MECHANICAL WORKS REPORT
Executed on GT5

Xxx CITY, March 2020 – Sept 2022

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1	XXX XXXXXX XXX	XXX XXXXXX XXX		FINAL
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1. Preface

This report describes all the combined mechanical works, which have been executed during the repair period from the original crash of the unit due to compressor blade stage 1 failure in March 2020 up to the final hand-over of the unit after replacement of the no 2 bearing vibration probe in September 2022.

The detailed mechanical work records, protocols, inspection reports, and suppliers reports can be found in the individual folders consisting of:

- Compressor failure march 2020
- Hot section damage during startup march 2021
- PT probe replacement June 2022
- Bearing no 2 sensor replacement September 2022

2. Summary

In 2020 the GT5 unit crashed due failure of the compressor blade 1. RCA investigation was performed by XXX XXX.
After removal of the engine from the package in CITY the unit was fully disassembled and inspected in the workshop in . A detailed inspection report can be found in the folder.

During commissioning of the unit a tip of the no 2 turbine blade was dislodged damaging the hot section upstream of turbine blade no 2. An investigation report and inspection report can be found in the folder. The gas generator was removed and brought to the workshop in for inspection together with the guide vane 3 module and guide vanes 4. The power turbine remained in the package. A used gas turbine was procured as a replacement unit. The original plan was to install this replacement unit, but detailed inspection of the compressor revealed that there was some damage on the compressor blades 6 to 8. Final decision was made by the client to use only the turbine blades 2 and upward to repair GT5 unit.

Subsequently during commissioning the insulation on the rear of the PT diffusor shifted. This caused the rear of the inner casing to become exposed to the exhaust casing heat. A rubber gasket on the lube oil supply line melted and caused a small oil leakage. The heat and the oil leakage resulted in a small fire, the heat also caused several of the cables to melt. The probes (including the no 3 bearing vibration probes were replaced using serviceable instruments from the replacement engine)

The unit was restarted for commissioning. However random spikes occurred on the no 2 bearing vibration sensor. Investigation revealed that the spikes were caused by and electrical and no mechanical problem. The decision was made to open the unit and investigate the problem.
Inspection during disassembly revealed that the cable and the no 2 vibration probe are not connected were there should be fixed together.
(Note: during creation of this report the root cause of the loose cable is still under investigation by the supplier. XXX XXX is under the impression that it was a production error)
After replacement of the probe the unit was restarted and balanced to reduce the vibration.

Several low priority punch list items are still open and have been recorded in the hand-over protocol.

3. Recommendations

It is recommended to replace the Power Turbine diffusor.
During assembly of the unit the position of the power turbine was too low and just outside tolerances.
PT fix has already been executed and in addition the labyrinth ring was already lowered to max down position during previous outages.
The option to install -3 excenters and new blocks might improve the position of the power turbine slightly.
Should a new diffusor casing be installed, it is also recommended to replace the mating ring. The ring that is currently installed does not match with the PT diffusor (ring has 63 holes, PT diffusor has 64 holes)

The PT oil return line (large DN250 flexible line at bottom) is to be replaced in the future as it is possible damaged an leaking a very minor amount of oil. Also the position could be improved to properly align the flanges.

4. General Information

4.1. Installation data

Unit:	GT5
GT Model:	SGT600
Serial number:	
Total operating hours:	Unknown
Total starts:	Unknown
Total EOH	Unknown
TSLI	Unknown

4.2. History

Date	CHP Hours	CHP Starts	Hours	Starts	EOH's	Reason
Aug 2022	163.730	1.396				No 2 bearing vibration sensor replacement
May 2022	163.715	1.355				PT probe replacement
Feb 2021	163.713	1.354				Hot section Damage
03-march-20	163.708	1.352		1.203	75.315	Trip due to compressor surge
19-feb-20						Bypass valve actuator adjustment due to position error
02-apr-19	157.508	1.340		1.194	70.246	PFR adjustment due to start failure
Dec-18	155.703	1.319		1.186	68.813	Turbine guide vane 1 replacement
May-16				1.175	60.933	Level D-inspection
Jan-12						Level C-inspection
Jan-11						GT replacement

