GAS TURBINE BASIC FAMILIARIZATION

LM2500, TM2500, LM5000
LM6000, and LMS100
Gas Turbine Engines

Robert Boozer
The BRAYTON steps are as follows:

Compression occurs between the intake and the outlet of the compressor (Line A-B). During this process, pressure and temperature of the air increases.

Combustion occurs in the combustion chamber where fuel and air are mixed to explosive proportions and ignited. The addition of heat causes a sharp increase in volume (Line B-C).

Expansion occurs as hot gas accelerates from the combustion chamber. The gases at constant pressure and increased volume enter the turbine and expand through it. The size of the passages is also increased, which allows a further increase in volume and a sharp decrease in pressure and temperature (Line C-D).
GE Terminology

- LM - Land and Marine. General Electric’s power plant, platform and marine versions of their flight engines.
- LM2500 based on the CF6-6 aero engine
- LM5000 based on the CF6-56 aero engine
- LM6000 based on the CF6-80 aero engine
TM Aeroderivative Gas Turbine
TM2500 Trailer Mounted Gas Turbine

- Heat rate 9800 Btu/kW-hr 50 Hz/9500 60 Hz
- 11.0 Kv (50 Hz) 13.8 kV (60 Hz)
- TM2500 ideal for temporary peak shaving, plant shutdowns, equipment maintenance, or emergency disasters.
- Liquid or natural gas
- Operating on Natural Gas at ISO baseload conditions 60 Hz 37% efficiency and 35% 50 Hz.
- TM2500 Power Plant on Wheels capable producing 21 Mw’s on short notice.
- Can be transported by ship, air, and road.
LM6000
LMS100

LMS100 comprises a low pressure compressor, an intercooler, a supercore and a power turbine. Supercore (comprising HP compressor, compressor rear frame, high pressure turbine and intermediate pressure turbine) is a development of the LM6000. The low pressure compressor is from the 6FA industrial gas turbine.
LMS100 Site

LMS100 comprises a low pressure compressor, an intercooler, a supercore and a power turbine.
LMS100

Quick Specs:
Power Class: 98 to 103 Mw
Thermal efficiency: 43.9% to 45%
Heat Rate: 7,592 – 7,773 BTU/kW-hr

Three Spool aero derivative industrial gas turbine hot-end drive.
Intake-Radial inlet
LP Compressor- Axial compressor 6 stages. Air deliver to an intercooler
HP Compressor- 14 stage. Over pressure ratio 42:1
Combustor – SAC/DLE
HP Turbine- Two stage
IP Turbine- two axial stages that drive the LP /Power Turbine.
LP/Power Turbine- five stage free power turbine. 3600 RPM 60-Hz and 3000 RPM 50-Hz
Turbine Install
Modules

LM2500 Gas Turbine

- Bullet Nose
- Bellmouth
- Front Frame
- Compressor Rear Frame
- Second Stage Nozzle
- First Stage Nozzle
- Turbine Mid-Frame
- High Pressure Turbine Rotor
- Combustor
- Low Pressure Turbine Rotor
- Rear Frame
- Low Pressure Turbine Stator
- Gearbox
- Compressor Stator
- Compressor Rotor
**Terminology**

HPC – High pressure compressor

LM5000 & 6000 - 14 stages,
LM2500 - 16 stages

CRF – Compressor Front Frame

**Modules/Frames:**

LPC – Low Pressure Compressor
LM5000 & 6000 - 5 stages

CFF – Compressor Front Frame
Terminology (Cont.)

LPT – Low Pressure Turbine
   LM5000 – 1 stage,
   LM6000 – 5 stage,
   LM2500 – 6 stage

TMF – Turbine Midframe

PT – Power Turbine
   LM5000 – 3 stage power turbine,
   LM2500 – PT (6 stage)

HPT – High Pressure Turbine
   2 stages
Terminology (Cont.)

