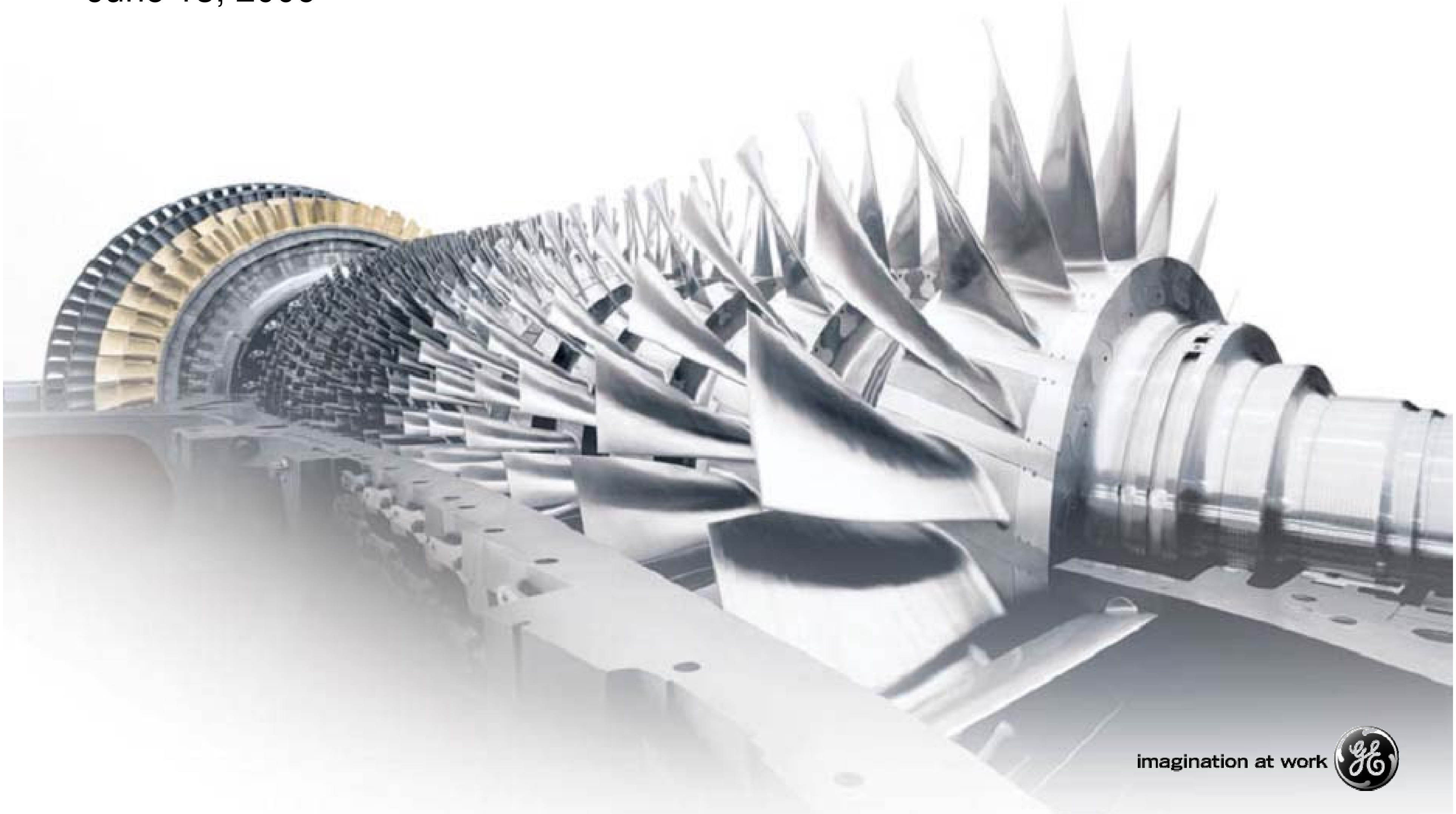
Frame 6 Users Conference
Phoenix, AZ

June 13, 2006



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MS6001 Performance History

Turbine Model	Ship Dates	Firing Temp. °F/°C	Output* kW	Heat Rate* BTU/kWhr	Exh Flow 10 x 3lb/hr	Exh Temp °F/°C
MS6431A	1978	1850/1010	31,050	11,220	1,077	891/477
MS6441A	1979	1850/1010	31,800	11,250	1,112	901/483
MS6521B	1981	2020/1104	36,730	11,120	1,117	1017/547
PG6531B	1983	2020/1104	37,300	10,870	1,115	1005/541
PG6541B	1987	2020/1104	38,140	10,900	1,117	999/537
PG6551B	1995	2020/1104	39,120	10,740	1,137	1003/539
PG6561B	1997	2020/1104	39,620	10,740	1,145	989/532
PG6571B**	1997	2077/1136	40,590	10,600	1,160	1005/541
PG6581B	2000	2084/1140	41,460	10,724	1,166	1016/546

