and gearboxes, and inspection.

## 20 years ago



Bob Anderson, Competitive Power Resources, recognized worldwide for his deep knowledge of heat-recovery steam generators, conducted a special workshop to alert plant owners and operators to challenges regarding the use of P91/T91 material for headers and tubes—including post-weld heat treatment, exposure to temperatures in the inter-critical region post production, control of properties through hardness testing, etc. Today Anderson co-chairs the HRSG Forum with Barry Dooley of Structural Integrity.

7F users focused their attention on compressor tip failures, latter-stage compressor failures, compressor clearances, early flame-outs on shutdown, combustion dynamics, varnish mitigation, gas-valve reliability, hydrogen seal damage, and other issues.

The operational benefits of using JASC water-cooled liquid-fuel check valves in dual-fuel gas turbines were acknowledged based on experience at Valero Energy Corp's Delaware City refinery.

Challenges in the 501F community with TXP controls came across loud and clear.



The dormant Frame 6 Users Group made a positive comeback with financial support from Foster Wheeler Martinez and technical leadership provided by Larry Flashberg of Saguaro Power and Jeff Gillis of Exxon-Mobil. Wickey and Mike Elmo organized the technical meetings and vendor fair.

The first 100,000-hr major inspections of V84.2 gas turbines conducted onsite by plant staff (with OEM oversight) were completed successfully at the Brooklyn Navy Yard cogen facility. Plant Manager Mike Brown shared the details of this landmark project with the industry.

Gas-side corrosion problems in HRSGs, borescope inspections, inspection and maintenance of air-cooled condensers, varnish issues, life management of GT parts, and gear maintenance were other hot topics at this time. [CCJ](#)

# Preempting a full stator rewind



Insights into the value of a proactive approach to planning a full stator rewind to prevent costly failures and extend the operational life of the 7FH2 generator

By Joe Hopfinger, ENTRUST Solutions Group

The GE 7FH2 generator remains one of the most widely deployed machines in gas-fired power generation. Introduced in the mid-1990s, nearly 1,000 units have been placed in service globally, providing a significant share of total installed gas-turbine-driven capacity. The model's long operational history and extensive user base make it a benchmark reference across the industry for large hydrogen-cooled, 60-Hz generator design and reliability.

Today, many utilities operate multiple 7FH2 generators across fleets that include both legacy F-class and newer configurations. As these units approach the three-decade mark, understanding their construction, known fleet issues, and long-term maintenance strategies, particularly stator rewinds, is essential to ensure continued reliable operation.

This article reviews the major design features of the 7FH2 generator stator, outlines common failure mechanisms observed in the fleet, and explains how a properly executed stator rewind can reset the life of this critical component. It also explores the operational and economic implications of deferring such work and offers planning considerations for utilities managing 7FH2 fleets entering mid-life renewal.

## Key stator components

The stator frame of the 7FH2 generator incorporates an integral base that mounts directly to a slab foundation. The gas-tight cylindrical casing, fabricated from welded steel plates, provides both mechanical rigid-

ity and containment for the hydrogen-cooled system. This configuration reduces vibration transmission and contributes to long-term structural stability.

The stator core consists of thin, insulated metal laminations, approximately 0.014 inch thick, stacked circumferentially in an interleaved pattern. Each lamination is coated with an insulating varnish to prevent eddy-current formation and interlaminar electrical contact (Fig 1). The core is typically assembled vertically, beginning at the connection end (CE) and building toward the turbine end (TE), where it is axially compressed via key bars to achieve uniform tightness across the stack (Fig 2). Ventilation ducts are distributed between the core sections to channel hydrogen coolant through the core and around the winding, ensuring efficient heat dissipation during operation.

Within the core, stator slots accommodate the copper armature bars. Each lamination includes open slots for the bars and dovetailed grooves for the wedges that secure them. The stator winding is composed of insulated copper bars transposed using the Roebel method, which ensures each strand alternates through every radial position along the bar. This design equalizes magnetic flux exposure, minimizing circulating current losses under load and promoting thermal balance along the length of the coil.

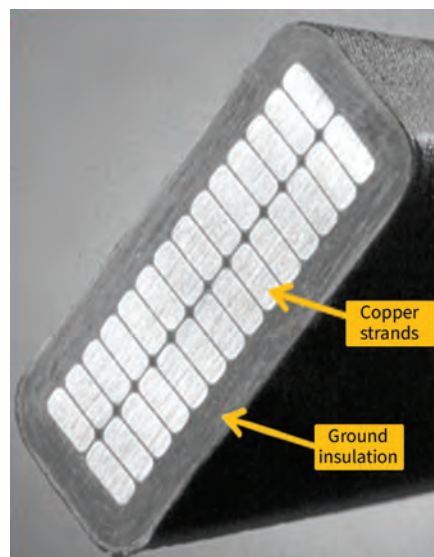
Each stator bar receives a multilayer insulation system forming the "ground wall (Fig 3)." This system typically uses mica tape bonded with a thermosetting epoxy or resin binder. During manufacturing, the bars are placed in a vacuum-pressure impregnation (VPI) tank, where pressure and heat cycles remove volatiles, compact the insulation system, and cure the binder. The result is a dense, void-free dielectric barrier with excellent mechanical strength and thermal endurance (Fig 4). The insulation is rated to maintain dielectric integrity across the full expected temperature range for hydrogen-cooled service.

To reduce abrasion within the stator slot, the bars are wrapped in armoring tape, while voltage-grading coatings extend sev-

eral inches beyond the core to reduce corona discharge. At the end-turn region, the coils are bound by molded fiberglass rings, supported by the stator core flanges and