4.3. Reason for inspection

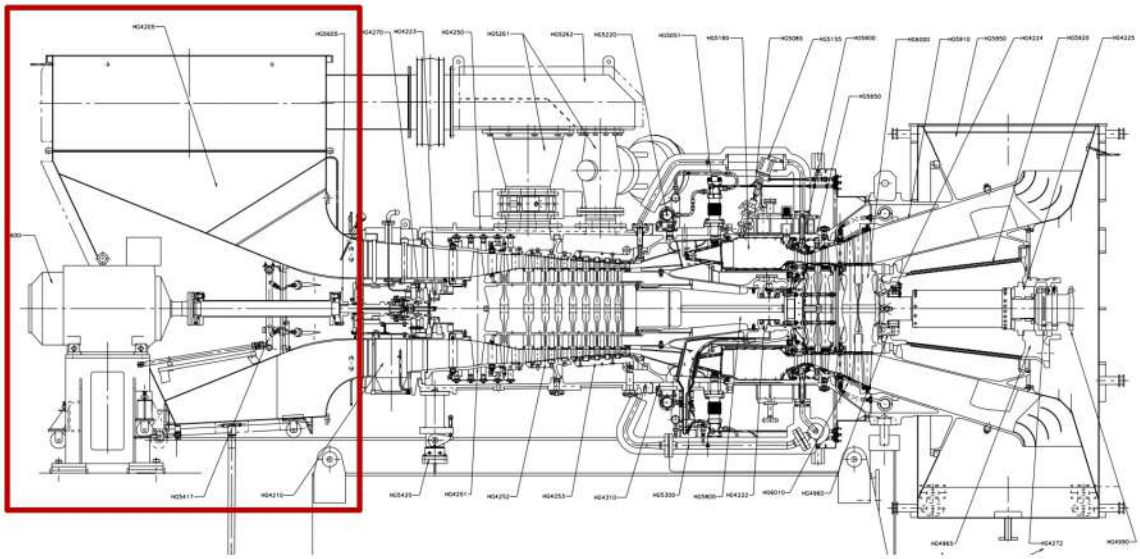
- Compressor failure march 2020
- Hot section damage during startup march 2021
- PT probe replacement June 2022
- Bearing no 2 sensor replacement September 2022

4.4. Personnel & duration

Daily progress reports can be found in the folder
Resource planning and time sheets are available for review at XXX XXX upon request due to privacy legislation.

5. Mechanical works

5.1. Compressor Inlet & starter



No work has been performed in the starter or flex coupling.

The inlet section has been fully repainted using Rustoleum 9100 2-component eposycoating (color Pastelblauw RAL5024) due to corrosion. Work was performed when the inlet duct was outside the package.

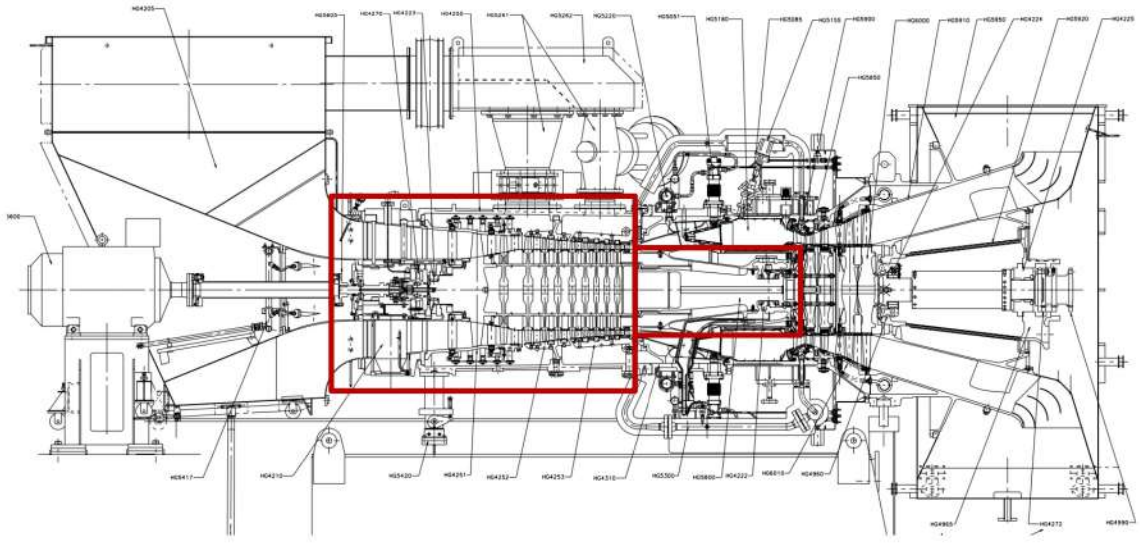
The inlet was modified with three T1 probes upon request of the client. New studs for the T1 probes were welded in place in the workshop in and area was recoated. Cabling was connected by Equans and system logic was changed by Controls.

