

MENU-DIRECTED INSPECTION SOFTWARE TO INCREASE PRODUCTIVITY OF GAS TURBINE VIDEO BORESCOPE INSPECTIONS

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Challenges in Today's Gas Turbine Maintenance

Today, gas turbines are managed at the customer fleet level; meaning inspections are directed and analyzed by engineering design. This process does not take into account individual turbine health, but rather the fleet average. To maximize the productivity of individual assets, they must be assessed individually. Furthermore, today's inspections are built around optimizing the act of inspecting. Pre-inspection, inspection, and post-inspection must be optimized to fully understand an asset.

Routine inspections based on engineering averages are just that, averages. Some turbines could perform at peak quality for a longer duration, and some will break-down before the routine inspection, causing forced outages. Routine inspections tend to lack structure because they allow for wasted time. Planning the inspection facilitates the most efficient use of time and resources.

The lack of a robust condition based maintenance (CBM) program can lead to catastrophic gas turbine failures. Flaws undetected and/or unchecked within the compressor and hot gas path sections of the gas turbine can grow to critical size resulting in component liberation and subsequent gas turbine shutdown. Such catastrophic failures result in lost generation revenue and major outage costs. Gas turbine down time, onsite tear down and replacement and offsite component repair contribute to the staggering costs of forced outages. Forced outage costs can easily reach into the millions of dollars.

Complicated or limited record keeping creates challenges with recalling information about an asset and increases non-value added man-hours. With inspections requiring skilled labor, the cost of keeping this workforce on-hand or the cost of not having the skilled workforce at the time of need could prove to be costly. This can be reduced or eliminated with the use of better planning and data management.

Menu Directed Inspection and Standardizing Workflow



Menu Directed Inspection (MDI) is software that runs on the VideoProbe to guide an inspector through the inspection process. This standardizes the inspection workflow, saves time, reduces error, and creates consistent quality. MDI also auto-generates a report at the end of the inspection, reducing reporting time by 70%.

Standardizing the workflow using MDI reduces the number of non-value-added man-hours by giving a systematic approach to each inspection and automatically creating a customized report at the end. This

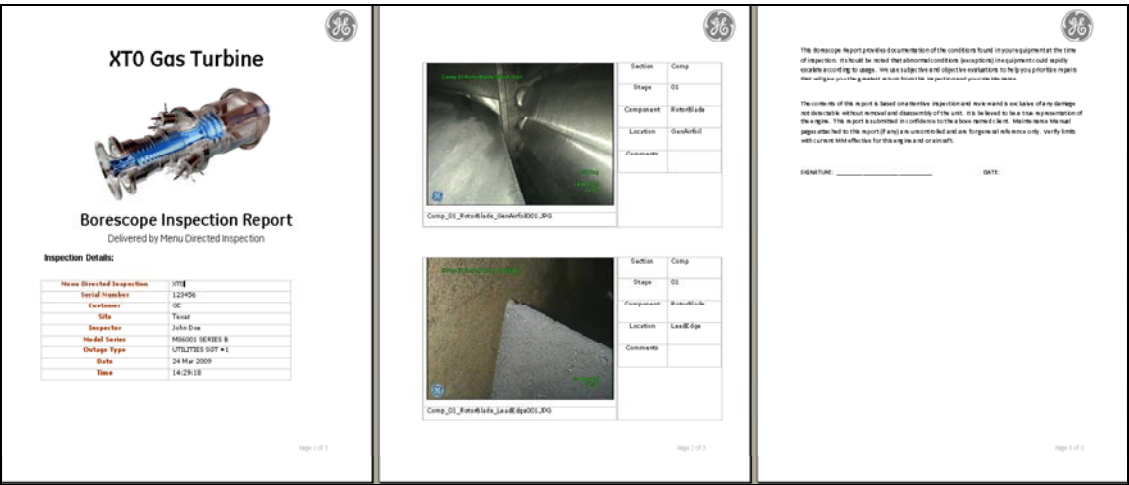
makes the skilled inspector available for additional inspections rather than spending hours or days creating a report. By guiding the inspector through the inspection process, it also reduces the learning curve necessary to inspect an asset. Creating a venue to educate workers on an asset by providing an on-screen guide will also reduce the time associated with shadowing an experienced worker. Cost benefit analysis at major gas turbine OEMs indicate implementing MDI can reduce labor costs by up to 40% over a standard non-MDI performed visual inspection.

Consistent quality is one of the key pillars of MDI. With this software, each turbine will be inspected with the same inspection template time after time. Even once the inspection protocol changes, the template can be altered so that the inspector is following a systematic approach to the turbine inspection without having to remember which changes were implemented. Each VideoProbe, with MDI enabled, will be able to complete an identical inspection.

Once the inspection has been completed using MDI, that turbine specific inspection is organized in a way that it cannot be confused with other inspections. Each image is associated with an inspection point and the specific turbine to which it belongs. For example, if the image were taken in the Low Pressure Turbine (LPT), Stage 2, Nozzle, the image name would be LPT_Stage2_Nozzle.jpg and would be located in a folder labeled with the turbine serial number. Further, each inspection is tagged with any identifying information the inspection deems necessary such as the inspector name or the hours operated since the last inspection.

The information gathered during the inspection, including the images and all identifying information, are now ready to be put into a report. At the end of the inspection, creating a report is easy with one-click reporting. Simply select “Generate Report” on the VideoProbe and a fully formatted Microsoft Word® report is delivered (Figure 1). Each image is identified with where it was taken (i.e. LPT, Stage 2, Nozzle) and any comments the inspector made during the inspection are automatically added.

