A primer on 'smart' maintenance

SPECIFYING THE JOB SCOPE AND PLANNING THE OUTAGE CAN SAVE MONEY

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Power generation has not been the same since 9/11, the collapse of Enron, and deregulation. Maintenance and training budgets have been drastically cut and outages deferred to improve the bottom line. Scheduled and preventive maintenance has been either postponed or totally ignored.

Ignoring maintenance actually costs more in the long run. A better idea is to stretch your maintenance dollar by performing the following jobs to keep your turbines running at their best:

- Plan your job scope carefully
- Choose an intelligent start date
- Carefully prepare your parts and expendables list
- Order parts as early as possible
- Schedule your part repairs
- Determine how to perform the outage
- Plan using the Critical Path Method (CPM)
- Brainstorm to shorten critical path
- Analyze Technical Information Letters (TIL) issued by the OEM
- Analyze upgrades
- Perform pre-outage borescope inspection
- Record pre-outage operating data and analyze it
- Perform tasks prior to outage
- Assemble special tools
- Consider Inlet Guide Vane (IGV) inspection and upgrades
- Request for Quote (RFQ) should be detailed

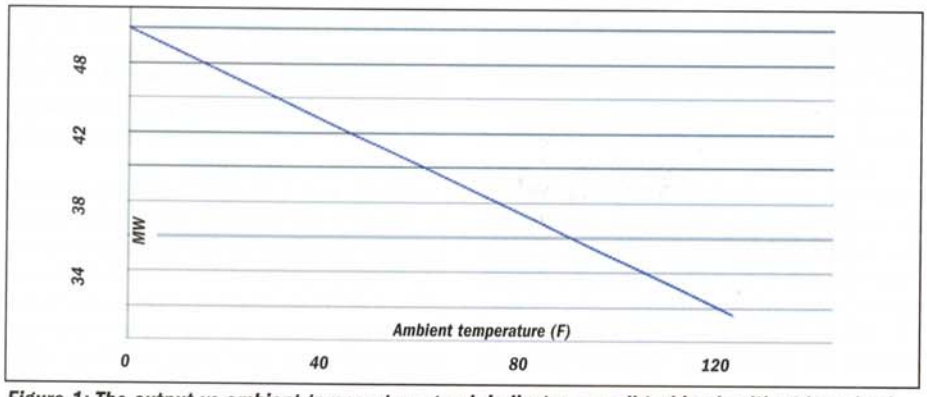


Figure 1: The output vs ambient temperature graph indicates overall turbine health at base load

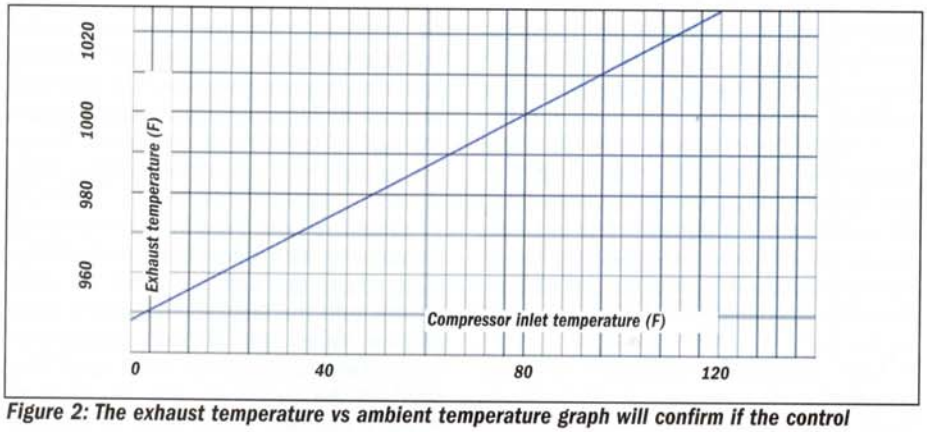


Figure 2: The exhaust temperature vs ambient temperature graph will confirm if the control systems are calibrated correctly

Plan your workscope

Determine if your turbine needs a combustion, Hot Gas Path (HGP), major, generator inspection or system maintenance. This decision is based on operating hours, starts, past maintenance (or the lack of it), type of service and outstanding TILs. Plan well in advance so that the work can be added to a future budget. It may get cut out of your budget, but if it is not in the budget initially, the money will likely never be there.

Plan to have the work completed well before your peak season. Avoid major holidays to reduce overtime and demobilization costs. Consider the weather to avoid delays.

Use a spreadsheet to list all the parts. This should include the name of the part, part numbers, quantity required and the type of inspection (combustion, HGP, major) that will be done. This allows you to sort the list depending on the type of outage or type of part, such as bolts or gaskets. Include expendables, such as rags, duct tape, plywood, tarps, rope, anti-seize compound, sealing compounds, prussian blue and parts cleaner.