The incorrect gaskets of the compressor wash nozzals were replaced to the correct High pressure type.

The damaged flexible compressor wash hose was replaced for a new component.

Remaining parts of the compressor inlet housing interior was cleaned from oil pollution

5.2. Compressor blades/vanes/IGV's/rotor/casings



All compressor blades have been replaced with new blades which have a 5380 DP aluminum oxide anti fouling coating. After installation of the blades the rotor assembly was high speed balanced at VDL including a 3 minute overspeed run at 10% overspeed. The blade tip clearances were checked during installation.

All compressor guide vane segments and IGV's were replaced by new. Including modification of the no 2 guide vane segments to the 8 segment type.

The compressor central compressor casing was replaced by new

All compressor stator rings stage 6-10 were replaced by new rings.

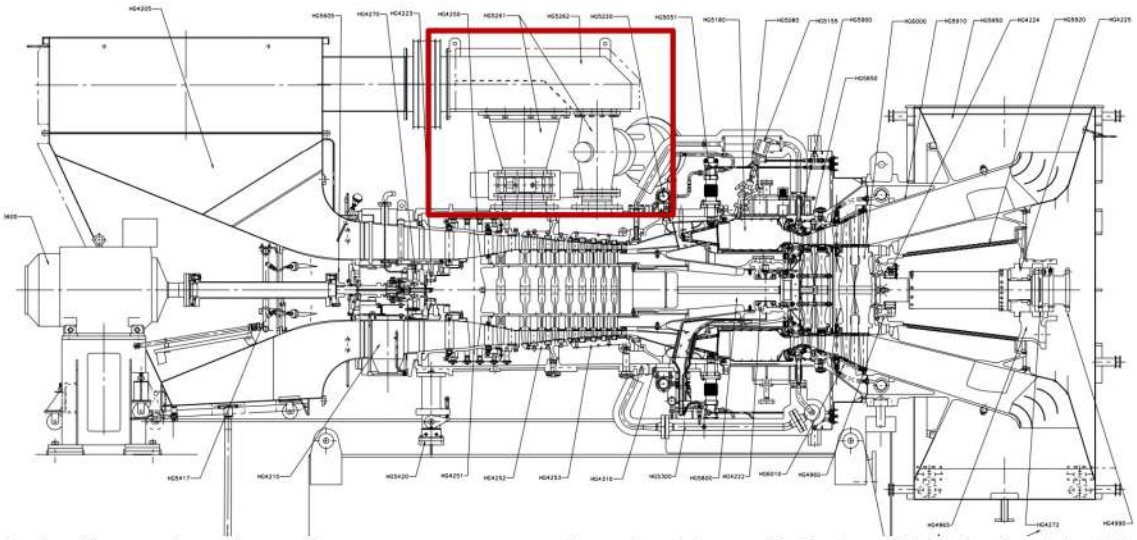
The front compressor casing inner diameter was machined and 0,15 mm was removed to correct the impact damages from the compressor crash. A sermatel 5380 DP aluminum oxide anti fouling coating was applied with a coating thickness of 100 to 200 µm to restore the diameter. New bushing, o-rings, washers and guide blocks were installed and lubricated with Kluberplex SK12 grease.
After adjustment of the washers thicknesses in order to achieve the correct S1, S2, and S3 gaps the IGV mechanism was tested and found to be opening and closing at 85 KG force.

