Siemens SGT6-5000F Gas Turbine: An Evolutionary Approach

Adam Foust, 5000F Package Frame Manager, Siemens Energy
### Siemens Energy Power Generation

**Gas Turbine Portfolio**

<table>
<thead>
<tr>
<th>Model</th>
<th>Power (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGT6-5000F</td>
<td>232</td>
</tr>
<tr>
<td>SGT6-8000H</td>
<td>274</td>
</tr>
<tr>
<td>SGT6-2000E</td>
<td>115</td>
</tr>
<tr>
<td>SGT5-8000H</td>
<td>375</td>
</tr>
<tr>
<td>SGT5-4000F</td>
<td>293</td>
</tr>
<tr>
<td>SGT5-2000E</td>
<td>172</td>
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<tr>
<td>SGT-800</td>
<td>50</td>
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<tr>
<td>SGT-750</td>
<td>36</td>
</tr>
<tr>
<td>SGT-700</td>
<td>31</td>
</tr>
<tr>
<td>SGT-600</td>
<td>25</td>
</tr>
<tr>
<td>SGT-500</td>
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</tr>
<tr>
<td>SGT-400</td>
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</tr>
<tr>
<td>SGT-300</td>
<td>8</td>
</tr>
<tr>
<td>SGT-200</td>
<td>7</td>
</tr>
<tr>
<td>SGT-100</td>
<td>5</td>
</tr>
</tbody>
</table>

**Power Ratings**

- **60 Hz large gas turbines**
- **50 Hz large gas turbines**
- **Small gas turbines**

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SGT6-5000F Gas Turbine Design Features

The Most Powerful 60Hz F-Class Gas Turbine in the World

Combustion
- Wide Wobbe operation
- Sub 9ppm emissions

Compressor
- 13 stages
- 19:1 pressure ratio

Turbine
- 4-stages
- Conventionally cast parts

Rotor
- Constant rotor cooling air temperature
- Steel discs w/ Hirth serrations

Lowest firing temperature in the market:
- Low NOx emissions
- Longer part life
- Conventionally cast turbine material (no need for single crystal material)

High power output on hot days:
- Without peak firing or other power augmentation

4-stage turbine:
- Reliable part life due to lower aerodynamic loading when compared to a 3-stage turbine at the same power output

Constant rotor cooling air temperature:
- Predictable rotor life regardless of ambient temperature

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SGT6-5000F Evolution
Successful Heritage of the 5000F Platform

SGT6-5000F Evolution

- 279+ units in operation
- 9.4+ million operating hours
- Reliability consistently >99%
  as reported by our customers (230 units)

<table>
<thead>
<tr>
<th>GTs in Operation</th>
<th>501F</th>
<th>FC</th>
<th>FD</th>
<th>FD2</th>
<th>F(3)</th>
<th>F(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993 Introduction</td>
<td>4</td>
<td>36</td>
<td>19</td>
<td>142</td>
<td>49</td>
<td>28</td>
</tr>
<tr>
<td>1997</td>
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<td>2013</td>
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<tr>
<td>2015</td>
<td></td>
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</tr>
</tbody>
</table>

- 80 units in simple cycle
- 30 units in 1x1 cc
- 127 units in 2x1 cc
- 30 units in 3x1 cc
- 12 units in 4x1 cc

Low Risk Evolutionary Design Approach with Proven Reliability

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SGT6-5000F(4) / F(5) / F(5ee)

Design Features

The F(4), F(5), and F(5ee) Have the Same Firing Temperature

- Improved rear stage aerodynamics from F(5) to F(5ee)
- Single tie bolt rotor for F(4), F(5), F(5ee)
- 13-stage compressor for F(4), F(5), F(5ee)
- Enlarged compressor inlet from F(4) to F(5)
SGT6-5000F Development Testing and Verification Before Implementation

Off nominal testing…
- Compressor surge limits
- Transient operation
- Fuel transfers
- Load rejections
- Over firing

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SGT6-5000F(5ee) Berlin Testing Update

Mechanical Verification and Performance Testing have been Successfully Completed in the Berlin Test Facility!

- Performance (base load, part load)
- Operations (start-up, off-speed, trip, restart, etc)
- Combustion stability and emissions
- Turbine row 4 blade flutter
- Rotor dynamics

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First SGT6-5000F(5) Achieves Base Load

5000F(5) gas turbine and generator shipping from the Charlotte, NC, USA factory

First 5000F(5) gas turbine achieves base load at the Ras al Khair site in the Kingdom of Saudi Arabia

232 MW Net Power

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Combustion
Fuel Flexible, Reliable, Low Emissions

25 ppm Emissions on Fuel Oil

- “SGT6-5000F sets a new benchmark in the industry demonstrating 25ppm NOx emissions on fuel oil.”
- <9 ppm emissions on natural gas from 40% to 100% GT load

Liquid and Gaseous Fuel Flexibility

- Diesel oil
- Light crude oils
- Bio-diesel
- Condensates
- Syngas with a wide range of H₂ content
- Natural gas + H₂
- Low-Btu natural gas w/ high N₂ content
- Gases with a wide Wobbe Index variation

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Operational Flexibility
Fast Start w/ Daily Cycling

Flexibility to Meet Grid Demands Rapidly without a Part Life Penalty

- 6 F(4) fast start units in operation
- 3 F(3) 1x1 fast start plants

**Additional Fast Start Benefits**

<table>
<thead>
<tr>
<th></th>
<th>Start up¹</th>
<th>Shutdown²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Fuel Reduced</td>
<td>~53%</td>
<td>~55%</td>
</tr>
<tr>
<td>Total CO Pounds Reduced</td>
<td>~42%</td>
<td>~55%</td>
</tr>
<tr>
<td>Total NOx Pounds Reduced</td>
<td>~53%</td>
<td>~56%</td>
</tr>
</tbody>
</table>

Start up¹ = ignition to base load compared to a normal start up
Shutdown² = base load to fuel cut off compared to a normal shutdown

Power Generation in 5 minutes

Load cycling @ 30 MW/min

Multiple daily starts

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SGen6-1000A
Air-Cooled Generator for Simplified Plant Interfaces

- Air cooled configurations (OAC and TEWAC) to meet the environmental conditions in the region

- 30 year design life @ IEEE Class F temperature rise
First SGT6-5000F(4) Hot Gas Path Inspection
Lower Firing Temperature  = Lower Risk in Service Operation

All Hot Gas Path Parts are in Good Condition After 22,000+ Hours of Operation!

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Thank You!

Gas Turbines, Steam Turbines, & Generators Manufactured in Charlotte, NC
Siemens SGT6-5000F Gas Turbine: An Evolutionary Approach

Name: Adam Foust  
Title: 5000F Package Frame Manager  
Phone: 407-736-6488  
Email: adam.foust@siemens.com