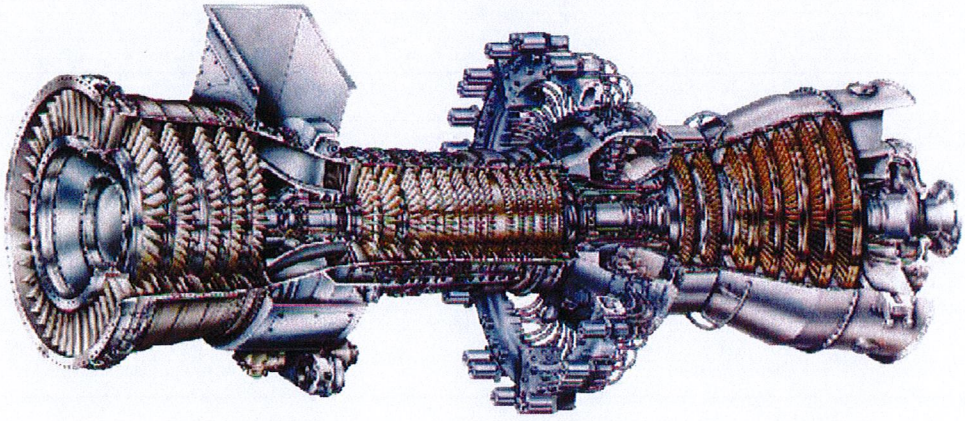
Aero Inspection & Vibration Report

ProEnergy

LM6000PC
BORESCOPE INSPECTION (HSE) REPORT
for
191-327

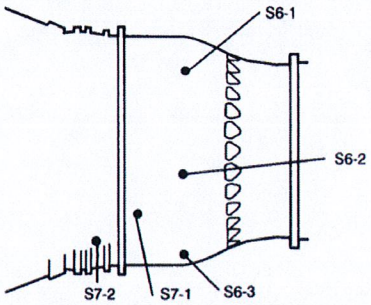


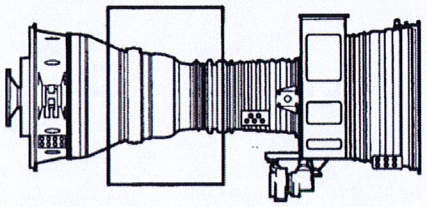
Engine Information

Customer	LS Power
Site	Wallingford
Address	115 John Street Wallingford, CT 06492
Phone	
Contact	David Evinrude
Unit No.	191-327
Engine Model No.	LM6000PC
Engine Serial No.	191-327
Fired Hours	13,478
Fired Starts	629
Inspection Date	April 9, 2018
Field Services Rep	Chris Harris
Job Number	1015-5113

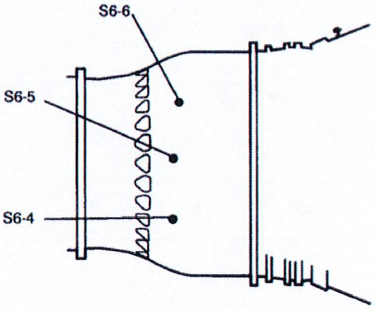
Combustion Liner & High Pressure Turbine (HPT) Borescope Ports

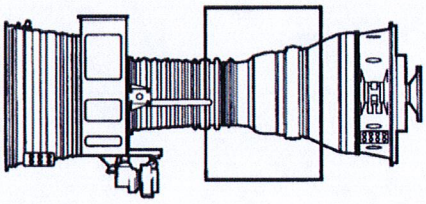
RIGHT SIDE





LEFT SIDE





Inspection Record
Combustion Liner & Stage 1 HPT Nozzle

General Remarks: The combustor is serviceable. The combustor is in excellent condition with no defects noted. The 1st Stage HPT Nozzles is serviceable. The 1st Stage HPT nozzle segments are in excellent condition.	
Combustion Liner Style:	
S6-1	No discrepancies noted.
S6-2	No discrepancies noted.
S6-3	No discrepancies noted.
S6-4	No discrepancies noted.
S6-5	No discrepancies noted.
S6-56	No discrepencies noted.
Recommendations: Continue to monitor the Combustor and 1st Stage HPT Nozzle assembly via periodic borescope inspections.	

