Recording data, manually

AT LEAST ONCE A YEAR, OPERATORS SHOULD ANALYZE DATA FROM GAS TURBINES THAT ARE NOT FITTED WITH AUTOMATIC DATA ACQUISITION SYSTEMS

CHARLES POND AND DAVID LUCIER
POND AND LUCIER

Most modern gas turbines record operating information automatically and store it in a database (historian). However, there are hundreds of GE gas turbines that never had automatic data-acquisition equipment installed. In those cases, manual recording of data by plant engineers and operators is necessary. This requires personnel with clip boards, a stop watch, and time keeper. Coordination is the key.

It is a good practice to carefully record and analyze starting and operating data. At least once-every-year, operators should plot variables versus a time base and analyze the signature of their gas turbines from the initial start signal up to Full Speed No Load (FSNL). This practice should be continued during synchronizing the generator to the grid, loading to base or peak load, unloading and shutdown. Even data recorded during shutdown sequences can be revealing.

A data

Once the operation location(either “AUTO” or “REMOTE”), starting-fuel type (typically natural gas or #2 distillate oil), and load level (Base or peak) are selected, a start signal can be initiated by an operator (Figure 2). Thereafter, the turbine should follow a nearly identical set of functional sequences during an allotted time (typically 7 to 10 minutes, depending upon the model and application).

Many turbine starting events are either speed- or time-related. For instance, firing is not permitted until the turbine-compressor rotor reaches minimum speed (20% or 720 rpm for the frame 7). Once this speed level (Figure 4) is achieved, fuel flow starts and sparking is initiated, typically for a one-minute period (2F timer in the frame 7’s control circuit).

Later, when a flame is detected as a result of cross-firing between chambers, a one-minute up timer (2W) starts. This signals fuel flow to reduce slightly from a “richer” mixture to a safer (warm-up) level. Turbine exhaust temperature (Figure 5) is then limited to about 550°F during the cycle. Once thermal soaking is

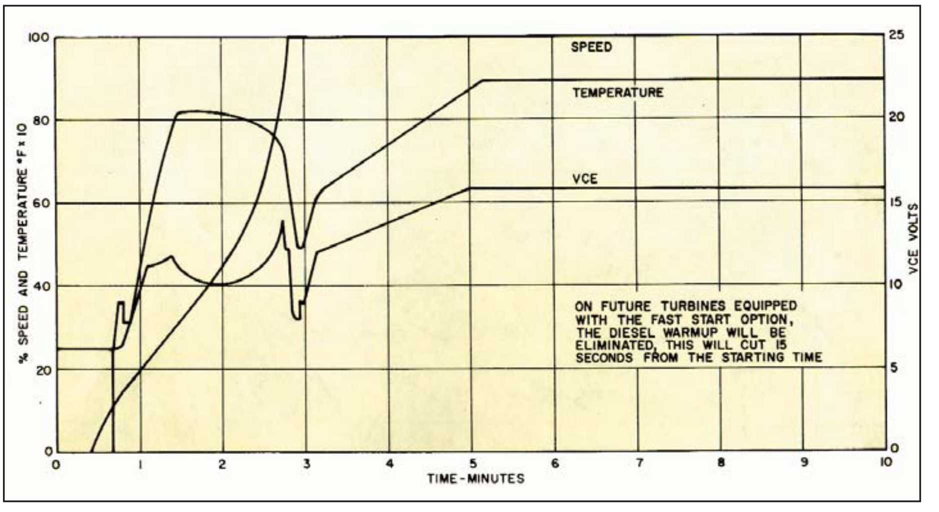
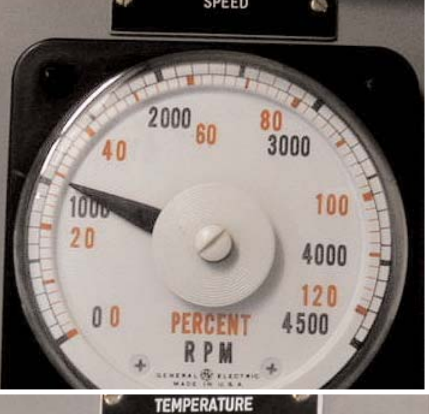
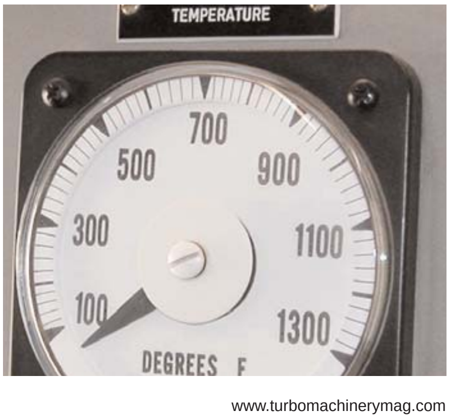
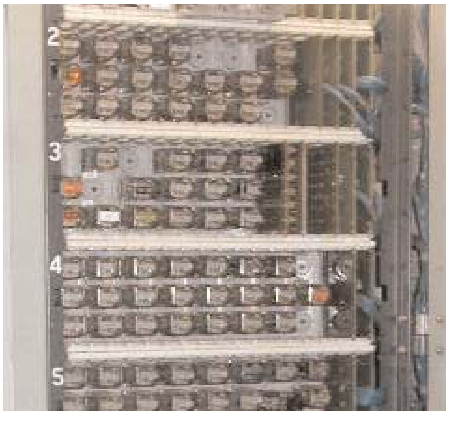