2. Vertical stacking of stator core iron laminations



3. Stator bar cross-section noting insulated individual strands and ground wall insulation



1. Individual insulated lamination punchings





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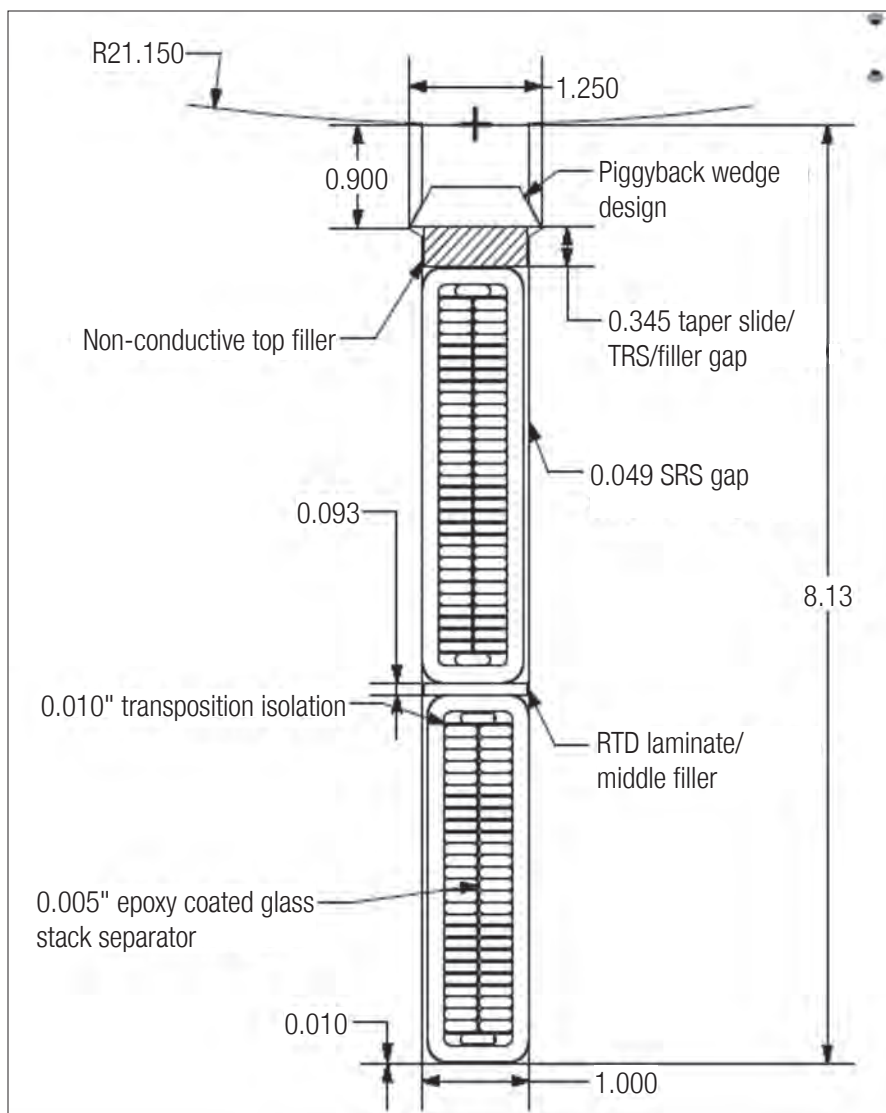
- ◉ Frame 5 Combustion Turbines
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- ◉ 7EA Combustion Turbines
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- ◉ 7HA & 9HA Combustion Turbines
- ◉ Combined-Cycle Users
- ◉ Generators
- ◉ P&W FT4 Gas Turbines
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(moderated by Bob Anderson)
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**4. Typical cross-section view** of stator armature and additional components within stator core

secured with thermosetting resin. Conformable materials are added to evenly distribute mechanical stress, and all components are bonded into a solid structure designed to withstand thermal expansion and electromagnetic forces during operation. Finally, the armature bars are locked into position by wedges driven into the dovetail slots, completing a tightly secured winding assembly (Fig 5).

### Planning for a stator rewind

The expected design life of the 7FH2 stator is approximately 30 to 40 years, at which point a comprehensive stator rewind is generally recommended. A rewind involves complete replacement of the stator windings and insulation system and, in many cases, inspection and rework of the core and frame. Once complete, this process effectively resets the generator's operating life to "as-new" condition.

A full rewind typically requires three

and a half to four weeks to complete once all materials are on hand, though total outage duration can extend if the field requires additional disassembly or repair. Because rewinds depend on the timely availability of key materials, including copper bars, core laminations, and fiberglass components, advance planning is critical. These components often carry manufacturing lead times ranging from several weeks to several months.

With the earliest 7FH2 units from the mid- to late-1990s now approaching 30 years in service, many owners are beginning to plan for these lifecycle overhauls. Proactive scheduling aligns with OEM guidance and ensures adequate time to secure both materials and qualified labor resources. For multi-unit sites, staggered planning also minimizes simultaneous downtime and helps avoid congestion in vendor or OEM production queues.

Failure to plan rewinds in advance can expose utilities to higher risk of forced outag-

es, especially if a stator fault arises unexpectedly. Because the stator is a non-redundant component, meaning there is no backup for its function, a major failure can take a unit out of service for an extended period, directly affecting plant capacity and market participation.

### Common failure modes

Over nearly three decades of operation, several recurring technical issues have been identified across the 7FH2 fleet. While not universal, these patterns are well documented among both OEM and user-maintenance communities.

Typical failure modes include:

- **Stator armature issues.** Vibration-related mechanical wear, thermal distress, fatigue spark erosion, ground faults, loose wedges, insulation dusting or greasing
- **Stator core issues.** Shorted laminations causing local hot spots, back-of-core burning, iron fretting, and in rare cases, melting
- **General assembly issues.** Dry-tie dusting, loose end-winding axial support hardware, core-iron manufacturing inconsistencies, and generator terminal-enclosure weatherization problems leading to moisture ingress

Each of these conditions can degrade reliability or lead to progressive deterioration if not addressed. Many users have adopted enhanced inspection protocols, including wedge-tap testing, partial discharge analysis, and end-winding vibration monitoring, to detect early indicators of insulation or mechanical distress.

Operational profile also strongly influences component aging. Baseload units tend to exhibit thermal aging of insulation systems, whereas cycling or peaking units face more pronounced mechanical fatigue from frequent start-stop transients. Other life-limiting factors include the total number of operating hours, number of starts, load ramp rates, and environmental conditions at the installation site. Understanding how these factors apply to a given machine allows utilities to prioritize maintenance and weigh the timing of a rewind within their broader asset-management plans.

### Risks of deferred maintenance

The consequences of deferring a stator rewind can be significant. Lead times for custom copper bar sets or core iron replacements are typically measured in months, not weeks. Manufacturing slots are limited, and availability can tighten further during peak outage seasons. In the event of an unexpected fault, such as a winding ground failure or inter-turn short, operators may face extended downtime while waiting for replacement materials.

This delay can translate directly into lost-generation revenue and potential contractual penalties for plants operating in ca-



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capacity or reliability markets. Furthermore, emergency rewinds conducted under schedule pressure often come at a higher cost due to expedited shipping and overtime labor.

Routine condition assessments and trending of key indicators such as partial discharge, vibration, and insulation resistance are therefore essential. If results show progressive deterioration, utilities should move from reactive inspection toward proactive corrective planning. Implementing a rewind before the onset of critical failure ensures controlled execution, predictable outage duration, and reduced exposure to secondary damage.

### Resetting generator life cycle

Executing a full stator rewind within the 30- to 40-year window effectively resets the generator stator to a new-life condition. By replacing the winding, insulation, and end-winding support system, the most age-sensitive components are renewed. The process also allows for inspection and, if necessary, refurbishment of the stator core, frame, and ventilation systems.

Utilities that undertake rewinds as part of long-term asset-management programs report improved reliability, reduced forced-outage rates, and enhanced monitoring baselines for future diagnostics. In many cases, rewind stators have been successfully integrated with upgraded auxiliary systems, such as improved hydrogen seals,

ventilation redesigns, or modern insulation coatings, to achieve even better performance than the original configuration.