Observations

Port S6-1 - Inner & Outer Liners, Dome assembly, Fuel Nozzles and HPT1 Nozzles

This is an over view of the combustor. No discrepancies noted.

This is an over view of the combustor. No discrepancies noted.

ProEnergy SERVICES
"Experience Our Energy"
Document Control
Apr 30,2018

Observations

Port S6-2 - Inner & Outer Liners, Dome assembly, Fuel Nozzles and HPT1 Nozzles

This is a typical view of a "trumpet" No discrepancies noted.

Observations

Port S6-3 - Inner & Outer Liners, Dome assembly, Fuel Nozzles and HPT1 Nozzles

This is a view of a stage 1 HPT nozzle . No discrepancies Noted.

This is a view of a stage 1 HPT nozzle . No discrepancies Noted.

ProEnergy SERVICES "Experience Our Energy"
Document Control
Apr 30,2018

Inspection Record
High Pressure Turbine Rotor (HPT)

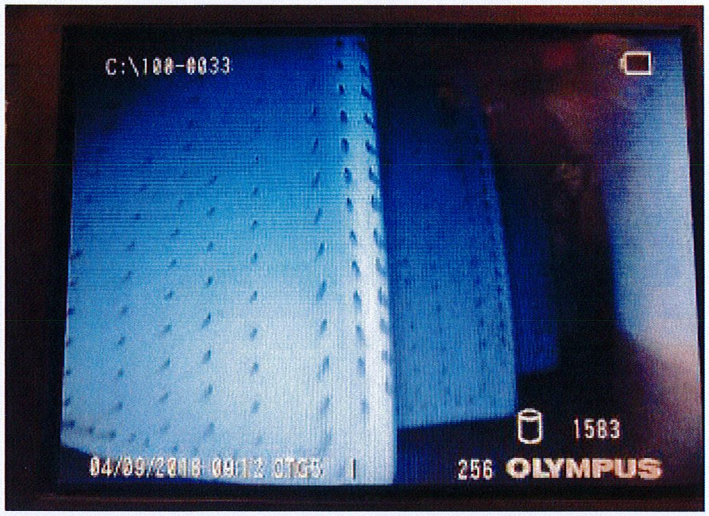
Borescope Port Number	Turbine Stage		Number of Blades	General Remarks: The HPT found to be in serviceable condition.
	Leading Edge	Trailing Edge		
S7-1	1		80	No Discrepancies Noted.
S7-2		1	80	No Discrepancies Noted.
	2		74	

Recommendations: Monitor condition of the HPT via continued periodic borescope inspection.

Observations

Port S7-1 - Stage 1 Blade Leading Edges, Tips, Platforms and Seal Bodies

This is a view of a stage 1 HPT blade. No Discrepancies Noted.

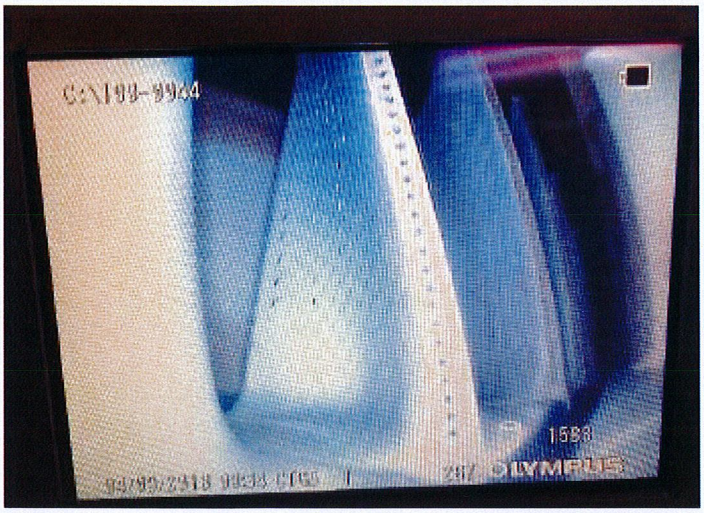


This is a view of a stage 1 HPT blade. No Discrepancies Noted.

