

PGT25+ to PGT25+G4 Uprate

Benefits

- ■ ■ Increased production
- □ □ Higher efficiency
- ■ ■ Compliance with environmental regulations
- □ □ Availability and Reliability
- ■ □ Life extension

Customer benefits include the following:

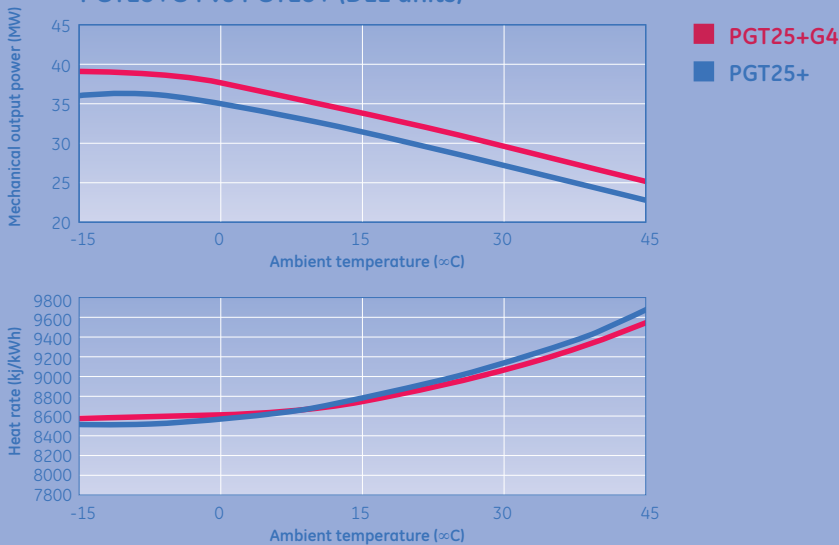
- Significant increase in shaft output power with limited modifications to the existing package
- Higher HSPT reliability resulting from the additional cooling manifold and heat shield
- True zero-hour gas generator and HSPT components

Especially if planned concurrent with a major overhaul of the existing PGT25+ and with a buy back of the existing LM2500+, this uprate has a small incremental cost and a relatively short pay-back period.

Performance

The figures below show the effect of compressor inlet temperature on output and base load heat rate with zero inlet and zero exhaust pressure drops at sea level, 60% RH, and natural gas, at 100% LP shaft speed.

PGT25+G4 vs PGT25+ (DLE units)



What it is

The PGT25+G4, with a rated ISO shaft power output of 34MW and 41% efficiency (DLE version), is the largest machine in GE's PGT25 series of aeroderivative gas turbines. The PGT25+G4 enhances the PGT25+ with increased flow capacity in the high pressure (HP) compressor, and HP and LP turbines. As with the previous version, the PGT25+G4 is derived from the coupling of an aeroderivative LM2500+G4 gas generator and a 6100 rpm HSPT/G4 power turbine. The LM2500+G4 builds on 15 ppmvd NOx aircraft engine combustors designed for LM6000 and LM2500+ technologies. The LM2500+G4 design with a single annular combustor has the same fuel flexibility as the LM2500+. It is capable of operating with steam injection for NOx abatement with a variety of fuels and water including:

- Natural gas
- Syngas and medium BTU gas
- Liquid fuel
- Dual fuel (natural gas or liquid fuel)
- Bi-fuel (natural gas and liquid fuel)

DLE applications include:

- Gas only DLE at 25 ppmvd
- Dual fuel DLE at 25 ppmvd

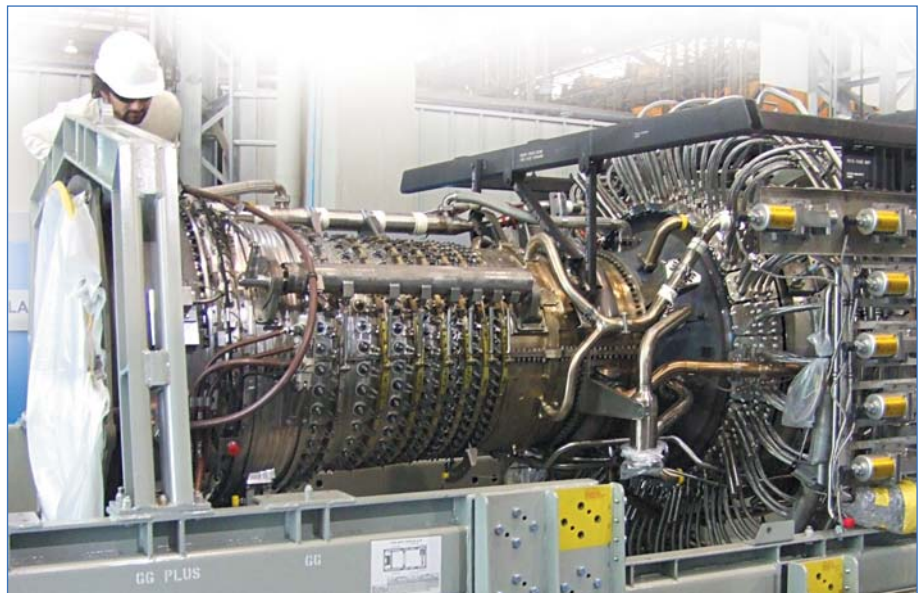
The Gas Generator has already been successfully tested on natural gas fuel at the GE Aviation Cincinnati Test Facility, where the design robustness and component structural behaviour have been verified, and the MarkVI core engine control tuned. PGT25+G4 DLE technology has already been released to a launch customer, and commissioning of the two/three units is set for mid-2007.