***ISO conditions, unit operating at Base Load on Oil Fuel and no inlet or exhaust losses.**
**** Available as retrofit only**

Current New Unit Production

Typical PG6581B vs. PG6541B

	PG6581B(new unit)	PG6541B
✓ Stage 1 Shroud	HR-120 Material with 'Pumpkin Tooth'	310 SS with 'Pumpkin Tooth'
✓ Stage 2 Shroud	Honeycomb Shroud	Non-Honeycomb Shroud
✓ Stage 3 Shroud	Honeycomb Shroud	Non-Honeycomb Shroud
✓ Stage 1 Nozzle	FSX-414, Improved Cooled	FSX-414, not Improved Cooled
✓ Stage 2 Nozzle	GTD-222 material	FSX-414 material
✓ Stage 3 Nozzle	GTD-222 material	FSX-414 material
✓ Stage 1 Bucket	GTD-111, Perimeter, BLE/DS, GT-29 I+	111, 12 hole, BLE/DS, GT-29 I+
✓ Stage 2 Bucket	IN738, 7 hole, cutter tooth design	IN738, 4 hole, non-cutter tooth
✓ Stage 3 Bucket	IN738, cutter tooth design	U500, non-cutter tooth design
✓ Inlet Guide Vanes	GTD-450 material, 86° maximum angle	403 SS material, 84° maximum angle
✓ Transition Piece	Nimonic -263 Body and aft-frame with TBC	Hast-X body and aft-frame with TBC
Liner	Standard combustion design with TBC	Standard combustion design w/o TBC
Inner Barrel	Standard labyrinth seal design	Standard labyrinth seal design
✓ Load Gear	5163 rpm load gear with 51 MW limit	5094 rpm load gear with 51 MW limit
Firing Temperature	2084° F	2020° F