IGV – Inlet Guide Vanes
VG – Variable Geometry
VSV – Variable Stator Vanes
VBV – Variable Bleed Valves (Doors)
Collector – LM5000 and LM6000

Non-Module
Accessories/Parts
AGB – Accessory Gearbox
IGB – Inlet Gearbox
Engine Locations

- Temperatures (T), pressures (P) and speeds (XN)

0 (Zero) – Temperature and pressure at ambient conditions
1 – Temperature and pressure at the inlet to the GT (after cooling, etc.)
2 – Temperatures, pressure and speed at the inlet of the LPC
2.5 – Temperature, pressure and speed at the inlet of the HPC
3 – Temperature and pressure at the discharge of the HPC (CDP)
4 – Temperature and pressure at the inlet to the HPT
4.4, 4.8, 5.4 – Temperature and pressure at the controlling thermocouples on the inlet to the LPT.
   (This where the numbering schemes for each engine line starts to deviate)
XNPT – Speed of the LM5000 power turbine
Terminology (Cont.)
**Terminology (Cont.)**

- Operating/Augmentation terms
  - **STIG** (Steam injection) – NOx control & power augmentation
    - STIG 80 8000 lb/Hr Steam 60 Hz 48.1 Mw 50 Hz 46.3 Mw
    - STIG 120 120000 lb/Hr Steam 60 Hz 51.6 Mw 50 Hz 49.6
    - PE
    - PH
  - Water Injected – NOx Control
  - Sprint – Power augmentation
    - Enhanced Sprint
  - **DLE** – Dry, low emissions
Troubleshooting Tables

- Maintenance Levels
- Level 1: Any maintenance associated with the exterior of the engine, up to and including engine removal
- Level 2: Any maintenance activity associated with the interior or flowpath. This includes engine module assemblies, and other components
- Level 1 and 2 maintenance activities are detailed in Work Packages (WP)
WORK PACKAGES

WORK PACKAGE

TECHNICAL PROCEDURES

IGNITER PLUG REPLACEMENT

(LEVEL 1 MAINTENANCE)

EFFECTIVITY: LM6000 PC GAS TURBINE MODELS

LIST OF EFFECTIVE WP PAGES

Total Number of Pages in this WP is 8

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 7</td>
<td>0</td>
<td></td>
<td></td>
<td>8 Blank</td>
<td>0</td>
</tr>
</tbody>
</table>

Alphabetical Index

<table>
<thead>
<tr>
<th>Subject</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Igniter Plug Inspection</td>
<td>4</td>
</tr>
<tr>
<td>Igniter Plug Installation</td>
<td>4</td>
</tr>
<tr>
<td>Igniter Plug Removal</td>
<td>3</td>
</tr>
</tbody>
</table>
## Troubleshooting Tables

### Lube Oil System

<table>
<thead>
<tr>
<th>System / Event</th>
<th>Alarm</th>
<th>Shutdown or Emergency Shutdown</th>
<th>Step Decel to Core-Idle, Shutdown 10 Seconds Later</th>
<th>Slow Decel to Minimum Load</th>
<th>Abort Start</th>
<th>Notes</th>
<th>Troubleshooting Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chip Detector Alert (Any Sump, TGB Assy)</td>
<td>&lt;100 Ohms &gt;2.5 sec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TS-13</td>
</tr>
</tbody>
</table>

### TS-13: Chip Detector

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Possible Causes</th>
<th>Troubleshooting</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chip detector alert</td>
<td>Sensor system failure</td>
<td>Check chip detector per WP 4017 00 SPAM</td>
<td>Replace chip detector per WP 1910 00 as required</td>
</tr>
<tr>
<td>Engine bearing failure</td>
<td>Check all scavenge screens, chip detectors, and system filters for debris (bearing debris plus increased engine vibration) per WPs 4017 00, 4000 00, and 4621 00</td>
<td>Flush lube and hydraulic systems. Replace engine as required</td>
<td></td>
</tr>
<tr>
<td>Lube or VG hydraulic pump failure</td>
<td>Check lube and hydraulic screens and system filters for debris per WPs 4020 00 and 4021 00</td>
<td>Flush lube and hydraulic systems. Replace defective VG or lube/scavenge pump per WP 1812 00 or WP 1813 00, as required</td>
<td></td>
</tr>
<tr>
<td>Chip detector failure</td>
<td>Sensor system failure</td>
<td>Check chip detector per WP 4017 00 Clean chip detector SPAM</td>
<td>Replace chip detector per WP 1910 00 as required</td>
</tr>
</tbody>
</table>
# Maintenance Intervals/Work Packages