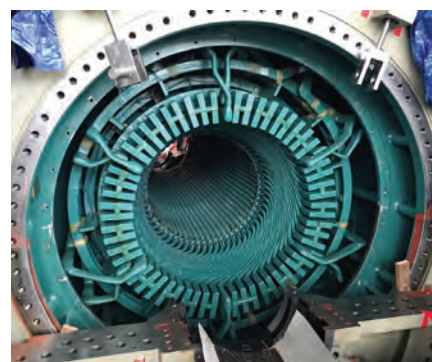
While some operators may elect to run beyond the 30-year target, the probability of in-service faults rises steadily with age. This does not imply an immediate failure at year 31, but the cumulative effects of thermal and mechanical stresses increase the likelihood of insulation breakdown or ground-wall cracking. ENTRUST, which supports multiple utilities with 7FH2 fleet management, recommends using the 30- to 40-year interval as a planning guide rather than a deadline. The intent is to encourage proactive investment before risk curves accelerate sharply upward.

### Final considerations

As with most long-life rotating equipment, the 7FH2 generator's reliability depends on timely maintenance decisions informed by operating history and condition monitoring. For units approaching or exceeding 30 years of service, a preemptive stator rewind offers one of the most effective ways to extend useful life and safeguard operational continuity.

Key takeaways for operators include:

- **Plan early.** Long material lead times demand advance coordination with OEMs or qualified rewind vendors
- **Monitor routinely.** Trending partial discharge, wedge tightness, and end-winding vibration can reveal early warning signs



**5. View from connection end:** Stator armature, connection rings, phase leads, series connections, and stator bore

- **Assess risk realistically.** The cost of a planned rewind is small compared to the potential financial impact of an extended forced outage
- **Align fleet strategy.** Multi-unit owners should consider staggered rewind scheduling to balance outage risk and resource allocation

Performing a stator rewind at the appropriate point in the unit's lifecycle restores the integrity of critical insulation systems, mitigates failure risk, and can extend operational life by another 30 years or more. For the 7FH2 fleet, an essential workhorse of gas power generation, this proactive step represents both sound engineering and business practice. [ccj](#)



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## PREDICTIVE ANALYTICS

# Machine learning for power plant managers



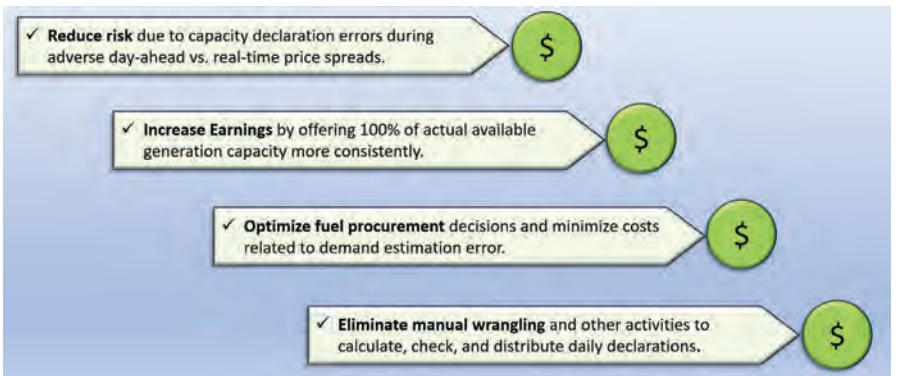
Primex is an established provider of mission-critical information for power plant managers. Stewart Nicholson, the founder, believes Primex's machine learning (ML) technology represents a step-change improvement in timeliness, precision, and confidence over traditional performance information systems. "The service helps managers make better decisions and make them sooner," he concludes.

In their webinar series, Primex shares how plant and operations managers use their ML technology to improve decision-making in power generation use cases. Using real-world examples, benefits are discussed, along with lessons learned and challenges remaining. The firm lists several big owners and operators as customers using their information systems at CCGT facilities.

The first session introduces an ML framework tailored to plant time-series data. Presenters define ML as a set of algorithms that

map inputs, such as ambient conditions and system parameters, to outcomes like output, heat rate, and efficiency. They emphasize that these systems support, not replace, human decisions. Primex organizes use cases into three actions: detect, diagnose, and opti-

mize. Detect identifies persistent deviations from a trained "normal," diagnose traces which predictors drive the deviation, and optimize quantifies how changing controllable setpoints or configurations influences outcomes.



**Machine learning technology** dramatically improves accuracy of generating and fuel demand forecasts



In the **Generation Monitoring and Diagnostics** session, Primex demonstrates process-level and component-level models. Process models track KPIs like plant net output, generator set efficiency, boiler efficiency, and SCR performance, while component models focus on pumps, compressors, motors, or individual instruments for predictive maintenance.

A CCGT case study modeled steam turbine-generator output using weather, CT exhaust conditions, duct-firing energy, and pressures. After training on a normal post-outage period, the model flagged months with 5-10 MW underperformance. Root cause was a hot-reheat bypass leak. The estimated lost revenue before detection was about 250,000, illustrating earlier detection and faster value capture compared to conventional trending.

Hydropower modeling extends the approach using detailed basin weather and topography. Primex integrates hundreds to thousands of weather predictors to compare expected versus actual production. One run-of-river facility produced over 98% of expected MWh in 2022, with peak months within 0-1% of model expectations, confirming a strong fit and practical value for daily operations.

Diagnostics use model internals to correlate anomalous outcomes with likely drivers. In an HRSG efficiency example, ML reduced a large parameter set to a shorter list of the most correlated signals, accelerating on-site investigation. Primex stresses that domain expertise and walkdowns remain essential and that more than half of apparent issues trace to instrumentation faults.

Optimization examples include identifying the single most influential controllable factor on HRSG thermal efficiency, such as reheater outlet steam temperature, and quantifying the gain and decay from offline CT water washes to set optimal wash intervals.

Lessons learned include reducing false anomalies by addressing character drift, extrapolation error, and model complexity. Primex highlights the need to simplify models, ensure data quality, avoid information overload, and tailor outputs to what is actionable for operators. They also note that ML systems have certain operating costs and that realized benefits depend on anomaly frequency and magnitude.

**The third webinar,** Capacity and Fuel Demand Forecasting, applies ML to day-ahead capacity declarations and fuel planning for merchant markets. Primex notes that plants can reduce declaration errors by 50% or more by replacing static correction curves with continuously updated ML models. Because models are retrained daily, routine degradation, maintenance effects, and abnormal changes are quickly incorporated.

Market context matters. Using PJM examples, Primex shows monthly average day-

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### Product Experience Chart

Customer History

| OEM             | Fog Systems Installed | Wet Compression |
|-----------------|-----------------------|-----------------|
| Ansaldo         | 8                     | 4               |
| GE              | 802                   | 220             |
| Hitachi         | 4                     | 1               |
| Kawasaki        | 4                     | 0               |
| Mitsubishi      | 50                    | 7               |
| Mitsubishi Aero | 106                   | 64              |
| Siemens         | 148                   | 64              |
| Solar           | 12                    | 1               |
| Total           | 1134                  | 361             |

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ahead prices of roughly 20-50 per MWh and persistent day-ahead vs real-time spreads averaging 5-26, with monthly maxima often above 100 and sometimes exceeding 500. Accurate declarations mitigate risk when actual delivery differs from day-ahead commitments.