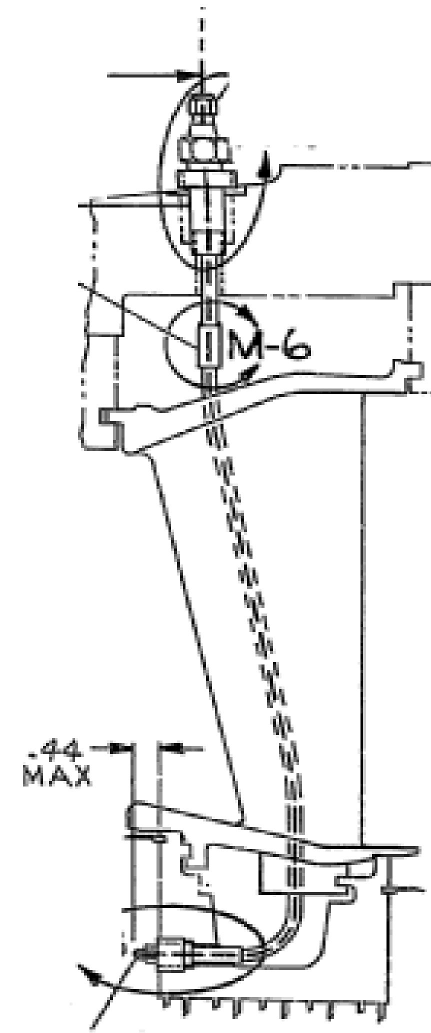
Typical PG6581B vs. PG6551B

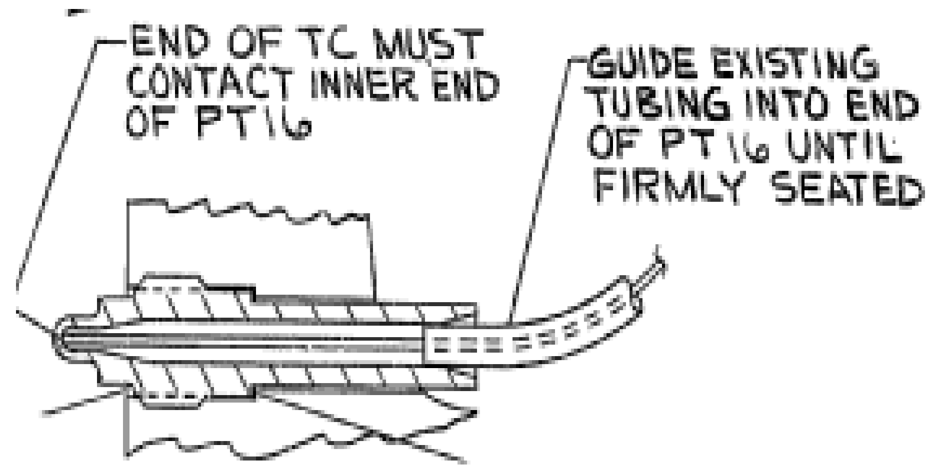
	PG6581B(new unit)	PG6551B
✓ Stage 1 Shroud	HR-120 Material with 'Pumpkin Tooth'	310 SS with 'Pumpkin Tooth'
✓ Stage 2 Shroud	Honeycomb Shroud	Non-Honeycomb Shroud
✓ Stage 3 Shroud	Honeycomb Shroud	Non-Honeycomb Shroud
✓ Stage 1 Nozzle	FSX-414, Improved Cooled	FSX-414, not Improved Cooled
✓Stage 2 Nozzle	GTD-222 material	GTD-222 material
✓✓ Stage 3 Nozzle	GTD-222 material	GTD-222 material
✓ Stage 1 Bucket	GTD-111, Perimeter, BLE/DS, GT-29 I+	111, 12 hole, BLE/DS, GT-29 I+
✓ Stage 2 Bucket	IN738, 7 hole, cutter tooth design	IN738, 4 hole, cutter tooth
✓ Stage 3 Bucket	IN738, cutter tooth design	U500, cutter tooth design
✓ Inlet Guide Vanes	GTD-450 material, 86° maximum angle	GTD-450 material, 86° max. angle
✓ Transition Piece	Nimonic -263 Body and aft-frame with TBC	Hast-X body N-263aft-frame with TBC
Liner	Standard combustion design with TBC	Standard combustion design w/o TBC
Inner Barrel	Standard labyrinth seal design	Standard labyrinth seal design
✓ Load Gear	5163 rpm load gear with 51 MW limit	5094 rpm load gear with 51 MW limit
Firing Temperature	2084° F	2020° F