All casings were cleaned from debris and final adjusted to the correct position after installation in the package.

The position of the no 2 bearing labyrinth casing could not be adjusted. The excenters could also not be removed from the casing and had completely seized. Decision was made to leave it in the as found position.

The compressor rotor was NDT (DP and Eddy current) inspected by XXX XXX as part of the LTA program, but found without any indications and reinstalled.

5.3. Bleed valve stage 1 & 2/duct



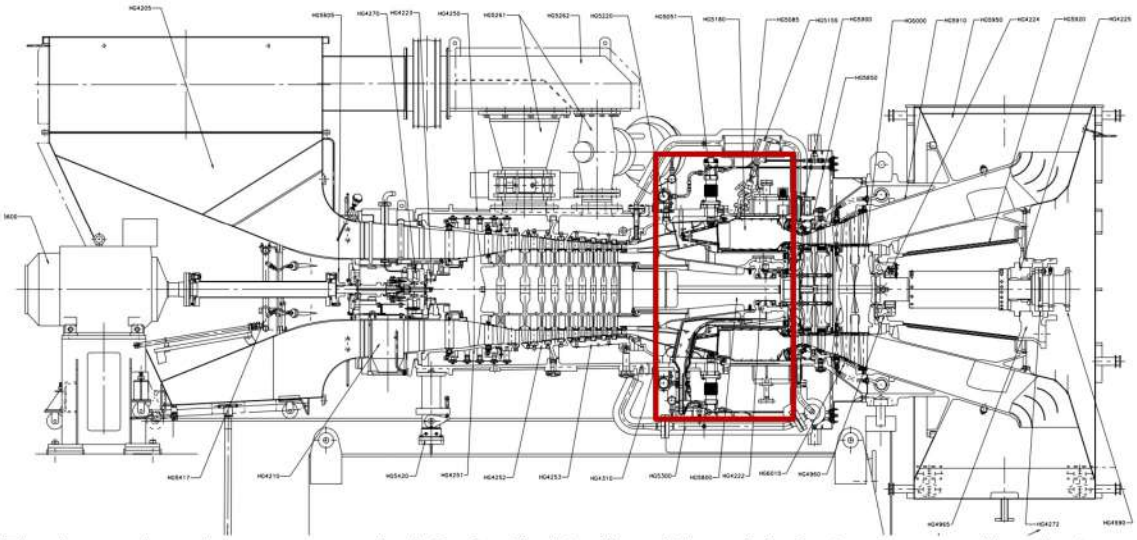
During the repair works another user experienced problems with their no 2 bleed valve. The DJP bleed valve was send to
The bleed valve no 2 from was overhauled at MLP and later installed in the DJP unit.

New air filters and connectors were installed om the bleed valve 1 and 2 air connection. As during installation it was noted that the brass filters were missing and the connectors were extremely brittle and had cracked.

The ducts were cleaned prior to installation and all debris was removed.

Graphite gaskets were installed as per Siemens service bulletin/MOD at the bleed valve flanges.

5.4. Combustion Chamber/EV Burners/Fuel Injectors/gas hoses/central casing



The damaged gas hoses were repaired. During final testing of the unit in September a small gas leakage was found at the #11 burner (connection of the main gas hose to the gas manifold. This could not be corrected by tightening, hence a gas hose from the replacement unit was installed.

The combustion chamber was replaced by a new component with latest version bypass sleeves (beer jug type). During installation of the burners it was noted that the connection of the EV cones to the burner was not correct on two positions. The manufacturer was notified and could be easily corrected on-site while the combustion chamber was installed by manufacturing a 1 meter pipe with M48 internal threads to slightly adjust the EV-cone position.

The fuel injectors were completely disassembled and cleaned. The compensators were modified as per Siemens service bulletin/Mod, which should reduce the chances of damages to the compensator. During incoming inspection of the compensators three flanges were found to be improperly positioned (not parallel). This was corrected by the supplier.