A 2x1 CCGT case illustrates the shift from spreadsheets to ML. With conventional methods, annual declaration error totaled about 23,000 MWh. ML, using more ambient predictors and daily updates, cut error to roughly 10,700 MWh on the same data set. The approach also optimizes weather inputs by blending multiple forecasts to reduce

temperature-forecast error, a primary driver of capacity and heat-rate variance.

Fuel demand forecasting improves in parallel. Instead of a static base-load heat rate, ML predicts heat-rate variation across ambient conditions, typically within about 0.5%, supporting more precise gas nominations and lower imbalance costs.

**How to watch.** Primex has posted recordings for Introduction to Machine Learning and Power Plant Use Cases, Generation Monitoring and Diagnostics, and Capacity and Fuel Demand Forecasting. Scan the QR code or visit [www.primexpreprocess.com](http://www.primexpreprocess.com) for access and additional materials. **CCJ**

# Handling RCAs with future disputes in mind: More is better!

The need to recover quickly from plant equipment failure is often at odds with the patient, methodical steps required to conduct a root cause analysis (RCA) that will be accepted by all parties to a potential dispute among stakeholders down the road. Stakeholders may include plant staff, owner/operator, original equipment manufacturers (OEMs), insurance companies, component suppliers, third-party operation and maintenance (O&M) service providers, etc. Independent experts are often brought in following unanticipated events to assist with remediation efforts and root cause investigations.

At the recent 7F Users Group conference in Birmingham, AL, Dan Getsinger and Blake Whitley of Exponent Inc, a leading failure analysis firm, offered a sampling of best practices for site personnel who are often the “first responders” to an unanticipated event. These practices namely included identifying, collecting, and preserving evidence that will become critical to a successful RCA process.

Evidence, of course, includes more than the “broken stuff.” It can refer to *all the pertinent information* related to an event, the conditions under which it occurred, and historical facts leading up to an event. The preservation of evidence is an important part that enables an effective RCA process.

ASTM standards exist for collecting and handling evidence. Such standards outline processes such as evidence labeling and chain of custody protocols. At the plant level, it is very important to protect evidence from damage from handling, packaging, storing, and shipping.

■ **Tip #1:** Document every movement of evidence material, not just location to location, but including photographs documenting condition prior to and on receipt of transfer. In this case, more documentation is usually better than less.

When it comes to expert analysis of broken components, there is a wealth of information contained at the microscopic level on a fracture surface. This type of evidence will likely become evident only with laboratory analysis and instrumentation (Fig 1), and is susceptible to being obscured or even lost if not handled properly. In addition, “spoliation of evidence” (loss, destruction or alteration of evidence resulting from a party’s failure to preserve) becomes a legal liability.

■ **Tip #2:** Do not try to “fit” fractured surfaces back together, as this can damage or even destroy the microscopic features of interest to experts investigating failure mechanisms.

Broken pieces should be packaged in

ways that avoid surface rubbing, impacts, or environmental exposure which may lead to corrosion, for example. Use gloves when handling evidence and bag all pieces separately.

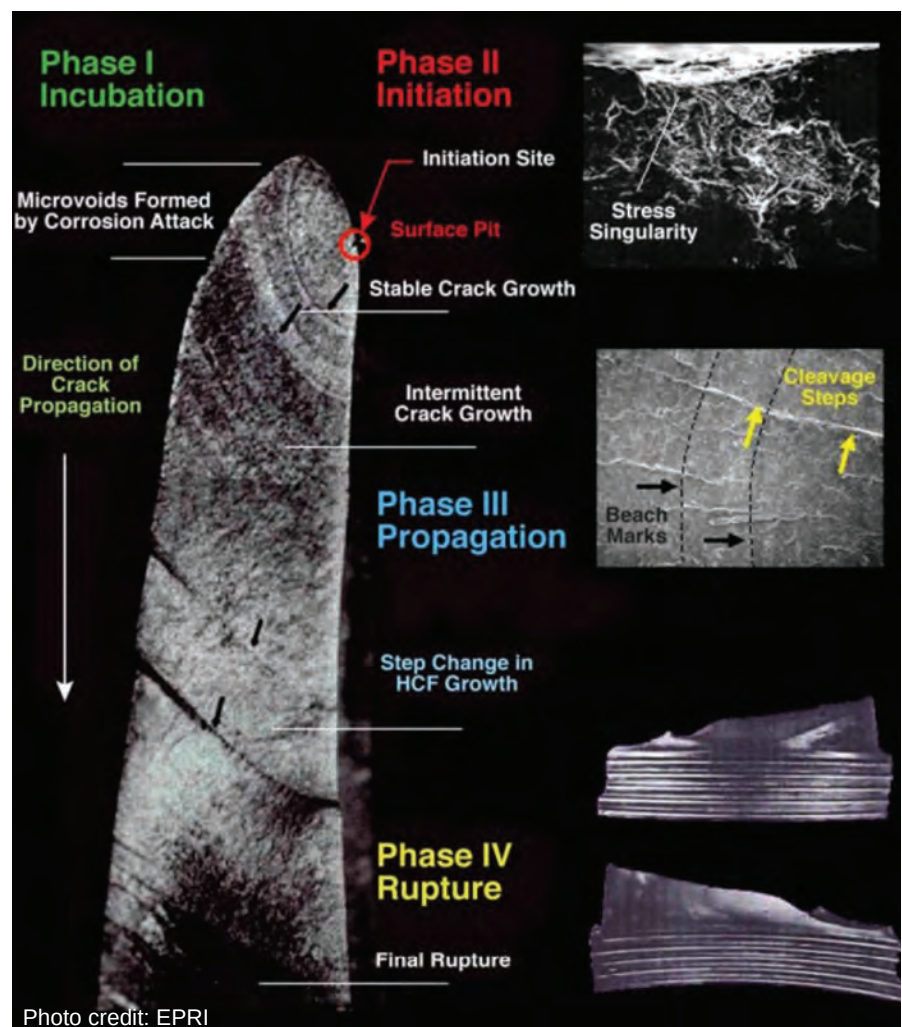
■ **Tip #3:** Don’t throw anything away that could be connected to the event. Even if a component’s involvement in an event is unknown, preserving and documenting may be important.

When disassembling equipment involved in the event, consider notifying stakeholders so they can be represented to witness the process. If a party cannot be present, they still can have an opportunity to provide input. Informing involved parties of RCA and rectification efforts can prove helpful in avoiding further disputes down the road. In keeping with the theme, more communi-

cation with stakeholders is probably better than less.