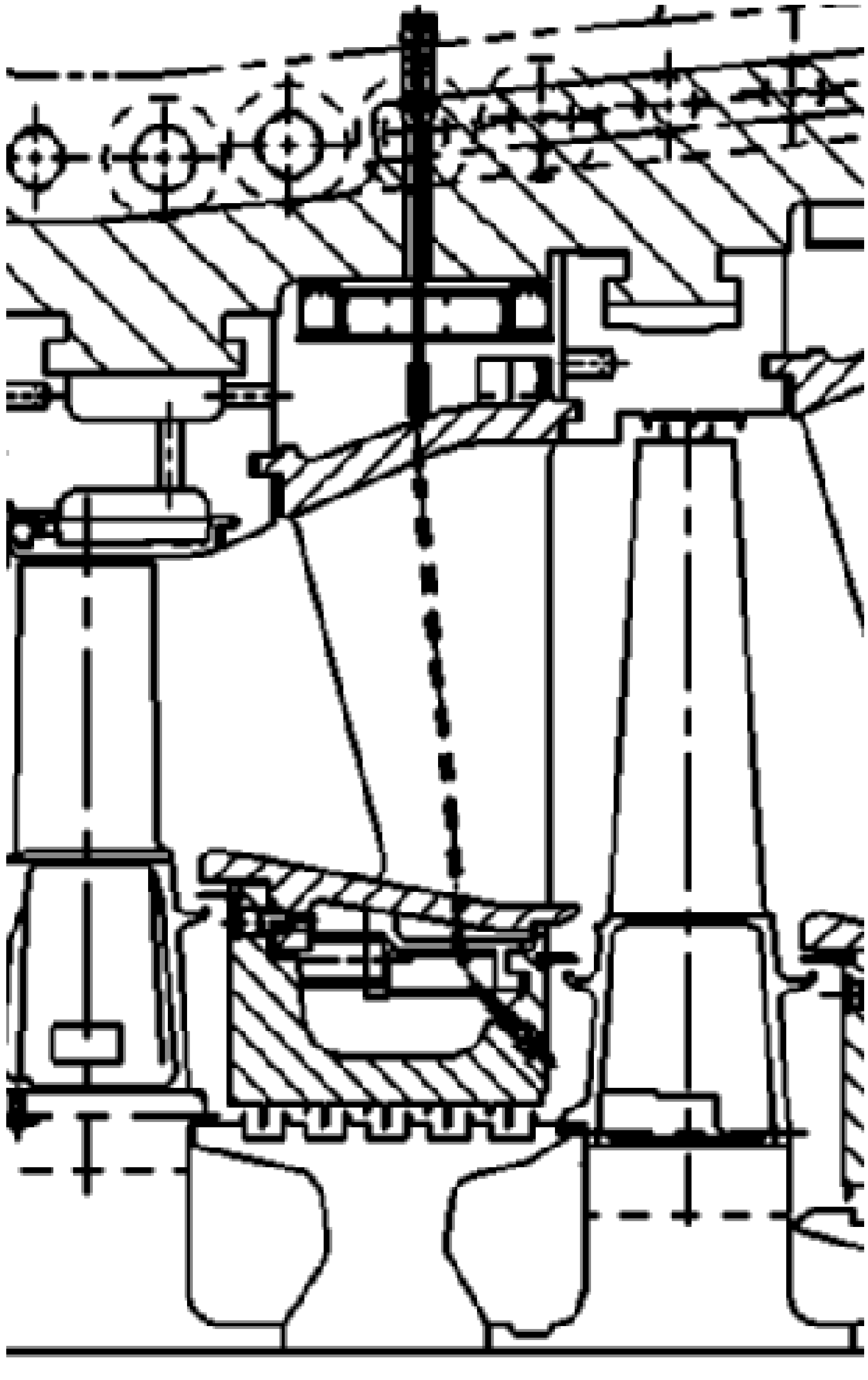
Typical PG6581B vs. PG6561B

	PG6581B(new unit)	PG6561B
✓ Stage 1 Shroud	HR-120 Material with 'Pumpkin Tooth'	310 SS with 'Pumpkin Tooth'
✓ Stage 2 Shroud	Honeycomb Shroud	Honeycomb Shroud
✓ Stage 3 Shroud	Honeycomb Shroud	Honeycomb Shroud
✓ Stage 1 Nozzle	FSX-414, Improved Cooled	FSX-414, not Improved Cooled
✓Stage 2 Nozzle	GTD-222 material	GTD-222 material
✓✓ Stage 3 Nozzle	GTD-222 material	GTD-222 material
✓ Stage 1 Bucket	GTD-111, Perimeter, BLE/DS, GT-29 I+	111, 12 hole, BLE/DS, GT-29 I+
✓ Stage 2 Bucket	IN738, 7 hole, cutter tooth design	IN738, 6/7 hole, cutter tooth
✓ Stage 3 Bucket	IN738, cutter tooth design	IN738, cutter tooth design
✓ Inlet Guide Vanes	GTD-450 material, 86° maximum angle	GTD-450 material, 86° max. angle
✓ Transition Piece	Nimonic -263 Body and aft-frame with TBC	Hast-X body N-263aft-frame with TBC
Liner	Standard combustion design with TBC	Standard combustion design w/o TBC
Inner Barrel	Standard labyrinth seal design	Standard labyrinth seal design
✓ Load Gear	5163 rpm load gear with 51 MW limit	5133 rpm load gear with 51 MW limit
Firing Temperature	2084° F	2020° F

Wheelspace Temperatures


M-6
.44
MAX


END OF TC MUST
CONTACT INNER END
OF PT16
GUIDE EXISTING
TUBING INTO END
OF PT16 UNTIL
FIRMLY SEATED



Fast Start & Black Start Capabilities

BLACK START CAPABILITY

- Diesel start
  Requires AC power for auxiliaries

- Motor start
  Requires diesel-generator set

Black start requirements – Diesel start

Auxiliaries requiring AC power must be separately supplied

- Fuel

Gas fuel is available at proper pressure. Otherwise a separate compressor required.

- Ignition Power – Spark Plugs

UPS is normally available for this. Converts battery supplied DC to AC.

- Lube Oil Pumps

DC emergency lube oil pump should be adequate.

- Lube Oil Cooling

Cooling water pumps must be energized.

- Diesel Engine Cooling

Cooling water must be provided to the diesel engine.

- Cooling Water Fans

Power must be supplied to cooling water fans

SCOPE OF SUPPLY (Diesel start)

•UPS system

•Battery system

•Controls modifications

Assumes cooling water system supplied by customer and has adequate power

OR

•A 250KW diesel-generator set with dead bus closure capability to pick up all aux. Power.

•Controls mods

Black start requirements – Motor start

All starting power must be supplied by a separate diesel-generator set with dead bus closure capability.
This will require about 1000KW set.