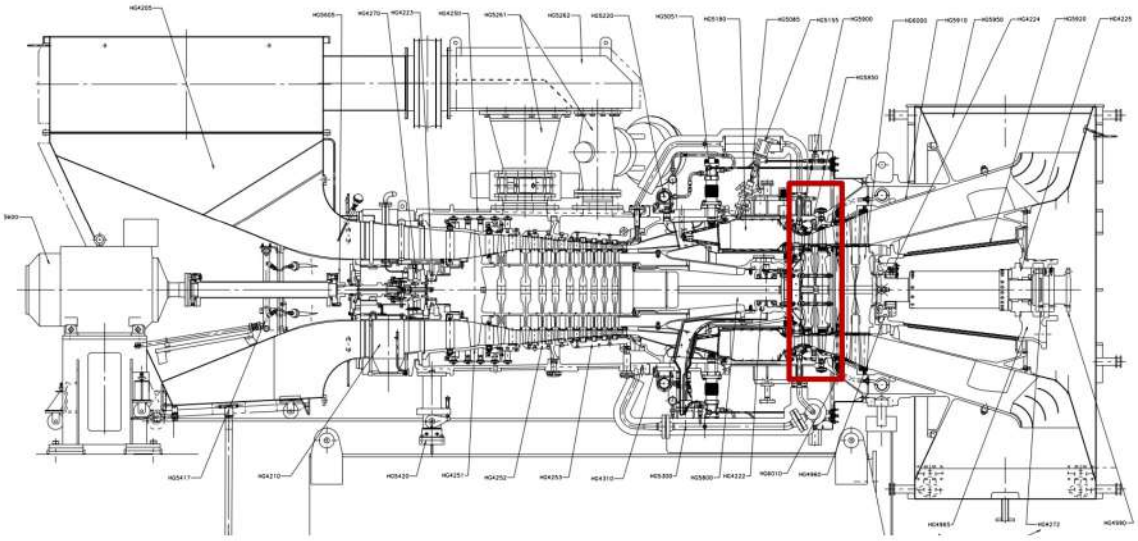
The fuel injector and combustion chamber were flow tested and orifices were adjusted by Xenerlyze. During 1st start-up a high temperature spread was noted. The assembly was therefore re-checked whilst installed. During flow testing it was quickly noted that the no 6 position burner was rotated 180 degrees causing the pilot gas connection to be connected to the main gas and vice-versa.
The combustion chamber and guide vanes were boroscoped and the error had not caused any damages to the combustion chamber or the guide vane 1 assembly.

The missing bolt from the no 2 bearing drain was installed and gaps were adjusted.

A weld repair was performed on the ignition burner and re-installed. The ignition cable from the secondary/spare spark plug was replaced during final commissioning in September 2022 as it was found not to be functioning. During disassembly of the cable the ceramic connection came loose.

The inner combustor casing was re-installed

5.5. Compressor Turbine blades/vanes/disks/turbine casing



All bypass sleeves were changed to new beer jug type. Additionally the bypass sleeve blocks were modified with cups and springs from the replacement unit. The locking pin was replaced and modification with T3910 locking plate was implemented, which should stop the hot air leakages.

The bypass valves were overhauled and graphite gland bushings were replaced. A T3910 locking plate was installed during assembly to stop the hot air leakages from the valve.
During final commissioning it was noted that the bypass system was not functioning properly causing positioning errors. Investigation revealed that the swiveling arm of the bypass actuator had been overstressed in the passed causing play on the keyway.
The bypass actuator was therefor replaced with the bypass actuator of the replacement unit. The removed bypass actuator will be repaired.
Additionally the no 5 position bypass valve was found to be heavy to move and replaced by a assembly from the replacement unit as a precautionary measure. The arm of the removed valve also revealed a crack.

The no 1 guide vanes were replaced by new together with the swirler plates. During the hot section damage incident they were visually and NDT inspected but did not have any indications and therefor re-installed.

The no 1 blades were replaced by new together with the no 1 honey comb segments. During the hot section damage incident they were visually and NDT inspected, but did not have any indications and therefor re-installed. The minor impact damaged on the disk 1 from the compressor crash were left as-is.

13 of the no 2 guide vanes were replaced by new.
During the hot section incident all vanes were visually and NDT inspected and one additional vane at pos 37 was replaced with a used serviceable vane from the replacement unit.