Documenting the disassembly process using a pre-planned agreed-upon procedure, notes, photographs, sketches, and/or video can be useful, especially in instances when another party may have questions (sometimes after-the-fact) about the process. Consider that disputes can transpire months or even years after the event occurs, and effort should be taken so that documentation is sufficient to clearly recall the equipment condition and disassembly process long after it takes place.

**Photography skills** is one area all plant staff can train for (Fig 2). Here, you can take a cue from your social media. Lighting is key! Include photos from multiple angles, far away, and up close. Again, more is better.



**1. What’s invisible to the naked eye,** notably on fractured surfaces, often constitutes the most important evidence for establishing and testing hypotheses through the formal RCA process



# SAVE THE DATE



7F Users Group<sup>®</sup>

## **Annual Conference May 18-23, 2026**

The Woodlands Waterway Marriott  
Hotel & Convention Center  
The Woodlands, TX

The 2026 Conference will feature:

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- 2 days of User Owner Sessions
- Tour of GE Vernova Houston Learning Center to see all the Turbines



■ **Tip #4:** Take photos in an order starting on a large scale and then zooming into smaller details in subsequent photos. This process will aid in understanding the locations and orientation of photographs when being reviewed down the road.

Check your photos before departing the scene to make sure they are clear and complete. Photograph as-found conditions and label relative positions prior to any disassembly. The goal is to provide clarity to others who will be viewing the photos in lieu of direct observation.

Collecting, transferring, and documenting evidence should be accomplished without bias towards the results or pre-conceived explanations. The RCA process involves proposing hypotheses about what happened and then seeking to disprove them using facts and reason (not seeking to prove them). Because bias often is subtle, independent RCA experts are often brought in to carry out objective, independent investigations of the evidence. Utilizing independent experts can improve the trust of the various stakeholders during the RCA process.

Similarly, notes should be around “facts” and direct observations only, not guesses, not assumptions, not emotional taint. Consider that communication, especially written-forms, like notes, emails, logs, and reports, should be thorough but ideally focused only on the facts.

**Evidence can also mean** O&M procedures, plant flow and piping and instrumentation diagrams (P&ID), and teardown and rebuild instructions. Disciplined and formal change management, document management, and version control processes at the plant will be helpful later (maybe even many years later) in RCA scenarios. The current state of the plant equipment should be captured and previous versions of the documentation retained. In situations in which sites do not record or maintain vital information about work performed (or not performed), it can detract from the RCA process.

Other examples of evidence include observations on, and the conditions of, spare or “twin” equipment, manufacturing records and certificates, maintenance and repair records, samples and analyses of fluids handled (before and after the event) by the equipment, and witness interviews.

Perhaps the most important takeaway is this: everything done following an incident will potentially come to light during an investigation, especially under a dispute situation, and could eventually be exposed to adversarial parties if the event develops into litigation. Imagine yourself in a courtroom proceeding concerning an event and consider your current processes and actions in light of such a possibility.

Sometimes it may not be obvious whether an event will become a dispute or litigation. Plant and owner/operator personnel must sometimes balance the demand to get back on-line with the value of proceeding with a

detailed RCA process. Under this situation, more documentation (photographic, written, operational data, formal change management processes) is generally better than less, along with communication with the known stakeholders. Independent failure analysis experts can help owner/operators work through unique situations and various judgment calls.

**The presentation slides** from the 7FUG conference, accessible to registered users at [www.powerusers.org](http://www.powerusers.org), review the fundamentals of RCA processes, all based, in some fashion, on the scientific method that includes defining the problem, collecting the data, forming hypotheses, testing hypotheses (to disprove), and settling on the root cause. Brief case studies are also presented to highlight instances of bias, what happens when proper evidence handling procedures are not followed, and how to photograph,

document, and analyze damaged components and systems.

For further reading, the slides also reference standards and guideline documents for conducting an RCA, evidence handling, labeling, and chain of custody – NFPA 921 (2024), API RP 585 Pressure Equipment Integrity Incident Investigation, DOE-NE-STD-1004-92 Root Cause Analysis Guidance, and ASM Handbook volumes 13C, 11A, and 11; and ASTM E1492 and E860.

Just as plant personnel are all trained in how to respond to emergencies like fires, chemical spills and explosions, owner/operators should consider formal training programs for “first responders” to the aftermath of an unanticipated event. This training would improve proper evidence collection, handling, documentation, etc., that can be used in a subsequent RCA or could be integral if the event becomes a dispute. [ccj](#)



**2. When taking photographs** for evidence, make sure the subject is in focus, properly lit, and consider using a ruler or other reference to indicate scale, orientation and/or positioning if possible. Organize photos so they align with notes



# SAVE THE DATE

## 2026 POWER USERS ANNUAL COMBINED CONFERENCE



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attend sessions from other groups.

# Practical fixes to steady HRSG performance

Calls to the CCJ editorial office from Tucker York, SVI Bremco's acoustical engineering guru, are always welcome. This outage season success story comes from a combined-cycle plant with chronic maintenance issues with the "egg-crate" turning vane weldment located in the HRSG transition duct immediately downstream of its 120-MW gas turbine. Over time, vane and support modifications intended to tame aerodynamic loading led to recurring weld failures and compromised flow conditioning into the first-stage, high-pressure (HP) tube module.

The plant contacted SVI for an engineering assessment of removing the vane set and substituting a simpler, more robust flow modifier in the aft half of the transition duct, such as a perforated distribution plate or a deflector (kick-plate). The objective was to preserve *acceptable* flow distribution and thermal performance while reducing structural risk and maintenance burden.

## WHY UNIFORMITY MATTERS

HRSG performance and reliability depend on how evenly exhaust is presented to HP, IP, and LP bundles. Maldistribution drives localized hot spots, uneven heat transfer, elevated thermal gradients, and tube-to-tube temperature differentials. Consequences include fatigue cracking, accelerated oxide growth and spall, creep damage in hot

zones, and elevated pressure drop where local velocities run high. For operators, the practical signals are familiar: rising  $\Delta P$ , unstable attemperation, drifting stack temperature profiles, and repeated tube repairs.

Properly conditioned flow into the HP inlet face supports:

- Uniform heat pickup across the bundle face for steadier steam generation
- Reduced thermal fatigue by avoiding persistent high-velocity jets
- Controlled pressure drop that preserves combined-cycle back-pressure margins
- Longer component life by limiting erosion, vibration, and dynamic loading

## MODELING APPROACH, ASSUMPTIONS

Using CFD modeling to evaluate the exhaust path from the gas-turbine diffuser through the transition duct to the front of the HP bundle allowed testing "what-ifs" without welding anything: keep the vanes, remove them, or add simple flow modifiers. The tube bundles were represented as porous blocks (to reflect real pressure drop), and the inlet swirl that GTs typically deliver was included so results matched field behavior.

The main scorecard was how even the face velocity is at the HP inlet. Measuring the percentage of area within  $\pm 15\%$  of the average velocity is a practical way to com-

pare cases on the same footing. The OEM geometry served as the baseline for judging improvement.

