Flexibility Enhancements for Gas Turbines

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TurbineTech.com
Situation

• Renewable Energy installed capacity is still increasing – currently >13% of US total installed capacity.
• Wind and Solar with their characteristic fast changing output profiles, account for >80GWe in the US.
• Gas Turbine Plants are being challenged to provide the necessary fast response to maintain grid stability.
Definitions

• The DOE defines fleet flexibility as:
  o The ability of the generation fleet to change its output (ramp) rapidly, start and stop with short notice, and achieve a low minimum turn-down level.

• Key classifications for Peaking Plants:
  o Non-Spinning Reserve... Generation and responsive load that is off-line but can be fully responsive within 30 minutes.
  o Supplemental Reserve... Generation and responsive load that is off-line but can be fully responsive within 10 minutes.
Topics

• Advance Class vs Legacy Fast Start
• Quantify Start Up Times – do you need to do anything?
• What options do we have to increase Flexibility?
• What are the O&M impacts?
Legacy vs Advanced Class Flexibility

Legacy Unit Traditional Fast Start
• Reduce Diesel Warm Up Timer
• Reduce Turbine Warm Up Timer (F5P only)
• Fast Sync (ΔV ignored)
• Increased Acceleration Rate
• Increase Loading Rate

Enhanced “F” Class Flexibility
• Get Purge Credit
• LCI Pre-connect
• Ignition During Acceleration (Fire on the Fly)
• Eliminate Warm Up
• Fast Sync (ΔV ignored)
• Increased Acceleration Rate
• Increase Loading Rate
## Start Up Times & Loading Rates (<10 Highlighted)

<table>
<thead>
<tr>
<th>Gas Turbine</th>
<th>Starting Device</th>
<th>Type Of Start</th>
<th>Diesel Warm-Up</th>
<th>Turbine Starting Time</th>
<th>Time To FSNL</th>
<th>Loading Rate</th>
<th>Time To Base Load</th>
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<tbody>
<tr>
<td>MS5001P</td>
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<td>20.00</td>
<td>20.00</td>
<td>40.00</td>
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</table>
Typical Start Up Curve for GE F7EA

- A: Start Auxiliaries
- B: Crank to Purge
- C: Purge
- D: Coast Down to Ignition
- E: Ignition & Crossfire Turbine
- F: Warmup
- G: Accelerate to FSNL
- H: Synchronize
- I: Loading

Approximate Time (Minutes)

Speed (%)

Load (%)

Baseload
## Components of a Startup

### Phase
- A. Start Auxiliaries
- B. Crank to Purge
- C. Purge
- D. Coast Down to Ignition
- E. Ignition & Crossfire
- F. Turbine Warm-Up
- G. Accelerate to FSNL
- H. Synchronize
- I. Loading

### Time Duration is a Function of:
- A. Equipment Reliability – O&M
- B. Starting Means installed – Diesel, Motor or LCI.
- C. Exhaust design, NFPA requirements
- D. Sequencing and inertia.
- E. Sequencing.
- F. Turbine design - constants within sequencing.
- G. Turbine design - constants within sequencing.
- H. Sync components and governor settings.
- I. Turbine & Generator design - constants within sequencing.
Increase Flexibility – Reduce Start Time

• Test & implement any existing Fast Start capability.
• Improve starting reliability.
• Establish Purge Credit if required.
• Implement techniques from Advanced Class units
  • “Fire On The Fly”
  • Fast Sync
Existing Fast Start

- Review Control Specification, Sequencing and HMI Application
  - Is Fast Start implemented, is it enabled, can you select it?
- What does it do?
  - Check constants for warm up timers, acceleration and loading rates.
- Test Fast Start the unit and record the start time.
- Modify, correct as necessary.
- Implementing the existing Fast Start will have a negative impact on Maintenance Factors, this impact must be considered.
Improve Starting Reliability

• O&M Practices
  o Fuel System Calibration
  o Device Calibration
  o System Testing

• System Modifications
  o SSS Clutch – a common issue is misalignment of the jaw clutch and 33CS not being set properly, this can be resolved through proper alignment checks or simply installing a SSS clutch for increased reliability.
Purge Credit