Compare the list to what is in the inventory, and order well in advance what is not in stock. The question is where do you draw the line on what parts to keep in stock? If the turbine is vital to an operation or makes large profits, then it is wise to have several spares. If the unit only runs 100 hrs/year, then fewer spares would make economic sense. If the unit is used for black start, then black-start testing is the key, not spare parts.

Order parts as early as possible. Some parts have a long delivery time. Also, ordering early allows you to shop around for the lowest price. The OEMs often charge a high premium for rush orders.

Determine what parts will need repair via a borescope, then share the borescope report with repair facilities to get accurate quotes for repairs. Once the repair quotes are in, select a shop and make a reservation to have your parts repaired in the least possible time. If you wait until the parts are removed from the turbine and send them to a shop, the turnaround time will be much longer and the cost of repair will likely be higher.

Determine how to perform the outage. There are several ways of performing the work and there are pros and cons of each. The Long Term Service Agreement (LTSA) is generally the most expensive option, but it is simple "one stop shopping" and the outages are planned well in advance and easy to budget for, albeit costly.

In a LTSA, be aware that low-time (fewer operating hours) capital parts, such as a first stage nozzle, may be swapped with serviceable high-time (more operating hours) parts, leading to a reduction in value. Further, the ability to keep a running history on key parts via serial numbers is often difficult. If your turbine generates millions of dollars in profits, the

LTSA might be justified. If the unit only runs 100 hrs/year it would be hard to justify the LTSA.

Turnkey outages are another option. The bid package is sent to potential contractors and the lowest qualified bidder wins. This is perhaps the second most expensive option. Be aware that bidders need to inflate the cost to cover for any unexpected surprises. Beware of the "low ball" bid where the contractors bid ridiculously low knowing they will lose money on the job. However, they secretly expect to make up any losses with extra work orders or service shop work. This can be avoided by clearly listing in the Request For Quote (RFQ) exactly what is and what is not included, e.g., cleaning parts, stoning joints, repair of broken bolts.

Demand that any extra work must be signed for in advance. Turnkey jobs also encourage shortcuts. Since contractors are running the entire job, you may never know what shortcuts were taken. The RFQ should demand that the Technical Advisor (TA) be a qualified engineer and you should demand to see his or her resume.

The third option is to hire labor and engineering separately. This ensures quality control because the TA is working for you, not the contractor. The engineer should also document the job completely, monitor extra work worders and delays, and strive to determine the root cause of problems.

An In-House Overhaul Process (IHOP) can also be used for jobs. If you have the necessary tools and enough trained personnel, this is the least expensive and often the best option. A field engineer oversees the crew, and the customer is assured that no shortcuts are taken and the crew takes pride and ownership in their work. Many managers balk at this option claiming their crew is untrained and not qualified. However, if the crew is green, an experienced mechanical assistant can supervise all tasks and work hand-in-hand with the crew to lead the way. The IHOP method can save up to $400,000 during a major outage.

Scheduling the outage

The job should be planned using CPM. Each task is sequenced and a duration is assigned. Programs such as Microsoft Project or Primavera can be used to calculate the best possible end date and the critical path of the workflow. If you can shorten the duration of a task on the critical path from two days to one day, the job will end a day sooner.

Many use CPM, but few brainstorm to shorten the critical path. Shortening can often be done by increasing manpower, using an extra set of tools, having special tools (hi-torque), and performing the following tasks in advance; labeling parts, marking bolt sizes, making shipping crates, and organizing key drawings and forms. This will shrink the critical path and a new one may emerge. Repeat the process for the latter.

Analyze TILs and decide which to perform, skip or postpone. GE has well over 1,400 TILs published. These letters are mailed to affected customers. Some are serious and require immediate compliance. Others do not.

Organize your TILs in a notebook and create your own index that lists the TILs, their titles, the turbines each of them affects, and the turbines that are in compliance. Often special parts are required to perform compliance work and they need to be ordered well in advance. Always take the opportunity to perform TIL work when the unit is down.

Analyze upgrades and decide what is best for you. There are many upgrades available for improving efficiency, power output, reliability, parts life and controls. You will need to determine what is best for your situation. If you run only 100 hrs/year you may never realize the savings of an upgrade. Be aware that some efficiency upgrades can reduce the heat

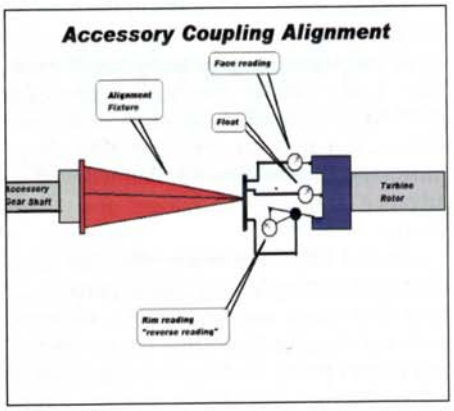


Figure 3: Special tools such as the "Christmas tree" above should be collected in advance to save time