## BASELINE VS REMOVAL: WHAT CHANGES

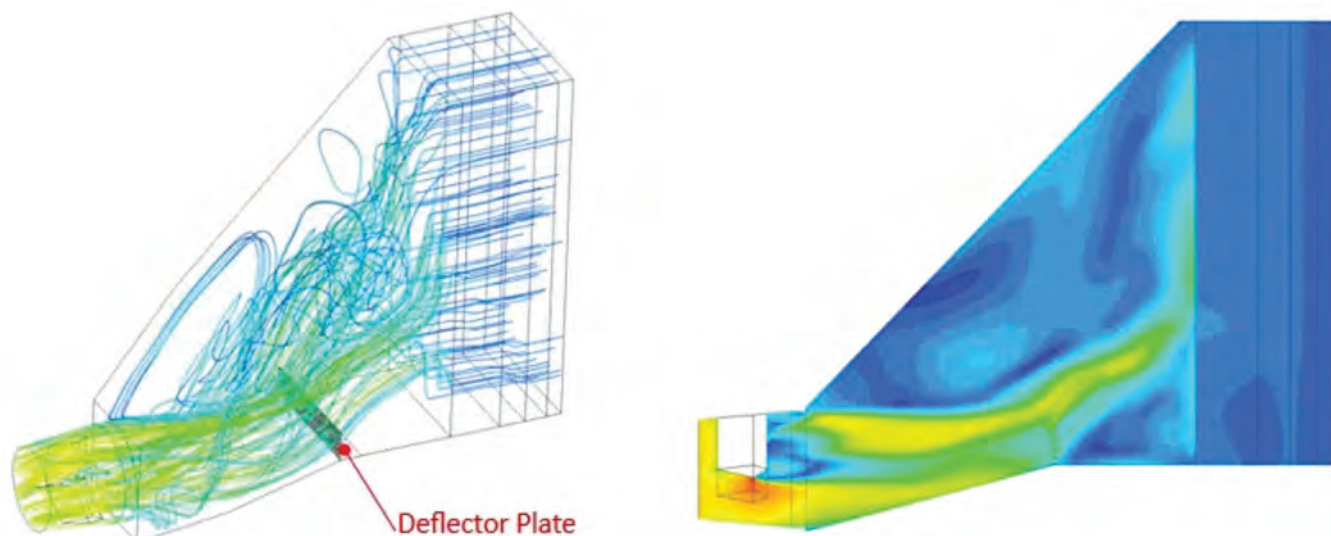
With the OEM egg-crate vanes in place, 33.5% of the HP face was within the target band. Pulling the vanes with no replacement dropped that to 18.0% and created bigger recirculation and high-shear zones. In other words, taking the vanes out may cure weld failures, but it invites hot streaks and localized high velocities—not a good trade for tube life.

## ITERATING TOWARD SIMPLER MODIFIERS

SVI Bremco then evaluated the following options for deflectors and perforated plates, hardware easier to fabricate, install, and service than multi-piece vane weldments:

- A 36-in deflector with 4-in holes (~15.7% open area) and a serrated top edge improved uniformity to ~29.9%, though there was a predictable wake right behind the plate
- Increasing height to 48 in and open area to ~37% (larger perforations) lifted uniformity to ~30.8%. The serrations helped break up large flow structures, smoothing gradients

Bottom line: a perforated, serrated deflec-



Perforated deflector concept (left) and modeled velocity contours at HP face (right), showing improved distribution and reduced hot streaks



tor reliably pushes flow toward under-served regions and tames extremes without the complexity of vanes.

#### ALTERNATIVE CONCEPT: PARTIAL DISTRIBUTION GRID

A tall, perforated grid (~114 in) performed best in modeling, ~45.7% in-band with acceptable modeled loss, but site realities dominated: higher loads, tougher installation, and maintenance safety concerns. The incremental uniformity did not outweigh those risks.

#### RECOMMENDED IMPLEMENTATION AND PRACTICAL NOTES

The preferred solution is a 48-in-tall, perforated deflector (about 37% open area) with a serrated top edge. Depending on fabrication preferences, 4-6-in holes will typically hit the open-area target while keeping plate stiffness reasonable. This choice balances better distribution, simpler structure, easier access, and safer maintenance (Figure). While the uniformity does not reach textbook best-practice ranges, it replaces a failure-prone vane set with rugged, serviceable hardware and reduces thermal-mechanical risk at acceptable cost and complexity.

#### WHAT OPERATORS SHOULD CONSIDER AT THEIR SITES

- *Establish a plant-specific distribution metric.* Use a consistent in-band definition and pair it with stack temperature scans, bundle  $\Delta P$ , and attemperation behavior to ground the model in operating data
- *Include realistic swirl.* Gas-turbine exhaust rarely enters the HRSG axially; small inlet angles can dominate downstream flow structure.
- *Model porous bundles.* Resolving every tube and fin is not practical; validated porous coefficients and duty sinks give useful answers with tractable meshes.
- *Right-size the modifier.* Taller or denser grids can raise uniformity, but loads, constructability, and confined-space safety may govern.
- *Plan for inspection and repair.* Simpler plates with serrations and controlled open area often provide the best life-cycle value where access is limited.
- *Track results.* After installation, trend  $\Delta P$ , thermography, and tube repair patterns to validate benefits and refine future designs.

For HRSG transitions that have struggled with turning-vane durability, straightforward flow modifiers offer a credible path to maintain thermal efficiency without re-creating complex weldments. A modest, perforated deflector plate can reduce structural risk, simplify outages, and improve distribution enough to protect bundle life, provided that site loads, access, and safety are addressed early in the design. **CCJ**

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# While new capacity waits in line, 7F upgrades deliver flexibility and output now

**I**ncreasing demand from data centers and extreme weather continues to push utilities and independent producers to find dispatchable megawatts fast. New-build capacity is on order, but lead times stretch years.

For owners of GE Vernova 7F units, one of the largest installed gas turbine fleets in the world, the near-term opportunity lies in upgrading the machines already in service. Two recent GE Vernova webinars outline complementary paths: a performance leap with the 7F.04-200 upgrade, and a package of reliability solutions addressing the most common trip and start challenges identified across three decades of operation.

The F-class fleet has logged more than 1.6 million starts across more than 1,350 units worldwide. That volume provides a rich dataset on what limits availability, efficiency, and start reliability. Upgrading and hardening existing 7F (and 9F) units can add capacity within months instead of years, helping balance renewables and meet near-term peak demand.

## WELCOME TO THE ADVANCED CLASS

7F upgrades sales leader Robert Campbell

and 7F product manager Jason Shaffer described the 7F.04-200 upgrade as a coordinated set of advancements across the compressor, combustion, and turbine sections. These upgrades extract more output, reduce heat rate, and expand turndown without changing the basic machine footprint. The scope also modernizes actuation and controls, enhancing part-load flexibility and simplifying maintenance. Scan the “7F.04-200” QR code to watch the presentation and Q&A session.

