

## Tracking the Life of Critical Gas Turbine Parts

*Losing track of time-sensitive parts can be expensive and potentially dangerous.*

**By Thomas Christiansen and Torgeir Rui, Strategic Power Systems Inc.**

As gas turbine technology has steadily advanced, "critical" gas turbine parts, such as combustion and hot gas path components, have significantly changed in terms of initial cost, repair cost, expected life limits and order lead times. Maintaining a detailed history of these critical gas turbine parts is fundamental to minimizing lifetime costs associated with owning and operating gas turbines.

Without the ability to monitor and measure the expected total cost of serialized gas turbine critical parts in an almost real-time manner, the owner's potential risk exposure is substantial. This risk can take the form of an expensive part that must be scrapped before achieving its expected life or a potential safety issue in which a part is unknowingly operated beyond its life limit. In either case, a large potential risk can be mitigated with a relatively straightforward process: tracking serialized parts by location and their accumulated age.

Although the requirement to properly track serialized parts may seem simplistic, most gas turbine owners/operators today do not adequately capture this business-critical information. Many depend on service agreement providers to track this information, primitively capture this information themselves with insular spreadsheet-based formats or depend on periodic written inspection reports to provide them with information. At best, maintaining and retrieving meaningful information from any of these sources can be a difficult, time-consuming task. At worst, the parts information may be lost forever, along with the opportunity to actively manage these critical and expensive assets.

### Critical Elements

When developing a parts tracking procedure, the owner must weigh the potential value of tracking parts within a fleet against the time and money spent to maintain the information contained within the tracking process.

A strong economic case exists for tracking critical parts. As one example, a first stage row of blades on an F technology gas turbine can cost as much as \$3 million. The time and cost required to properly track these critical parts from a remaining-life perspective would pale in comparison to the possibility that these parts exceed their assigned time at temperature limits and are not repairable as a result. As another example, consider an owner who must take the most conservative approach in removing, destructive-testing or even scrapping high-cost parts because the lack of accurate parts-life information means their continued use could pose a safety concern. A simple, well thought-out and executed parts tracking procedure could support a more informed, accurate business decision at a fraction of the potential incurred cost.

Finally, when developing a business case in favor of implementing a serialized parts tracking system, the owner should determine if such a tracking system is necessary when an original equipment manufacturer (OEM) service agreement exists. In almost all cases, the service agreement has a contractual end point, at which time it may or may not be renewed. Should it not be renewed, ownership of all serialized parts in the fleet remains with the owner. If no serialized parts tracking system is in place with complete data transparency and clearly defined data ownership, the owner is likely to inherit a lot of paperwork, but not a fully functional system that can be used to effectively manage the assets from that point forward.

### Which Parts to Track?

Once the owner justifies the need for a parts tracking process, it must decide which parts to track. As a rule of thumb, the owner should include only serialized parts, typically those the OEM has identified as critical and which have a specified life limit. Unless a part contains a unique serial number by which it can be identified, little value exists in attempting to track its age or movement throughout a fleet.

The owner's second decision is to identify the specific serialized parts that will be tracked in the process. In general, all serialized parts considered critical to safe operation of the gas turbine, as well as those that have a significant effect on operations and maintenance costs, should be tracked. In practice, many of these serialized parts are both critical to safe operation and carry a sizeable initial and life-cycle cost. The owner should also consider tracking serialized parts that do not have any major safety risk associated with them, but are so costly in terms of both capital investment and repair cost that knowing their condition and expected remaining life is crucial to responsible gas turbine asset management.

The common theme across most companies is that all serialized parts having a replacement cost above a specified dollar value should be tracked. The most commonly tracked serialized parts in a gas turbine are the combustion and hot section components. In an F technology gas turbine (arguably the type of unit with the largest number of tracked parts) this would involve tracking around 350 individual serialized parts per unit.

The owner must next decide how to track the serialized parts. Typically, all serialized parts are tracked on a transaction basis. In other words, each time a serialized part is either installed or removed from an operating unit, its status must be tracked. However, the owner must also decide how to track a serialized part while it is stored in a warehouse or sent to a component repair facility. These are places where the part may undergo modifications or whose

inclusion provides an uninterrupted chronology of the serialized part's history.

### Serialized Parts Age Criteria

Probably the most important motivation for tracking serialized parts is the ability to measure age against pre-determined life limits. This helps the owner understand remaining life from an operational as well as a financial perspective (economic depreciation). To track a serialized part's age, the owner must first determine relevant age parameters. Age can be measured using many different criteria or values. Typical criteria include some measure of operating hours (fired, equivalent or factored), starts (fired, factored or equivalent), cycles (full or partial) and, often, trips. In most cases, the OEM provides guidelines on age criteria that are relevant to the serialized parts it manufactures. These guidelines may vary in terms of the relevant age criteria based on the wear characteristics of the individual parts (low cycle fatigue, creep and corrosion). The owner must define the specific age criteria to be tracked, based on the OEM limits and/or its unique operating experience.