Table 4.1: START SIGNAL TO ISO RATED LOAD E-CLASS SIMPLE CYCLE UNITS

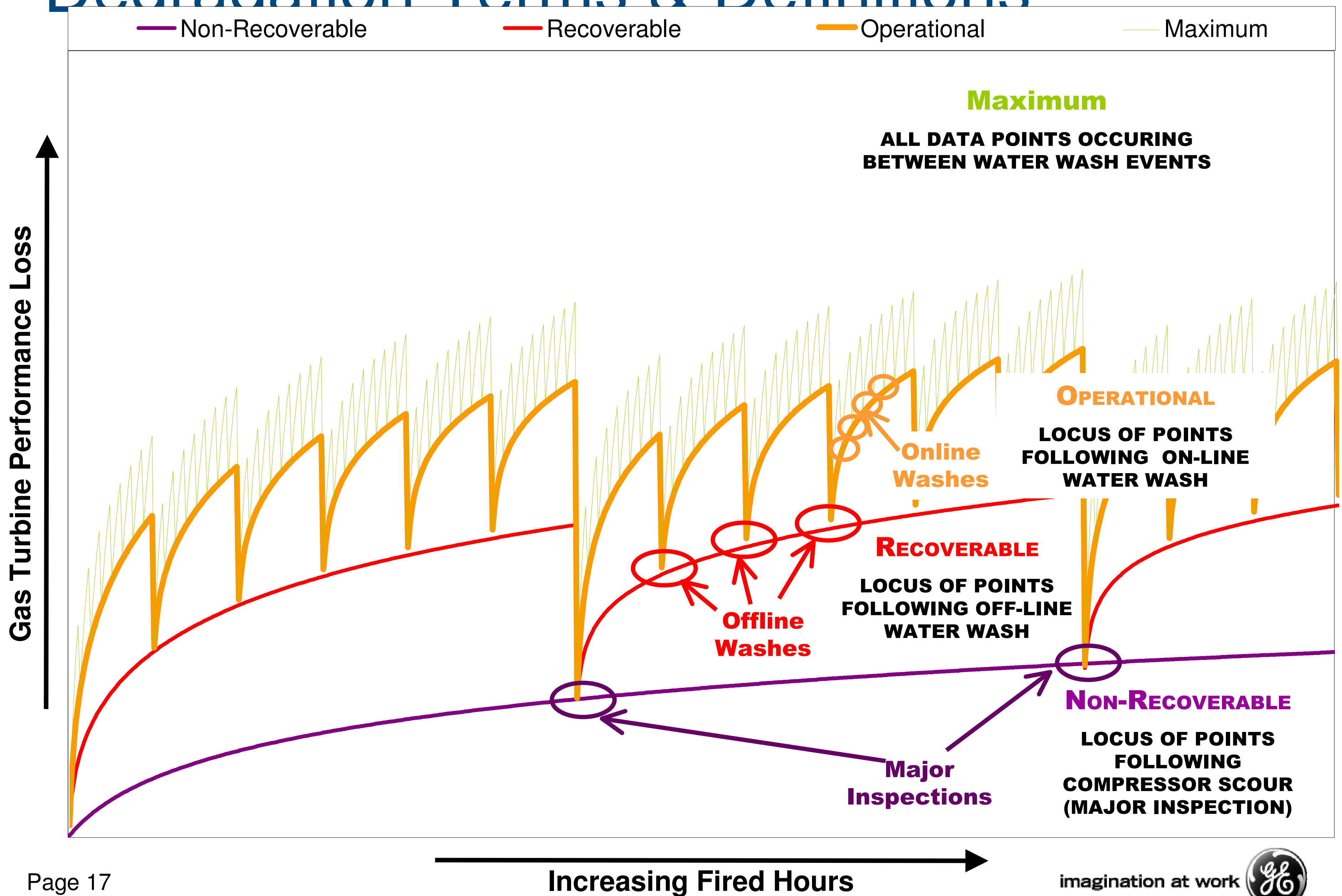
		Mean Time from Start Signal to FSNL No Purge Time included			Mean Time from FSNL to FSFL (3)						
Type of Start/Load	Starting Device	Starting Time	Stand Dev	Qutoing Limits	Load Time without DLN	Load Time with DLN	Stand Dev	Quoting Limit without	Quoting Limit with DLN	Total Time without DLN	Total Time with DLN
PG6581B											
Normal St/Normal Load	670 HP Diesel (2300 rpm) (4)	10 min	1 min	12 min	4 min	4 min	1 min	6 min	6 min	16 min	16 min
Normal St/Normal Load	600 HP Motor	10 min	1 min	12 min	4 min	4 min	1 min	6 min	6 min	14 min	14 min
Normal St/Fast Load	670 HP Diesel (2300 rpm) (4)	10 min	1 min	12 min	30 sec	2 min	1 min	2 min 30 sec	4 min	12 min 30 sec	14 min
Normal St/Fast Load	600 HP Motor	10 min	1 min	12 min	30 sec	2 min	1 min	2 min 30 sec	4 min	10 min 30 sec	12 min
Fast Start/Fast Load	670 HP Diesel (1) (4) (2300 rpm)	6 min 40 sec	1 min	8 min 40 sec	30 sec	2 min	1 min	2 min 30 sec	4 min	7 min 40 sec	9 min 10 sec
Fast Start/Fast Load	600 HP Motor (1)	6 min 40 sec	1 min	8 min 40 sec	30 sec	2 min	1 min	2 min 30 sec	4 min	7 min 10 sec	8 min 40 sec