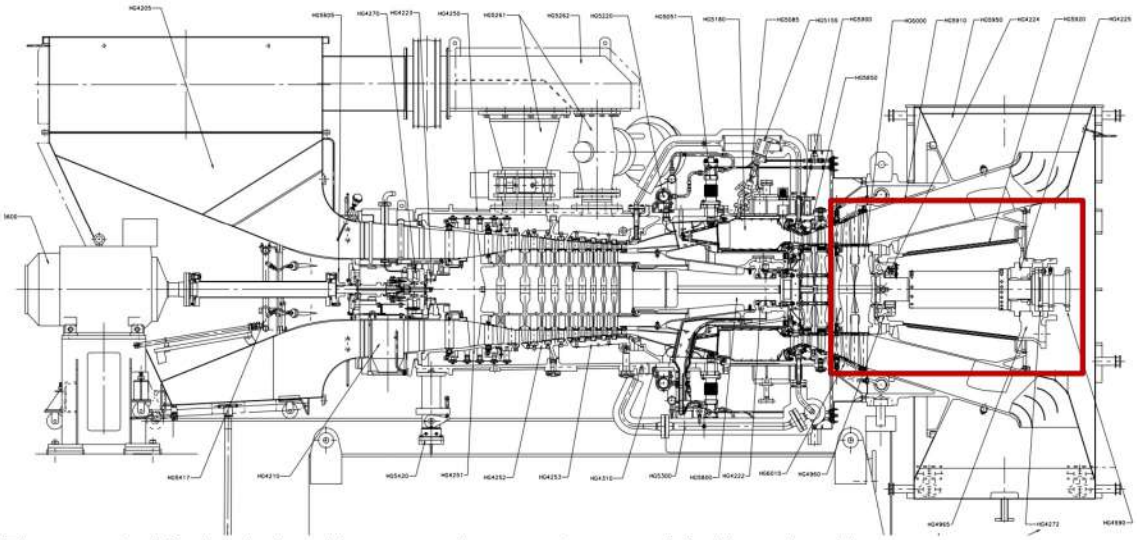
The no 2 blades were originally replaced by new but during 1st commissioning the tip of one blade ruptured damaging the hot section down-stream.
Used blades no 2 and honey comb stage 2 were replaced with components from the replacement unit during the hot section incident. In addition the guide vane 2 ring diameters was checked for un-roundness, but was found to be within limits.
The position of the HPT assembly was adjusted on-site after installation.

Disk 1 and 2 were NDT (DP and Eddy current) inspected by XXX XXX as part of the LTA program, but found without any indications and reinstalled.

After the hot section incident the flex coupling was replaced by the coupling from the replacement unit to improve the axial and radial run-out of the turbine.
Additionally also the Tie bolts and tie bolt nuts were replaced from the replacement unit. Reason was that two of the original tie bolts were from a different set. This was not noted during previous inspection and installation.

During 1st commissioning a large air leakage was noted on the compressor wash drain line of the turbine casing. The flexible line was found damaged and was replaced to correct the leakage.

5.6. Power Turbine blades/vanes/disks/rotor/inner casing



The power turbine blade 3 and honey comb segments were originally replaced by new.
After the hot section damage the blades were damaged and replaced on-site by used serviceable blades from the replacement unit together with the honey combs 3 (complete guide vane 3 assembly form the replacement unit was used.