Once the age parameters are defined, the owner must formulate the process for tracking this information. Because serialized parts have no built-in mechanism for determining their accumulated age, the information has to be inferred. The simplest and most effective way is to determine the unit's age, both at the time of installation and the time of removal. Figure 1 illustrates how a serialized part accumulates service hours as a function of the operating unit (s) in which it has been installed. To effectively track the age of all serialized parts, it is critical that all units in the fleet consistently collect the same age information and that this data is in line with the various age parameters the owner defined.



[Click here to enlarge image](#)

The final critical element that the owner must address is how to initialize information on serialized parts that have been in operation for a period of time. The ultimate initialization process starts with the first installation of each serialized part and then identifies each subsequent transaction and all associated age accumulation. The reality is that this detailed information is typically not available when a formal tracking process is initiated. Therefore, at a minimum, the owner must determine the current location of all serialized tracked parts and assign the defined age criteria to each one at that time. This limits any historical reporting, but allows the process to move forward with the most accurate information possible for making future decisions.

### Best Practices

Once the owner defines the basic elements, the mechanism that will tie the parts tracking system together must be put into practice. Many features can be added to the basic elements to make it more useful, but for each additional feature there can be an equal increase in the time required to administer the process. Many good ideas implemented at the start of a project can quickly turn the entire process into an unmanageable quagmire of tasks requiring extensive manual labor to provide even the most basic serialized parts tracking information.

The most basic requirement of any data collection system is the means by which the data is stored for future reference and use. The data repository can range from a file cabinet to a database system. The former is not widely used for the obvious reason that any time information is needed, a significant amount of time will be required to collect the information. An MS Excel spreadsheet is by far the most common tool used for tracking the movement and age of serialized parts. MS Excel is a powerful, easy-to-use tool, but when applied to more than a few units, quickly becomes unmanageable. Over time, as serialized parts are scrapped and replaced the spreadsheet continues to grow and a single incorrect sort or mistyped value may not be discovered until the data is needed.

The only reliable data repository for a serialized parts tracking system is a fully functional, relational database with a graphical user interface designed to minimize errors and the time required to perform data entry. A properly designed database will help eliminate duplicate entries of the same serialized part in multiple locations. It will also allow the user to select data drop downs, eliminating the potential for mistyping parts and serial numbers, which often stretch to a dozen or more characters.

A standardized data collection system is always a best practice. A level of quality and consistency can be gained from following a repeatable standard when recording and processing serialized parts information. The owner should develop a written procedure that describes step-by-step exactly how the data entry process should be performed. This is especially valuable in tracking serialized parts, where the transaction data is recorded infrequently and the recording responsibility is often transferred among various individuals.

The user interface is the primary mechanism by which the user interacts with and judges the parts tracking system. Having a common user interface that "guides" the user to follow the same data entry protocols every time information is recorded will reduce data inconsistencies, while easing the labor involved. From a reporting perspective, a common user interface ensures that all personnel use the same structure and terminology and that information is provided through a common source. The user interface should be simple to use, require as little typed input as possible and contain as much error checking as possible. Ease of use is a subjective measure, but can generally be classified as providing intuitive user selections and menus and providing functionality within a few "mouse clicks." Finally, the user interface should trap errors and provide warnings to the user, but care should be taken not to include error checking at such a level that it becomes prohibitive to the data entry process.

If the user interface represents the system to the users, the reports represent the business value of the entire process. Most personnel making business decisions will do so based on the output provided by these reports. There are three distinct types of business users—facility management, financial personnel and corporate management.

In general, facility management uses parts tracking reports to understand the pedigree of the serialized parts that are currently on-site, which parts are driving the next outage and which parts are available for installation to minimize downtime.

Financial personnel are primarily interested in reports that allow them to understand the expended and remaining life on the capital parts so they can accurately calculate depreciation.

Corporate management is typically interested in reports that provide a fleetwide view of where assets are in their useful life, what assets need to be purchased to maximize revenue opportunities and to maintain the appropriate level of inventory to support the business, while minimizing carrying costs.

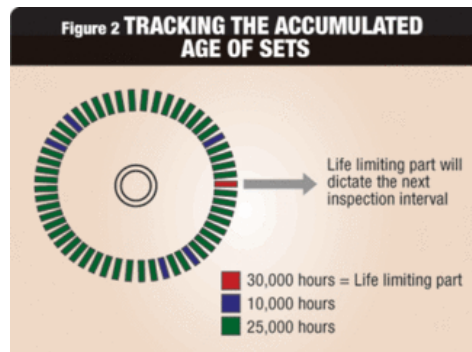
The issue of assigning responsibility for the entry of serialized parts information cannot be underestimated. The best designed system will be absolutely worthless if the required information is not input on a timely basis and in a quality manner. Data entry can be effectively performed at either each individual site or at a central location. The key is to ensure that an individual person or position is assigned responsibility for overseeing input of all serialized parts data and establishing and accepting a procedure that supports the efforts.