- NFPA® 85 2015 8.8.4.6 (Gas) and 8.8.4.7 (Liquid) allow for a Combustion Turbine Purge Credit
- In simple terms, after a normal stop, the unit is purged and this purge counted as the purge for the next start, resulting in significant start up time savings.
- There are specific requirements detailed in NFPA® 85 2015 that must be adhered to in order to establish and maintain the Purge Credit.
NFPA® 85 2015 8.8.4.6
(A) Valve Proving Method

- Normal Shutdown
- Valve Positions Continuously Monitored
- Inter-valve Pressures Continuously Monitored
- On shutdown and startup, block valves are validated for gas leak tightness via a valve proving system.
- Credit is for a maximum of 8 days, can be renewed.
- If any monitoring or testing fails then purge credit is lost.
NFPA® 85 2015 8.8.4.6
(B) Pressurized Pipe Section Method

- Normal Shutdown
- Air or Inert Gas used to pressurize inert-valve.
- Valve positions continuously monitored.
- V2 $\Delta P > 3$ psid continuously monitored.
- On shutdown and startup, block valves are tested.
- Credit is unlimited as long as conditions are met.
- Ensure fuel gas cannot enter air or inert gas supply line – check valve.
- Any monitoring or test fails then purge credit is lost
NFPA® 85 2015 8.8.4.7 (A) Proof-of-Closure Method

- Normal Shutdown
- Valve positions continuously monitored
- Inter-valve pressures continuously monitored
- On shutdown and startup, block valves are validated for fuel leak tightness via a valve proving system.
- Credit is for a maximum of 8 days, can be renewed.
- If any monitoring or testing fails then purge credit is lost.
**NFPA® 85 2015 8.8.4.7**

**(B) Pressurized Pipe Section Method**

- Normal Shutdown
- Air or Inert Gas used to pressurize inert-valve.
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- $V_2 \Delta P > 3$ psid continuously monitored.
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- Credit is unlimited as long as conditions are met.
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- Any monitoring or test fails then purge credit is lost
NFPA® 85 2015 8.8.4.7
(C) Liquid Level Monitoring Method

• Normal Shutdown
• Addition of vertical pipe section with vent.
• Valve positions continuously monitored.
• Liquid level continuously monitored.
• Credit is unlimited as long as conditions are met.
• Any monitoring or test fails then purge credit is lost.
Implementing Purge Credit

Fuel delivery system design is key to obtaining a Purge Credit and achieving Fast Start compliance. TTS’ Fast Start Program offerings include:

- Redesign of fuel delivery system to meet the NFPA standards with Purge Credit.
- Implementation of the necessary control system changes to support the fuel system upgrade.
- Consulting with clients to provide them with the best strategies to achieve fast start on their machines.
Implementing Purge Credit

• Fuel System
  o Triple Block & Bleed will be necessary.
  o Latest valve options include hydraulic and electric actuation.

• Controls
  o Implementation of control algorithms for new valves – electric actuation.
  o Implementation of control algorithms for method chosen – for example Valve Proving.

• O&M Considerations
  o Initial expenditure for new valves, piping, instrumentation and controls modifications.
  o Ongoing device calibration and valve maintenance for additional devices.
  o No impact on Gas Turbine or Generator Maintenance Factor.
Fire on the Fly

• There are two components to Fire on the Fly
  o Initiating Fire while accelerating the Gas Turbine
  o Removal of the Warm-Up period.

• This can be easily implemented through sequencing changes alone.

• Implementing Fire on the Fly will have a negative impact on Maintenance Factors, this impact must be considered.
Summary

• Flexibility – Fast Start already exists in some form or other for Legacy Peaking Units.

• There are options to improve this Flexibility
  o Major – Purge Credit through Fuel System redesign.
  o Minor – Sequencing changes
  o Routine – adherence to good O&M practices on the critical starting components.

• In all cases close reference to GER-3620M Heavy-Duty Gas Turbine Operating and Maintenance Considerations is strongly advised.
We know gas turbines.