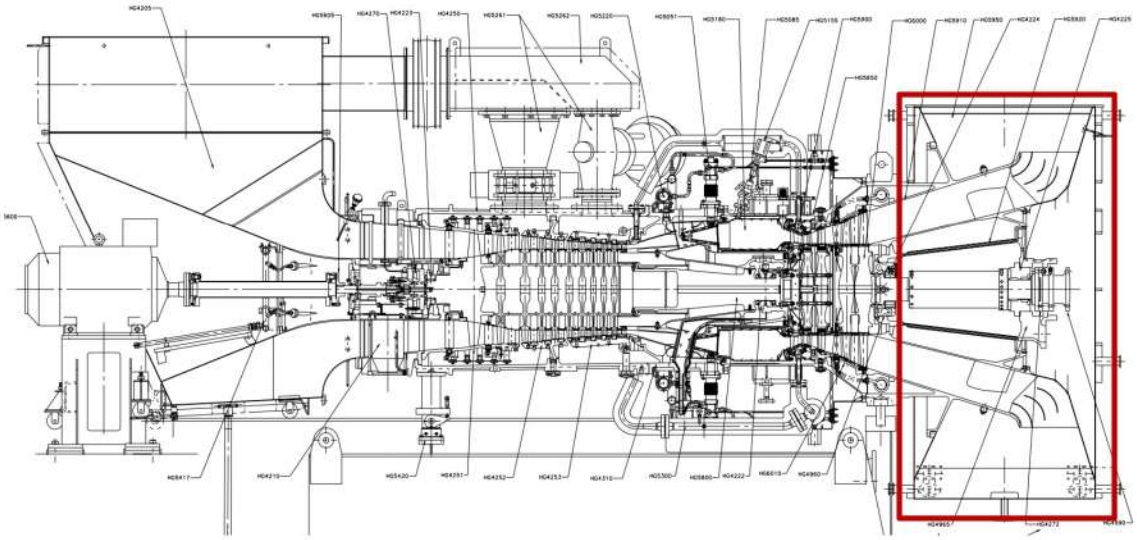
The power turbine blade 4 were originally re-installed, but replaced on-site by used serviceable blades from the replacement unit during the hot section incident.

The guide vanes 3 were originally re-installed. During the hot section incident the complete guide vane 3 assembly from the replacement unit was installed because of damages to the guide vanes and inner and outer platforms.
The guide van angle plates which position the angle of the guide vanes 3 were changed from the original unit.

The original labyrinth ring was re-installed. However during final installation it was noted that new holes had been drilled to compensate for the sagging of the PT.
The ring was previously positioned in such a way that it is in the absolute lowest position.
New -2 version excenters were installed, but during final installation it was noted that this was insufficient to adjust the PT position to the center. It was therefor decided to leave the position as is and outside tolerance.
For future outages it is recommended to replace the PT diffusor because there is a very small chance that -3 excenters will be able to bring the PT position within limits.

During start-up after the hot section incident the insulation on the rear of the power turbine came loose. This caused the area to be overheated and resulted in a small fire.
The cabling in the area was damaged and subsequently all the probes

5.7. Exhaust/ PT diffusor

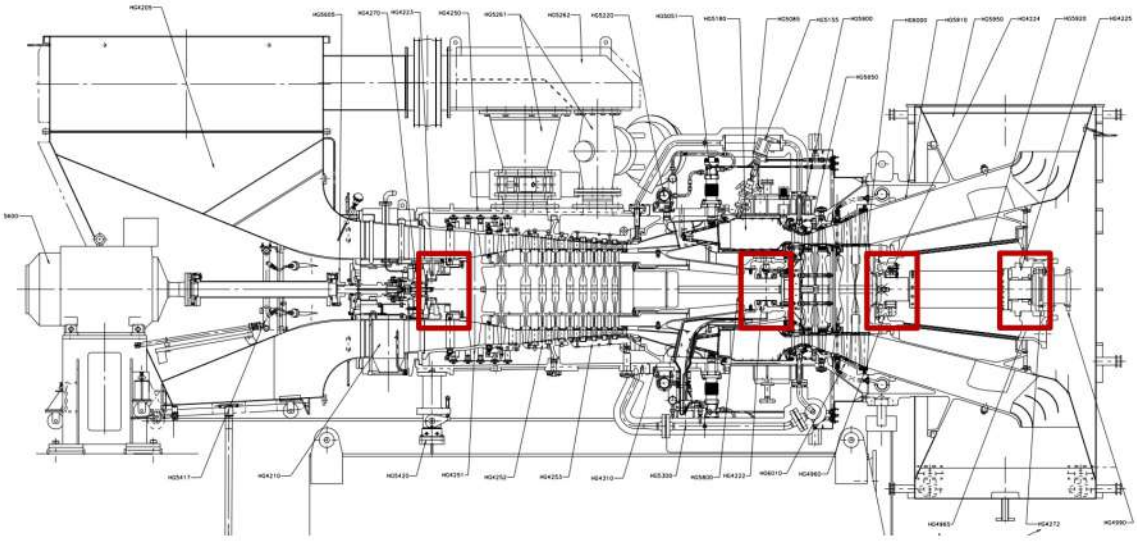


Cracks in the corners and flanges of the exhaust were repaired by the client. Additionally the insulation and the horizontal compensator were replaced by the client.