A part's serial number can be defined in several different ways. A serial number is the unique identification of a specific part within the tracking system. Without a serial number, a part doesn't "exist" and cannot accumulate age or be moved between gas turbines. The owner can use the serial number assigned by the OEM or assign a different one. However, if the serial number is not physically stamped on the part, there will be confusion and errors at the sites and in the component repair facilities. Additionally, modifying a part's serial number is inefficient and should be avoided whenever possible.

While a serial number should never be modified, the associated part number or drawing number may be modified as upgrades are performed. The system should allow for these changes, tracking the part or drawing number as an attribute of the serialized part. Other attributes that could be tracked include life limits, coatings, materials, OEM, alternative part numbers and other serial number references. Remember that as more items are entered and maintained within a system, time requirements and expense will increase. All optional attributes for serialized parts, therefore, should be scrutinized to ensure they have a defined value in the overall process.

One common practice is to track serialized gas turbines parts as a set. This allows the owner to track a large group of parts as one single serialized part, all accumulating age at the same rate and undergoing the same transactions. While this is a good way to limit the work required to track individual parts for a whole fleet, it can introduce challenges when the sets are reconfigured during outages or repairs.

A set is an artificial container that represents a large number of serialized parts. The set's age is always determined by its high time serialized part. As serialized parts are installed and removed from the set, the age of the set can change dramatically because its conditional age is based on the worst-case value among its constituent serialized parts. For example, Figure 2 (on page 56) shows that a single serialized part in a set has reached 30,000 hours, making it the life limiting part in that set and the driver of the next repair interval. If that single 30,000-hour serialized part were to be removed and replaced with a new part, the age of the set would immediately drop to 25,000 hours.



[Click here to enlarge image](#)

Also note that more than one age characteristic often needs to be monitored. The "high time" part for another age type (perhaps equivalent starts) might be a different serialized part; one that has a lower number of hours, but that still could be the driver of the next outage.

Another optional, though highly recommended feature of a serialized parts tracking system is electronically attaching pictures and documents to specific serial numbers or transactions. By embedding this information electronically, the risk of losing a repair report or a picture that shows crack propagation on a specific component is negated. It also provides a central repository for information that is readily accessible to all defined users via the user interface.

In any case where information is manually entered into a system, the owner should raise the issue of sharing information with other corporate systems. The information discussed here may have many multiple uses within a company and should never have to be entered multiple times. Therefore, the ability to electronically share information with other systems may become a priority. Many ways exist to share this data, from simple formatted text extracts to XML data file transfers. Each mechanism carries an associated development and maintenance cost. As a general rule, the more automated the process (usually a higher development cost) the more successful its implementation over the long term.

### Build vs. Buy

A final issue is whether an owner should custom-build its own or buy an off-the-shelf tracking system. There is no correct answer to this question. Both cases typically have an initial price and an ongoing maintenance fee that must be considered. Typically, off-the-shelf products will be more robust and reliable because they have been tested and improved through use with other companies.

The internally built system will generally be tailored to the owner's specific needs, whereas the off-the-shelf product will be less customizable, depending on its design. The off-the-shelf product typically provides better customer support. Long-term support of an internally-built system is always in question because

the system is not a fundamental part of the overall business objectives. As with most software products, the best practice is typically to buy an off-the-shelf product with a proven track record and features that match the defined critical requirements.

To actively manage gas turbine assets and minimize the financial risk associated with the critical parts, the owner/operator should consider the following, with respect to the development or adoption of a serialized parts tracking system:

- Devise a business case to underscore and communicate the importance of a serialized parts tracking system
- Define the critical elements of the system, keeping it short and simple
- Utilize a relational database to store serialized parts information
- Develop a standardized user interface for the data entry and reporting aspects of the system
- Write a formal procedure for performing the administrative tasks and assign a person or position the responsibility and authority to ensure that these are performed in a timely and quality manner
- Implement output that is easily accessible and utilized by management, accounting and operations and maintenance staff.

A solid parts tracking system properly implemented will be an invaluable tool for making business decisions relating to the critical parts within a fleet.

## Authors

**Thomas Christiansen** is Strategic Power System Inc.'s chief operating officer. He has 20 years experience in the design of information technology systems and the application of reliability engineering design principles. Torgeir Rui is a project engineer at Strategic Power Systems Inc.

*Power Engineering* February, 2008

**Author(s)** : Thomas Christiansen Torgeir Rui