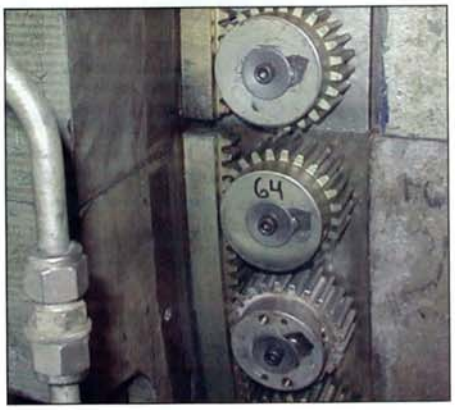


Figure 4: Operators should always consider IGV inspection and upgrade every outage. A high-flow IGV yields more output

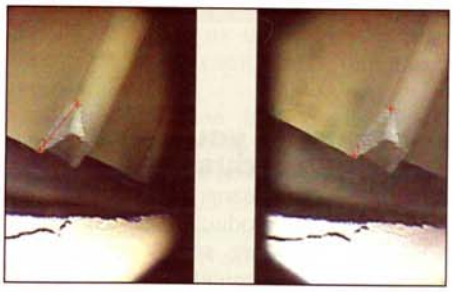


Figure 5: Borescope inspection estimated that the length of the damage on these first stage buckets was 0.363 inches

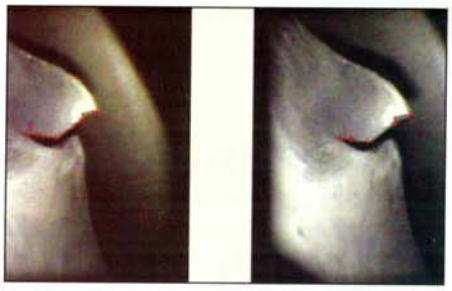


Figure 6: Borescope inspection estimated that the length of the crack on this compressor rotor blade was 0.278 inches

energy going to your Heat Recover Steam Generator (HRSG).

A pre-outage borescope inspection can save money. Knowing whether or not a problem exists helps in job scheduling. For instance, if the buckets and shroud blocks are found to be in good condition, they can simply be inspected during a hot gas path inspection versus bucket removal. Be aware that the latest borescopes can actually measure the length of cracks or the amount of damage (Figure 5, 6). A pre-outage borescope may also allow you to postpone the outage if no damage or defects are observed.

Know your turbine

It is important to take a full set of pre-outage operating data. This data may steer you to a specific inspection to get to the root cause of a problem. For instance, inspection of seals and thermocouples can be included in the job if high wheelspace temperatures are observed. Pre-outage data can also help operators to prove to the contractor that a certain problem occurred during the outage and was not a pre-existing problem.

Two handy charts to post on the control room wall are:

- Megawatts vs. ambient temperature
- Exhaust temperature vs. ambient temperature.

The first chart will quickly tell you the overall health of the turbine at base load (Figure 1). The second chart will confirm if the control system is calibrated correctly (Figure 2).

The RFQ should state that there should be "no loss in performance" because of outage work. If upgrades are being paid for, a performance guarantee should be mandatory.

Perform as many tasks as possible in advance. Keep the following ready before an outage: Parts, expendables, cribbing, special tools, load-gear centering ring, shipping crates, nozzle pulleys, alignment tools, coupling jacking bolts, precision measuring instruments, turbine support jacks, special rigging and rotor stands. This is important because a task on the critical path could be performed before the job starts, shortening the total duration of the job.

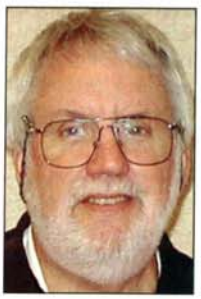
Collect special tools in advance to save time (Figure 3). Special tools such as generator skid pan and rotor shoes, jacking bolts and guide pins are often lost, but they are essential. Special tools should have a special storage location or be painted yellow for easy identification.

Always consider Variable IGV inspection and upgrade (Figure 4). Upgrading to the high-flow IGV adds 1.5% airflow and MW output. Increasing the IGV angle can also increase performance 0.5% per degree. An IGV angle of 87° should be your limit. Operating beyond 87° can induce IGV "flutter," which can lead to IGV failure. With special tools and processes, it is possible to change the IGVs without removing the rotor, saving over $200,000.

The final and the most important step is writing the RFQ. The RFQ often has omissions that come back to haunt you. Obviously the RFQ must include all of the standard items commonly found in your company's RFQs. But it is important to spell out exactly what is included and what is not included down to the last detail. TI

Authors

Charles Pond has over 32 years of experience of heavy rotating equipment, gas and steam turbines, aircraft turbines and cogeneration.



David Lucier has over 39 years of experience in gas and steam turbine field engineering, training, trouble shooting and consulting. His experience includes expertise in GE gas and steam turbines.

Charles Pond and David Lucier are owners of Pond and Lucier, LLC