The T7 thermocouples and bushings were cleaned and checked for proper installation.

The broken bolts of the PT diffusor were replaced and the incorrect bolts were replaced. It should be noted that the PT diffusor is of the latest version, but that the ring installed in the exhaust has not been changed during modification. The diffusor has 1 bolt hole more than the ring. Therefor previously M10 bolts and nuts whereas M12 bolts should have been installed.
This was not corrected during the outage and was re-installed as found. In order to minimize the risk of hot air leakage a high temperature sealing compound was used on the front and rear flanges.

5.8. Bearings



All bearing housings were cleaned from oil coking. Oil analysis revealed that although the oil has a dark color it is still in suitable condition.
Radial bearing pads 2 and 4 and axial bearing pads 4 were replaced by new as per recommendation.

5.9. Gas turbine Externals

The non-standard bolts were replaced by the required T1663 version.

The bronze insert was not replaced as it was later found that it's function is only to guide the front support and not for alignment of the unit as was presumed during inspection.

The missing studs on the exhaust as well as the compensator and insulation were replaced by the client. Also cracks in the corners of the exhaust and boiler inlet section were corrected by the client.

5.10. Lube oil system

The oil temperature control valve was removed cleaned and new AMOT control elements were installed.

Due to issues with maintaining the lube oil temperature the lube oil cooler was removed for cleaning. It was send to Kelvion were after inspection it was noted that the cooler could not be cleaned due to amount of pollution. A second opinion was performed by CP heat exchanger who came to the same conclusion. Both coolers were replaced by new.
During the 1st start-up it was noted that the oil system/tank was polluted by oil coking. In total 12 filters were replaced due to high delta pressure.
The lube oil coolers was therefor removed again, cleaned and pressure tested at CP heat exchangers during the hot section incident as part of the oil system flushing.
The 3-way valves were overhauled and pressure tested during the initial works at

The duplex filter unit was cleaned and overhauled in the workshop and pressure tested with air.

The main lube oil and booster pumps were overhauled at During 1st start-up oil leakages were noted at the lube oil pumps originating from the mechanical seals. This was corrected by however oil leakages are still present on oil pumps 1 and 2.
Additionally and oil leakage is present on the right hand booster pump.
These leakages have been marked as low in the hand-over protocol and should be corrected at a later date

The emotor of both the lube oil and booster pumps have been replaced by new. The grounding cabling was upgraded by

During first start-up of the unit a large amount of debris was noted in the lube oil filters. During the hot section incident it was decided to drain the oil tank and internally clean it. After the oil was pumped into the oil tank again the system was flushed using bypass lines and strainers. Additionally the no 2 drain tank was opened and cleaned.

During final commissioning several oil leakages were noted (partially responsibility of XXX XXX) which have been marked as Low priority on the hand-over protocol.

5.11. Fuel system

The pilot and main gas control valves were overhauled and tested by in the UK.

The gas shut-off and bleed-off valves and actuators were overhauled and tested by .
The electrical connectors of the actuators were replaced as the plastic had become brittle and worn due to age.

5.12. Gearbox

The gearbox was bearings opened for overhaul and inspection of the bearings. Both the high speed bearings were repaired at GLT and were re-installed after measuring the bearings dimensions.
The gear teeth contact was checked after re-installation of the bearings and therefor no adjustment of the casing twist was required (the gearbox does not have adjustable bearings)
During the hot section incident the cover was removed and gear teeth contact pattern was re-checked looking at the 8 red dye marked gear teeth.

For the gearbox maintenance XXX XXX created additional special tooling consisting of torsion shaft positioning shells, dummy bearings gearbox cover pedestals.