How it works

Gas Generator

The LM2500+G4 gas generator is the updated version of the LM2500+ with increased flow capacity in the High Pressure (HP) compressor and increased firing temperature. The LM2500+ gas generator incorporates a 17-stage axial-flow compressor capable of reaching a 24:1 pressure ratio. Inlet guide vanes and adjustable stator vanes on the first seven compressor stages provide efficient stall-free performance over the entire operating range. An annular combustor delivers a uniform temperature profile to the two-stage high pressure power turbine driving the axial compressor. The LM2500+G4 builds on the LM2500+ heritage and its demonstrated reliability, and incorporates proven technology advances and a high percentage of parts commonality to deliver the same outstanding reliability. The design changes were limited to increased mass flow and firing temperature, while maintaining the

same overall dimensions and frame of the LM2500+. Structurally, all frames and HP compressor front and aft cases remain unchanged. The sump hardware and the number of main shaft bearings also remain unchanged, and all share the successful experience of the PGT25+.

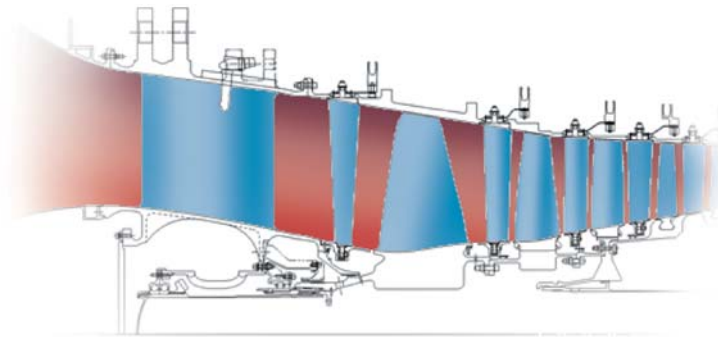


How it works

Main Modifications:

Axial Compressor

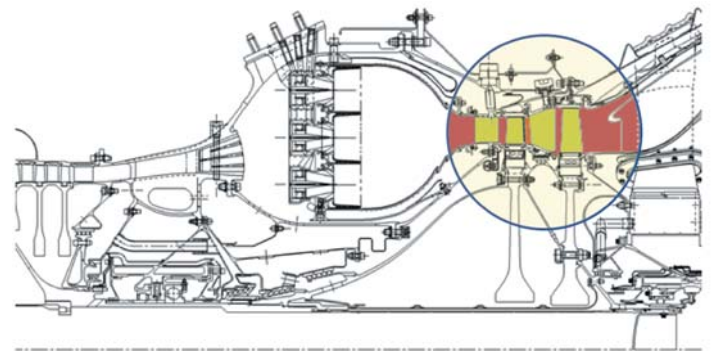
- The extent of design changes is limited to minor blade and stationary vane airfoil adjustments that provide the required mass flow increase



Axial compressor flow path

High Pressure Turbine

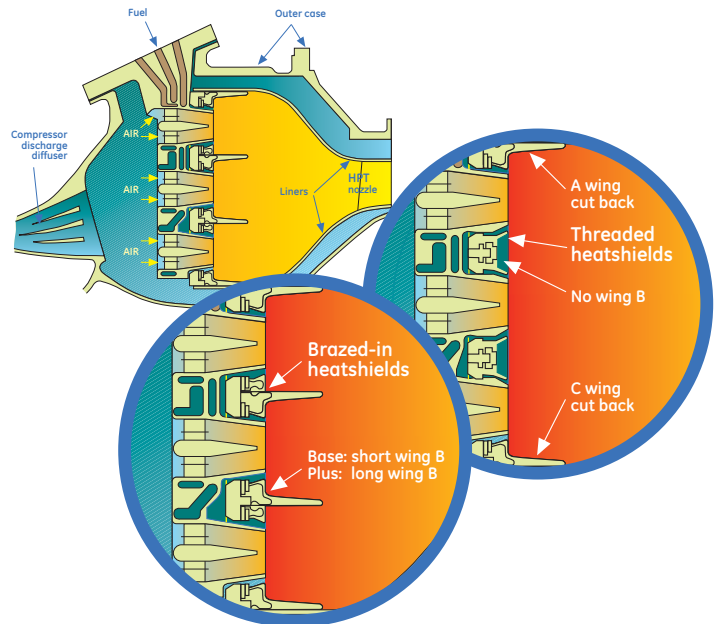
- The HPT modifications include minor blade cooling improvements and proven material upgrades from recent aircraft engine technologies that provide reliable higher temperature capability