Performance Degradation and Recovery

Performance Degradation and Recovery

- Recoverable and Non-Recoverable
- Degradation of the compressor and turbine
- Degradation factors (fouling, influence coefficients)
- Minimizing performance degradation
- Detection
- Recovery of performance
- Hot Gas Path Audit Services

Degradation Terms & Definitions



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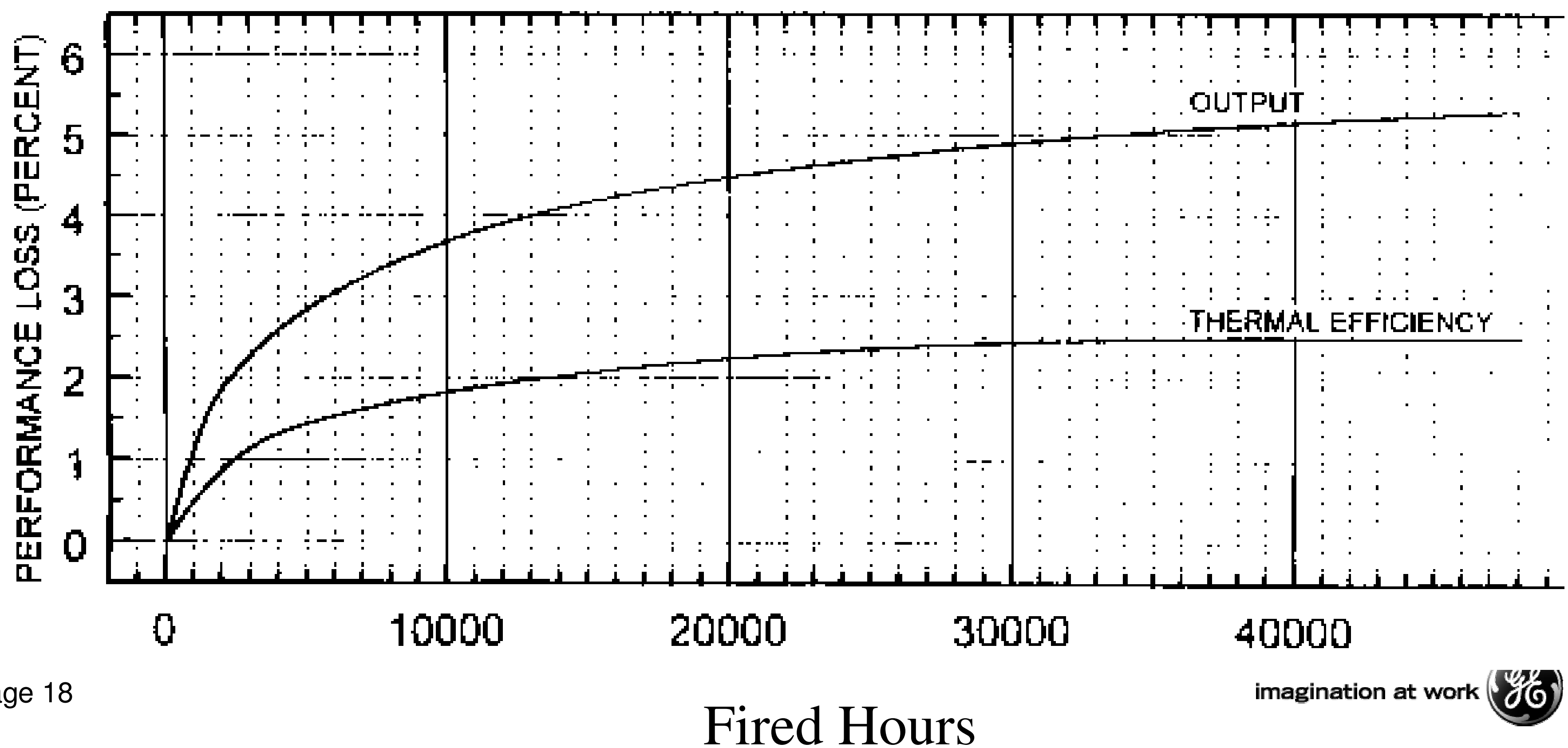
Expected Gas Turbine Plant Performance Degradation Following Normal Maintenance and Off-Line Compressor Water Wash