Figure 1: Above are starting and loading graphs derived from data recorded on frame 7. Maximum exhaust temperature during startup was 810°F







Clockwise from top
Figure 2: Operation selector switch in remote start position at base load
Figure 3: Panel lights (speed relays, flame detection, fuel controls)
Figure 4: Turbine compressor speed indicator (rpm and percent)
Figure 5: Average exhaust temperature, TXA
Figure 6: Typical MS7001B control panel with over 100 relays

Model Series	Type of start	Starting device	Diesel Warmup time	Turbine starting time	Time to Full Speed No Load	Total time to base load
LM2500	Normal	Gas exp	NA	1.50	1.50	5.50
LM5000	Fast load	Gas exp	NA	1.50	1.50	2.00
MS5001P	Normal	Diesel	2.0	7.17	9.17	13.17
	Fast load	Diesel	0.5	7.17	7.67	9.67
	Emergency	Big diesel	0.5	1.00	4.50	5.00
MS6001B	Normal	Diesel	2.0	10.0	12.0	16.00
	Fast load	Diesel	0.5	6.67	7.17	9.17
MS7001E (A)	Normal	Motor	NA	7.50	7.50	19.50
	Fast load	Motor	NA	7.50	7.50	9.00
MS7001F	Normal	Motor	NA	13.50	13.5	25.50
MS9001E	Normal	Motor	NA	8.17	8.17	20.17
	Fast load	Motor	NA	8.17	8.17	9.67

Figure 7: Above is a chart of GE model series and expected starting and loading times in minutes (NA stands for not applicable). Manufacturers specify expected starting, synchronizing, loading, unloading and shutdown times

completed, controlled acceleration is allowed while continuously monitoring shaft acceleration (rate of speed change in %-per-second) and temperature rate (°F-per-second).

On older gas turbines (those installed in the 1970s and 1980s), there are over 100 relays and contactors; and many timing circuits are required for start-up, loading, unloading, and shutdown sequences. As many as 50 circuit boards are also needed.

Using a GE MS7001B, Speedtronic Mark I as a good example (Figure 6), there are specific parameters (i.e., variables) that should be recorded including (GE symbols noted below):

- Time, T, in seconds from start signal (record every 15 seconds)
- Turbine shaft speed, NHP (in RPM or percent)
- Fuel command signal, VCE (in DC volts or units)
- Average turbine exhaust temperature, TXA (°F)

Also, the following events should be recorded, noting when they occurred (ANSI code symbols are given):

- Speed Relays (14HR, 14HM, 14HA, 14HS)
- Sparking (2TV)
- Flame (28FD)
- Alarms, if any

Finally, when panel lights go on or off, they should be noted (Figure 3, GE color of lights noted)

- Fuel limits control (blue)
- Acceleration Control (yellow)
- Speed-load control (green)
- Exhaust temperature and temperature rate control (red)

Analyzing the data

Data recording takes as many as five people to accomplish. However, it will be time well spent, if performed at least on an annual basis. Also, plotting the data in a consistent manner (similar graph paper and scaling) will allow for revisiting the graphs on occasion and comparing well-running turbines to others that fail to start or operate correctly.

The graph shown (Figure 1) was derived from data collected by plant operators on a frame 7 gas turbine. The data was plotted on graph paper (simplified version depicted). The time base is for a 10-minute period. Every minute represents 4 data points (i.e., recorded data ever 15 seconds). Curves were "smoothed out" for clarity. The shapes of the graphs and time duration between events can be revealing.

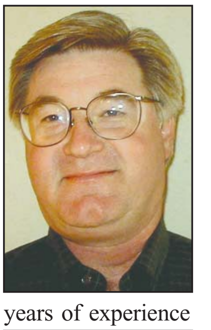
By studying the data, a plant engineer should be able to determine if the turbine is starting and operating correctly. Experience is the key to analysis. Observation of data peaks, for instance the hottest temperature (810°F in Figure 1), was noticed during start-up. It occurred at approximately 1 minute, 30 seconds after the start signal at time zero. This is when exhaust temperature control (red light) reduced the fuel command level. Also, acceleration control "kicked in" at about 2 minutes, 45 seconds to cut back VCE (Yellow light on) before the turbine reached 100% operation speed.

Turbines have an expected starting, synchronizing, loading, unloading and shutdown plan as designed by the manufacturer (Figure 7). The time periods will vary according to the starting means (gas expander turbine, diesel engine, electric motor) and the type of the turbine.

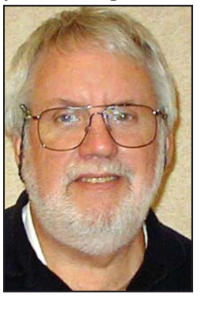
The gas turbine can reveal a great deal about itself during starting, synchronizing, loading to base load, unloading, and shutdown. Many events are speed-related; some are time-related. Recording pertinent operating data and plotting it versus a time base can be useful in troubleshooting. Understanding normal turbine operation is the key to recognizing abnormal conditions should they arise. Being able to compare start-up and shutdown curves from years past can be useful to operators, technicians, and plant engineers. TI

Author

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.



For more information about starting and operating criteria, contact Dave Lucier of Pond and Lucier, LLC at dave@pond-lucier.com or by his cellular phone: 518-330-4801.