**The compressor upgrade** introduces a new 14-stage configuration with redesigned inlet and casing, and field-replaceable blades. GE Vernova reports up to about 16% additional hot-day output and a ~3% heat-rate improvement. Electric variable-guide-vane actuation replaces hydraulics, enhancing reliability and reducing maintenance.

**In the combustor**, the DLN 2.6+ system with updated fuel nozzles and liners maintains 9/9 ppm NOx/CO compliance while extending turndown to roughly 25% of base-load with Axial Fuel Staging. The upgrade replaces legacy hydraulic valves with electric gas control valves, reducing leak points and enhancing response.

The AGP hot-gas-path kit brings ad-

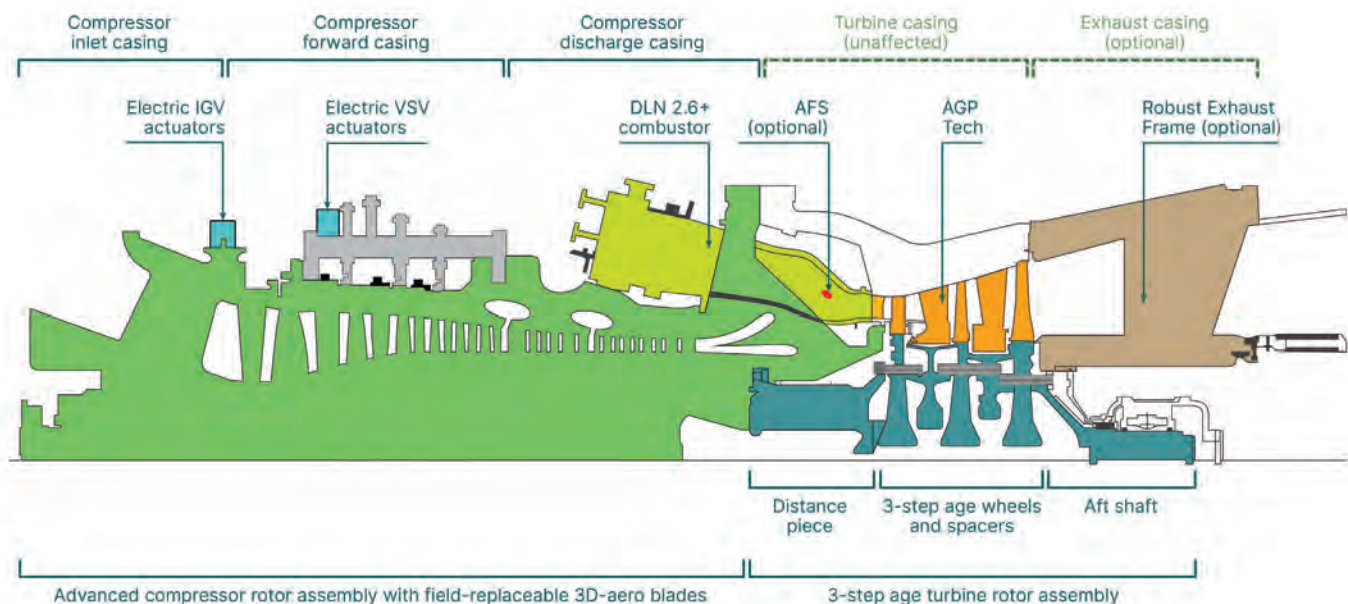
vanced-material buckets, nozzles, and shrouds that raise gas turbine output by as much as 12% and enhance cooling effectiveness. A more robust rotor material further strengthens the platform for higher output and longer life.

Controls are modernized to Mark VIe with integrated BOP signaling and diagnostic capability. Across the fleet, GE Vernova cites gains of about 46 MW on hot days and 32 MW on cold days from a 7F.03 baseline.

## CCGT OUTPUT BOOST

HRSG and steam turbine upgrades sales leader Jason Bowers emphasized that more gas-turbine exhaust energy must be matched by downstream capabilities. Before committing to a performance upgrade, owners should conduct a balance of plant (BOP) impact study to evaluate plant limitations such as HRSG pressure-part limits, steam-valve sizing, pump capacity, and generator ratings.

Pairing the gas-turbine scope with an Advanced Steam Path (ASP) upgrade often multiplies the combined-cycle benefit. ASP enhancements to blade and seal configurations can add roughly 2% more output and nearly 0.7% combined cycle heat-rate im-



The anatomy of a 7F.04-200 upgrade





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provement from the steam turbine alone. When combined with the gas turbine uprate and additional exhaust energy, plants have reported greater than 10% more output from the bottoming cycle.

Lead times for the upgrade are about 30 months from engineering release to site delivery, with on-site installation typically completed within a 45-day major-inspection window. As of mid-2025, GE Vernova has completed upgrades in more than 30 units, totaling about 1.4 million operating hours and 25,000 starts. Aligning the project with rotor maintenance or life-extension intervals helps contain outage time and cost.

### **RELIABILITY ENHANCEMENTS: LESSONS FROM 91 MILLION HOURS**

Complementing the performance program, Mohamed Sayed, Houssein Zoghmar, and Noora AlAmiri reviewed recurring reliability challenges across the 7F and 9F fleet and offered practical solutions that can be completed in a single outage. The trio of engineers focuses on four areas that repeatedly drive forced outages and failed starts: flame-detection systems, exhaust thermocouples, compressor bleed valves, and control-system logic. Scan the “Reliability” QR code to view the recording.

**Flame detectors.** Cooling-water leaks and sensor drift in legacy flame scanners cause nuisance trips and maintenance

challenges. GE Vernova's software-based Non-Optical Flame Detection (NOFD) removes the UV/IR hardware entirely by using pressure and combustion dynamics algorithms within the Mark VIe system. The modification can be performed in a week-end-length outage.

For sites preferring hardware replacement, the company offers a robust dry flame detector with fiber-optic probes and remote electronics, typically installed within one week and compatible with multiple control architectures.

**Exhaust thermocouples.** False high exhaust spreads are often traced to vibration-fatigued thermocouples or worn connectors. New thermocouples, adopted from HA technology, feature thicker sheaths, stiffer probes, and simplified junctions—roughly half the number of replaceable parts—reducing noise and enhancing accuracy. Fleet data show more than 100 installations with significantly lower false-trip rates.

**Compressor bleed valves (CBV).** Sticking bleed valves are another common trip source, caused by corrosion, weak springs, and degraded solenoids. The stainless-steel CBV package replaces vulnerable components, adds limit switches, and updates control logic. GE Vernova estimates over 100 unplanned outages have been prevented in the past five years through this modification alone.

**Control-system and sensor hygiene.**

Many dynamics or scanner alarms stem from wiring and logic aging rather than true combustion challenges. Modernized control logic prioritizes safety and diagnostic transparency, using triple-modular-redundant voting on critical signals so a single-sensor failure results in an alarm rather than a trip.