Degradation of the Compressor/Turbine

Compressor

- Accounts for 70 - 85% of power loss
- Caused by loss in airflow and efficiency
- Results of

Fouling	-	Recoverable
Corrosion	-	Non-recoverable
Erosion	-	Non-recoverable
FOD	-	Non-recoverable
Rubs	-	Non-recoverable
Surface rough	-	Recoverable

Turbine

- Loss in efficiency and increased leakage/cooling flows
- Results of

Corrosion	-	Non-recoverable
Erosion	-	Non-recoverable
Rubs	-	Non-recoverable
FOD	-	Non-recoverable

Compressor Fouling

- Primarily in the front stages (no moisture in rear stages)
- Impacts air flow more than efficiency
- Caused by:
  - Air borne contaminants and availability of moisture
    - dust, sand, salts, hydrocarbons, pollen, insects, industrial chemicals, etc.
    - Humidity, rain, fog, evaporative cooler
  - Other
    - Internal oil leaks
    - Evaporative cooler malfunction
    - Fogger

Minimizing Performance Degradation

Filters

- Addresses erosion problem along with fouling
- Not effective for vapors

Coatings

- Aimed at corrosion problem - roughness and fatigue
- Blade profile - surface finish trade-off
- Reduced fouling by maintaining smooth finish
- Current GE recommendation
  - GTD 450 - IGV plus first three stages
  - GECC-1 coating - middle stages
  - 403 stainless uncoated - rear stages

Siting

- Wind direction
  - Proximity to coal piles
  - Proximity to steam blowoff (cooling tower plume)
  - Gas turbine exhaust

Detection

Corrected Power and Heat Rate

- Performance monitor at base load
- Use manufacturers data to adjust for ambient conditions
- Small ratio of heat rate change to power change = airflow loss

Compressor Pressure Ratio (clean fuels)

- Compressor discharge pressure/inlet flange pressure
  - Independent of barometer, inlet system losses
  - Base load, full open IGV, constant ambient and injection
- Direct indicator of compressor airflow (1% pressure ratio = 1% air flow)

Detection (continued)

Compressor Airflow

- Calibrated bellmouth - performance monitor package
  - Inlet flange total pressure
  - Annulus static pressure at IGV
  - Compressor inlet temperature
  - Standard equation for flow nozzle
  - Bellmouth flow coefficient - from factory test

    Not required for trending
- Must “correct” for ambient conditions

Recovery of Performance

Compressor Washing - GEK 103623A

- Dissolves deposits
- Need to understand nature of fouling - detergent
- On-line wash - does not interrupt operation, minimal build-up
- Off-line wash - more effective - more liquid. Use of “hot” water for heavy front end fouling, hand clean first
- Discourage abrasive cleaning on - line

Filter Replacement

- Inlet filter plugging -- 4 inches water = at least 1% power

Compressor Cleaning

- Hand scour or solid CO2 blast
  - Mechanical removal of deposits
  - Casing off procedure

Maintenance Considerations/Clearances

Precision Clearances Taken During Outage

Hot Gas Path (HGP)

1. Turbine and Compressor Open 6 Point Clearance
2. Turbine Clearance Checks
   a. First stage nozzle support ring to first stage nozzle segment support pad
   b. First stage nozzle clamp
   c. Axial rotor clearances
   d. Axial seal clearances
   e. Axial diaphragm to turbine wheel
   f. Radial seal clearances
   g. Bucket tip clearance
   h. Diaphragm radial seal clearance
   i. Rotor set point
   j. First stage nozzle support ring shim
   k. Shroud to bucket clearance
   l. Axial clearance support ring set dimension
3. Rotor Float (Thrust Clearance)
4. First stage nozzle radial concentricity check (opening and closing)
5. Recheck first stage nozzle radial concentricity check
6. Recheck turbine clearance checks
7. Verify transition piece side seal clearances and clearance to first stage nozzle
8. Turbine and compressor closing 6 point clearances