## Table 12-1 Preventive Maintenance and Servicing Checks

<table>
<thead>
<tr>
<th>Maintenance Item (Note 1)</th>
<th>Maintenance Interval: 4000 Operating Hours, 450 Fired Starts, or Annually (whichever comes first)</th>
<th>Procedure Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borescope Inspection</td>
<td>X and (Note 5)</td>
<td>WP 4015 00</td>
</tr>
<tr>
<td>Inlet and Coupling Inspection</td>
<td>X and (Note 4 and 5)</td>
<td>WP 4010 00 and Packager’s Manual</td>
</tr>
<tr>
<td>Enclosure Inspection</td>
<td>X and (Note 4 and 5)</td>
<td>Packager’s Manual</td>
</tr>
<tr>
<td>External Engine Inspection</td>
<td>X and (Note 4 and 5)</td>
<td>WP 4012 00</td>
</tr>
<tr>
<td>Lube and Scavenge Pump Inlet Screen and Filter Inspection</td>
<td>X and (Note 5)</td>
<td>WP 4020 00</td>
</tr>
<tr>
<td>GR Blow off Flange Cleaning and Internal Inspection Check</td>
<td>X and (Note 5)</td>
<td>WP 4020 00</td>
</tr>
<tr>
<td>GR Blow off Flange Cleaning and Internal Inspection Check</td>
<td>X and (Note 5)</td>
<td>WP 4020 00</td>
</tr>
</tbody>
</table>
NOTES:
1. Inspections within the enclosure shall not be made with engine operating above idle speed.
2. Semiannual inspections shall be made with the engine shut down.
3. Change on-engine liquid fuel filter element whenever a 5-7 psi filter ΔP is noted on user gage.
4. Inspections shall be made anytime maintenance is performed in the area or when the area is accessible.

Table 12-1B. Special Inspections

<table>
<thead>
<tr>
<th>Maintenance Item (Note 1)</th>
<th>Maintenance Interval: 4000 Operating Hours, 450 Fired Starts, or Annually (whichever comes first)</th>
<th>Procedure Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Pressure Turbine Diffuser</td>
<td>X (Until Service Bulletin LM6000-IND-0216 is incorporated)</td>
<td>Service Letter LM6000-03-06 R1</td>
</tr>
<tr>
<td>Inlet Gearbox Spline</td>
<td>X</td>
<td>Service Letter LM6000-04-01 R2</td>
</tr>
<tr>
<td>High Pressure Compressor Stage 11 Manifold Check Valve</td>
<td>X</td>
<td>Service Letter LM6000-04-02</td>
</tr>
</tbody>
</table>
BOP Equipment

Hyd Start

Sprint
BOP Equipment

Generator

Aux Skid
BOP Equipment

CHILLER

COOLING TOWER
BOP Equipment

Gearbox

Duct Burner
BOP Equipment

Air Compressor

Aux Boiler
BOP Equipment
Steam Turbine
OTSG
BOP Equipment

AMMONIA INJECTION

AIR DILUTION BLOWER
BOP Equipment

SCR

50 Hz GEN/GEARBOX OIL
Recommended SOP’s

- Do you have access to LM Tech Doc’s? Contact CSM
- Oil/Gas Analysis Program
- Vibration Analysis (BOP)
- Site Specific Start and Stop Procedures
- Material History
- CMMS/Inventory/Special Tooling/Budgeting/Spare Parts
- Training Plan
Enjoy Your Conference