### **PLANNING A COORDINATED APPROACH**

Sayed advised owners to bundle reliability scopes within their next scheduled inspection to reduce downtime. Completing scanner modernization, thermocouple replacement, and CBV upgrades together delivers a noticeable reduction in start-related delays and unplanned maintenance.

With those reliability gains in place, plants can then plan for the larger 7F.04-200 performance scope during the next major inspection, preceded by a BOP study to confirm steam-cycle readiness.

Access the on-demand webinars for detailed scope definitions, fleet applicability, and lead-time guidance via the QR codes. [CCJ](#)



7F.04-200



Reliability

# Offline diagnostics keep big generators honest



At the 2025 CIGRE International Symposium in Montréal, Kinectrics engineers Sunny Gaidhu, Krzysztof Pyc, and Ashfak Shaikh presented a practical message for powerplant owner/operators based on the paper, “Comprehensive Off-line Diagnostic Testing and Visual Inspections for High-Voltage Turbo Generators.”

Offline diagnostic testing and visual inspections remain a high-value tool for large turbo generators in combined-cycle service. The paper also explains what online monitoring does well and where it can fall short. Readers who want full test images, plots, and acceptance details can download the complete paper via the nearby QR code.

## OFFLINE TESTING STILL BELONGS IN THE PLAN

Offline testing puts the machine in a controlled state, having the ability to pinpoint insulation degradation, overall quality of insulation, and even partial discharge issues well before they become dangerous and pose a risk to the machine of interest. This early detection extends the life of the machine and improves overall system reliability. All the while plant electrical noise is lower, which improves sensitivity. By conducting Offline PD testing at low frequency, more of the winding is visible, including neutral-end coils that sit at low potential during operation, allowing for deeper penetration into the stator winding for greater enhanced condition assessment. Offline does require an outage window, so Kinectrics positions online and offline as complements. Use online partial discharge trends to decide when to act. Use offline tests to decide what to fix

and to confirm results before return to service.

## PRACTICAL OFFLINE PROGRAM

A standard package covers the main insulation risks and gives fast guidance to maintenance planning, including:

- Insulation resistance and polarization index. Quick view of cleanliness and dryness. Also a gate to safe high-voltage work.
- Capacitance and dissipation factor. Tracks dielectric loss and flags aging, voids, or delamination in the groundwall.
- Offline partial discharge. Higher sensitivity than online in most plants because background noise is low. Captures activity across the entire winding.
- Slot survey with a TVA probe. Walks the slots to localize discharge sources under wedges and side-packing.
- Ultraviolet corona camera. Visual check for surface discharge at end windings and grading interfaces.
- DC ramp with current monitoring. Proves withstand and reveals abnormal leakage behavior as stress rises.
- ELCID core test. Low-flux screen for interlaminar faults before loading the unit.

## ONLINE VS OFFLINE PLAINLY

Online monitoring shows how the generator behaves under real thermal and mechanical loads. It does not require an outage. Coverage is limited by sensor placement and signal attenuation, so absolute comparisons across units are difficult. Offline testing provides better coverage and signal to noise, but it does not include operating vibration and temperature gradients. Read the two to-

gether. Use online for drift and duty effects. Use offline for coverage, sensitivity, and acceptance before return to service.

## 100-MW AIR-COOLED UNIT

A full diagnostic suite found a fundamentally sound stator with localized issues. Insulation resistance exceeded 100 MΩ on all phases. Polarization index was roughly 3.7 to 4.7. Dissipation factor change and tip-up were less than 1 percent, which is consistent with healthy epoxy-mica insulation. Offline partial discharge identified one phase with the highest activity. The TVA probe crossed typical thresholds in three slots. The UV camera showed weak to moderate corona at two end-winding sites near grading. ELCID was clean at less than 100 mA. Visuals showed greasing at wedges and minor rub marks at end-winding supports (Figure).

Actions for the outage were direct:

- Repair the two corona sites
- Plan a wedging-tightness survey when the rotor is out
- Repeat the offline suite in five to six years
- Add semiannual online PD trending

The practical takeaway is that small, targeted fixes now prevent nuisance trips and protect against an early rewind.

## 540-MW HYDROGEN-COOLED UNIT

Testing before and after remedial work showed how diagnostics guide the list and verify results. Initial findings included contamination in the isolated-phase bus, slot-coupler leads routed too close to end windings, and a few bent tooth corners around one slot. Insulation resistance and polarization index supported high-voltage



Grease tracking at stator slot wedge interfaces (left) and at end-winding support blocks (right), indicating relative movement and vibration that warrant wedging and support checks



testing. One borderline PI result was tied to moisture in the inner water system. Dissipation factor trends were stable. Offline PD on the white phase was high before cleaning. After bus cleaning and lead re-routing, PD levels dropped to acceptable values. Online phase-resolved PD plots confirmed the improvement. ELCID remained well below the 100-mA concern threshold.

Actions were to keep the new lead routing, maintain a clean bus, and continue on-line PD trending with periodic offline confirmation. The takeaway is that cleaning and lead management often remove false positives that mask real insulation health.

### GUIDANCE FOR PLANT PERSONNEL

The paper provides detailed thresholds and example plots. For the more mechanically inclined, a short checklist is often more useful in the field:

- Pair online PD alarms with a standing of-line playbook. Run the offline suite when trends move or before heavy runs.
- Use TVA probe plus UV camera to find locations fast.
- Keep a short acceptance table in the work plan. As a rule of thumb for epoxy-mica, aim for IR above 100 MΩ, PI of 2.0 or greater, ELCID less than 100 mA, and tan-

δ tip-up less than 1 percent. Trend against your own history first.

- After corrective work, repeat the same tests in the same configuration. Lock in a new baseline and archive the plots.

Offline diagnostics turn guesswork into evidence and help avoid premature failures. Online tools decide timing. Offline tools decide scope and confirm results. The two field cases show the pattern. Find the issue. Fix it. Prove the improvement. Trend it going forward. For full procedures, acceptance tables, and case study figures, download the complete paper: [CCJ](#)

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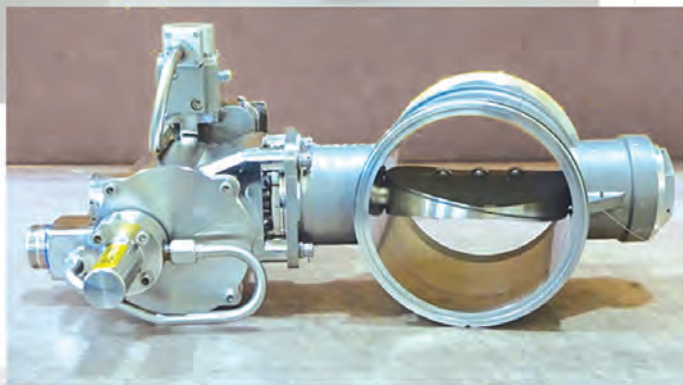


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