Precision Clearances Taken During Outage

Major Inspection (MI)

1. Initial unit alignment check
2. Initial compressor and turbine rotor 6 point clearance
3. Rotor thrust check
4. Initial compressor half shell clearances
5. Turbine clearance check
6. First stage nozzle radial concentricity check
7. Bearing seal clearance
8. Recheck compressor half shell clearances
9. Recheck rotor thrust
10. Recheck first stage nozzle radial concentricity check
11. Recheck turbine clearance checks
12. Verify transition piece side seal clearances and clearance to first stage nozzle
13. Turbine and compressor closing 6 point clearances
14. Recheck unit alignment

Precision Clearances Taken During Outage

At the second major, precision clearances are pretty much impossible due to
- **Case distortion**
- **Foundation shifts**
- **parts not repaired to spec, etc**

Closing clearances need to be evaluated on an individual basis against the next planned outage, history, etc

Compressor Section Recommend Inspections

The following recommendations are for compressor's 2nd, 3rd and 4th major inspections and peak operation units:

Compressor Blades

- Bent Tips
- Airfoil surface for nicks and dents
- Blade rock
- Erosion, Corrosion, and Deposits on the vane
- Pits

Stator Vanes

- Bent Tips
- Airfoil surface for nicks and dents
- Blade rock
- Erosion, Corrosion, and Deposits on the vane
- Verify stator rock and stator vane drops.
- Pits

Compressor Casings

- Inspect for cracks in the casing and signs of rubbing.
- Inspect stator vane slots for excess wear and hook fits for damage.

Compressor Section Recommend Inspections

Most critical to watch for are corrosion pits, especially on the 3rd stage stator vanes and on VIGV's (TIL on pitting sizing and location limits)

Check for corrosion/rusting on the back end blades/vanes

Check the wheel rim gaps on four places per stage (if the rotor is not to be removed)

Consider changing out blades/vanes if performance loss is significant

If through bolts are checked (rotor removed/dismantled) and more than 3 need to be replaced, replace the whole set.

If vibrations are creeping up, check the marriage joint and clean it up. Replace the marriage bolt set (do not reuse).

Technical Information Letters – Issued 2005

TIL #	Title	Description
1275-1R2	Excessive Gas Flow at Start-Up	Inform users of the startup characteristics for gas turbines
1535-2	6B (PG 6581) Wheelspace TTWS1FI 1-2 Settings	To inform customers the constant WSKALM1 must be changed from 820F (438 C) to 800 F (427 C)
1537-1	High Gas Flow at Startup - Lratoohy Logic Sequence	To inform users of possible issue with the startup control sequence related to high gas flow protection implememnted prior to 2002 and enhanced control sequence that includes a P2 highpressure check during startup and Bottle Check test is available.
1448-2R2	6B TNHCOR CORRECTED SPEED MODIFICATION	To inform users of a correction factor to the TNHCOR corrected speed value and change the overspeed trip setpoints.
1505-2	6B EXPANSION JOINT COUPLING MODIFICATION	To advise users that the stop stakes are not installed on some 6B EJC.
1214-3R3	6B, 6C, 6FA, 6FA+E, 7F, 7FA, 7FA+, 7FA+E, 7FB, 7H, 9F, 9FA, 9FA+, 9FA+E, 9FB, AND 9H bucket lockwire dowel pin assembly procedure and lockwire inspection	Assembly procedure for bucket lockwire dowel pins and recommended inspection of bucket lockwire
1480-2R1	MARK V FIRMWARE UPGRADE	Mark V firmware upgrade to increase operating reliability of control outputs.
1518-2	MAINTENANCE AND INSPECTION REQUIREMENTS FOR GAS TURBINE AIR INLET SYSTEM	Explain the required maintenance, inspection and recommendations for the inlet filter compartment, inlet ductwork and plenum.
1469-2R1	DC EMERGENCY PUMP RECOMMENDATIONS	Recommenations for reliability of the emergency DC pump
1520-1	HIGH HYDROGEN PURGE RECOMMENDATIONS	Inform users of the risk associated with operating gas turbines with high hydrogen content fuel without protection of a nitrogen purge system.
1528-3	LUBE OIL VARNISHING	Provides information over the formation of varnish or lacuers within the lube oil system and their effects and information reagrding mitagation technologies.
1524-3R1	COMBUSTION SPREAD MONITOR UPGRADE FOR MK V AND MK VI	Provide a new and improved combustion monitoring protection software that will enhance the reliability and operation of the gas turbine