High pressure turbine

DLE Combustor

- For DLE applications, the combustor is upgraded with B ring wingless heat shields, by cutting back the A and C ring heat shields, and through bolt in heat shields that will allow field replacement and hence an improved overall combustor maintenance cycle
- The fuel metering system is upgraded to 5 fuel metering valves in order to keep NO_x emissions at the same level as the LM2500+, even with the increased firing temperature



DLE combustion system

With these very limited changes, the LM2500+G4 provides the same efficiency, reliability, availability, emissions and maintenance intervals successfully demonstrated by the LM2500+ fleet.

How it works

Power Turbine - HSPT/G4

The PGT25+G4 HSPT power turbine is an improved 2-stage HSPT that has been developed to take advantage of the increased flow and temperature of the G4 Gas Generator. The HSPT/G4 is based on the proven technology already developed for the PGT25+ Gas Generator; it also incorporates lessons learned in the field as well as enhanced frame cooling. Most of the hardware is common with the PGT25+ HSPT including the same frame, bearings, lubrication system, and proven materials. Thanks to this heritage, the HSPT/G4, will provide the same reliability, availability and maintenance intervals as its predecessor.

Main modifications:

(Figure 1)

1st Stage nozzle

- Scalloped outer platform
- New casting

1st Stage blade

- No aerodynamic change;
- Material changed to GT111 DS
- Modified OS fillet

Casings

- Additional cooling manifold (air taken from 9th stage bleed), see Figure 2
- Insertion of heat shield

Outer Transition duct

- Material changed to Haynes 230

Scope of Supply

The PGT25+G4 is the natural evolution of the PGT25+ when the customer

requires higher shaft output power. Thanks to the commonality of the footprint, centerlines and flanges with the PGT25+, the conversion can be carried out with little modification to the PGT25+ standard packages. The basic scope of supply includes:

- New LM2500+G4 gas generator
- Upgrade kit for HSPT to HSPT/G4
- Upgrade kit for fuel metering skid
- Control panel software/hardware upgrade

The following items must also be evaluated on a case-by-case basis:

- Ability of the Inlet air system/filter house to deliver the increased airflow
- Driven equipment rating to be verified (load coupling, gear box, etc.)
- Space to accommodate new fuel metering skid within the base plate.

Scope of Work

The basic scope of work includes:

- Removal of existing LM2500+ gas generator and HSPT
- Upgrading or replacement of the existing fuel metering skid
- Replacement of the DLE rack (fuel skid drivers and transducers)
- Installation of upgraded or new HSPT/G4
- Unit control panel upgrade
- Pre-commissioning activities (loop checks, lube oil flushing, etc.)
- Engine mapping (DLE applications)

On a case-by-case basis the following activities may also be required:

- Inlet air system modifications
- Driven equipment modifications
- Base plate modifications in order to accommodate new fuel skid.

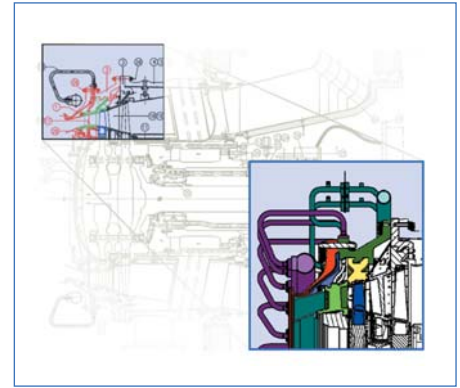


Figure 1

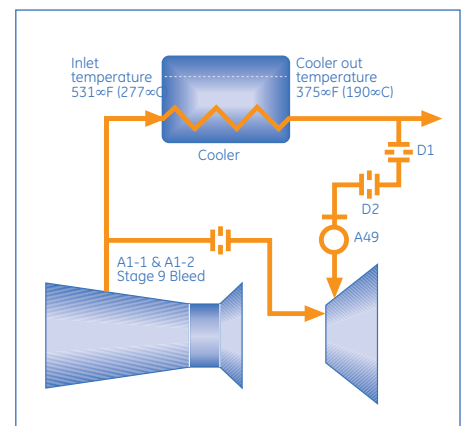


Figure 2



GE imagination at work