Figure 1. MDI Report



Data Management Using DICONDE



With all of the information from each inspection organized, it is an easy transition to Rhythm, a data management platform following the DICONDE (Digital Imaging and Communication in Non-Destructive Evaluation) standard.

DICONDE, first released by ASTM in 2004, is essentially a dictionary that describes all necessary syntax, attributes, and data elements to allow users to acquire, store, archive, transmit and receive saved image data in a way that is universally compatible. It is derived from the pioneering work accomplished in the medical field for the last 12 years, DICOM (Digital Imaging and Communication in Medicine).

Data Management starts with the ability to digitally store inspection data in replacement of paper reports, DVDs, photos, etc. The question is how to effectively manage this increased volume of digital data and how to make it more productive. This will drive better quality inspections and in turn, asset management.

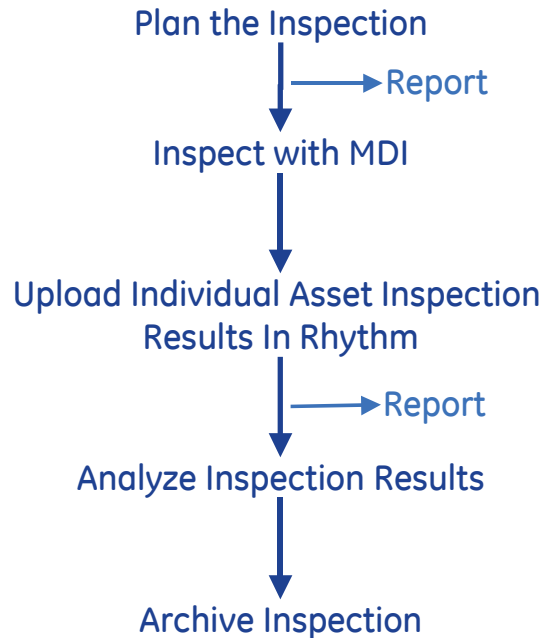
Rhythm allows more efficient searching for inspection data from many modalities such as remote visual inspection, ultra sound, x-ray, and eddy-current. It can control the information workflow so that data can be routed to other experts for further analysis. Quick access to previous inspection data can increase productivity output by as much as 50%. Pre-inspection plans can now be formulated more efficiently by taking actual inspection history into account. A similar order of productivity improvement can also be achieved in post-inspection, as only relevant inspection data needs to be sent for further analysis. Also, by storing the information in a centralized archive, the data will be backed-up and retained, minimizing the risk of losing data.

The Rhythm archiving solution ensures that inspection data will never become obsolete or inaccessible. It simplifies tagging of information without elaborate naming conventions, and allows rapid filing and data retrieval. Data can now be readily accessed from a central storage source by any number of remote interrogation sites.

A DICONDE based software data management platform such as Rhythm can assist inspectors in improving the communications dramatically through the inspection process (i.e. from pre- to post-inspection stages) and perform on-going asset management and evaluation through the life of the assets independent of its origins (i.e. modality source). Rhythm also helps extend knowledge with users such

as experts or customers who are not on a DICONDE network. This enables a user to bring in the data to the experts instead of taking the experts to the data.

Asset Management and Condition Based Maintenance (CBM) Benefits



Performance specific analysis can be accomplished on an individual basis rather than a fleet standard or engineering design by recalling information on an asset over time. Within the Rhythm platform, users are able to optimize their assets individually by using identifying information as search terms. By assessing each asset individually, Condition Based Maintenance (CBM) can be accomplished. CBM has many benefits such as reduced operating maintenance costs, spare parts and lead-time planning, technical analysis, and maintaining design performance.

Streamlining the workflow of data management is the first step in achieving CBM. Starting with MDI to collect the data in a standardized process, inspections are organized with information needed to assess individual turbines. Rhythm is designed to then accept that information, store it, allow for analysis, and share the data across locations utilizing existing communication infrastructure. These locations could be within one site or across multiple sites world-wide. By collecting data on individual turbines, maintenance can be scheduled on an as-needed basis and decisions can be made quicker. Thus, estimates of turbine component end of life can be predicted and turbine operation maximized.. When the turbine reaches a repair interval, a trigger can be implemented to create the next MDI and notify the proper parties that components may need to be ordered to shorten lead-times. This helps to lower costs associated with spare part inventory and insures the necessary components are available when needed.

As inspection information is collected and stored for archiving, those components starting to see wear can be monitored over time. This gives the ability to shorten the interval in which the turbine needs to be inspected to focus on critical components or extend the interval if turbine component health is normal. Analyzing the data over time also allows the inspection to be altered to fit the need of the turbine. For example, if a crack had grown by .2mm over the last 3 inspections and is within .1mm of

being out of limit, the interval until the next inspection on that particular turbine might need to be shortened. With CBM, the interval of the other turbines in that fleet will not need to be altered. Further, altering the MDI for that turbine to have the inspector verify the measurement of the crack early in the inspection will save time. This planning will eliminate spending unnecessary time analyzing the entire turbine if there is high probability it will come off-line due to the cracked component.

Monitoring individual assets over time also allows for better root-cause analysis if there is a forced outage. With the ability to quickly and easily retrieve component data, the source of the problem can be evaluated over time. The corrective action for that asset can be achieved, as well as provide information to evaluate similar assets if preventative maintenance must occur.

Improved outage planning and condition based maintenance can be achieved by managing each turbine on an individual basis and organizing the results in a structured way to standardize the inspection process. Advances in technology such as Menu Directed Inspection and Rhythm provide the tools to enable Condition Based Maintenance by assessing each turbine individually and standardizing on the process to pre-plan the inspection, carry-out the inspection, and manage the inspection results post-inspection.