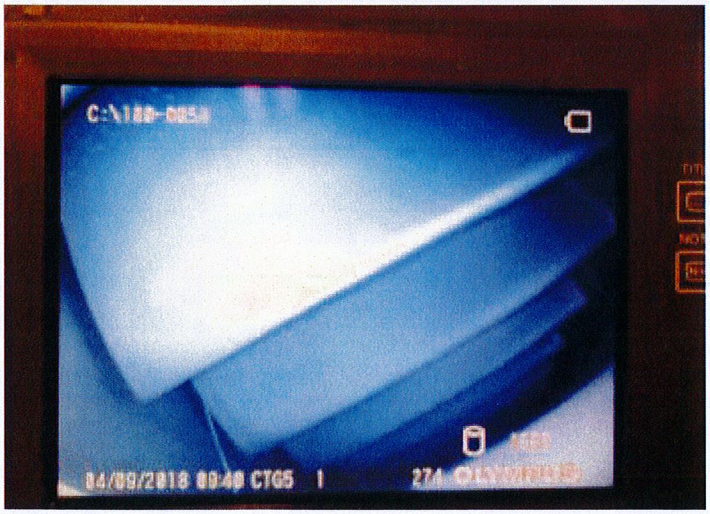
Observations

Port S7-2 - Stage 1 Blade Trailing Edges / Stage 2 Blade Leading Edges, Tips and Platforms

This is a view of a stage 1 HPT blade trailing edge. No Discrepancies Noted.



This is a view of a stage 2 HPT blade. No Discrepancies Noted.

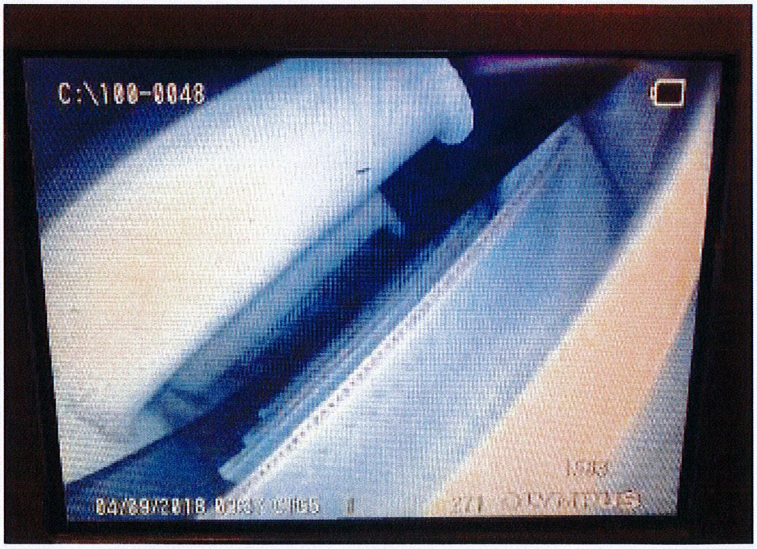


Observations

Port S7-2 - Stage 2 HPT nozzle

This is a view of a stage 2 HPT nozzles trailing edge and leading edge of stage 2 blades. No Discrepancies Noted.

This is a view of a stage 2 HPT nozzles leading edge and trailing of stage 1 blades. No Discrepencies Noted.



CLOSING COMMENTS:

- The Hot Section shows no signs of TBC chipping or spalling.
- The airfoils do not exhibit any signs of defects and are in excellent condition.
- Unit 6 is in serviceable condition

Report Prepared by Chris Harris

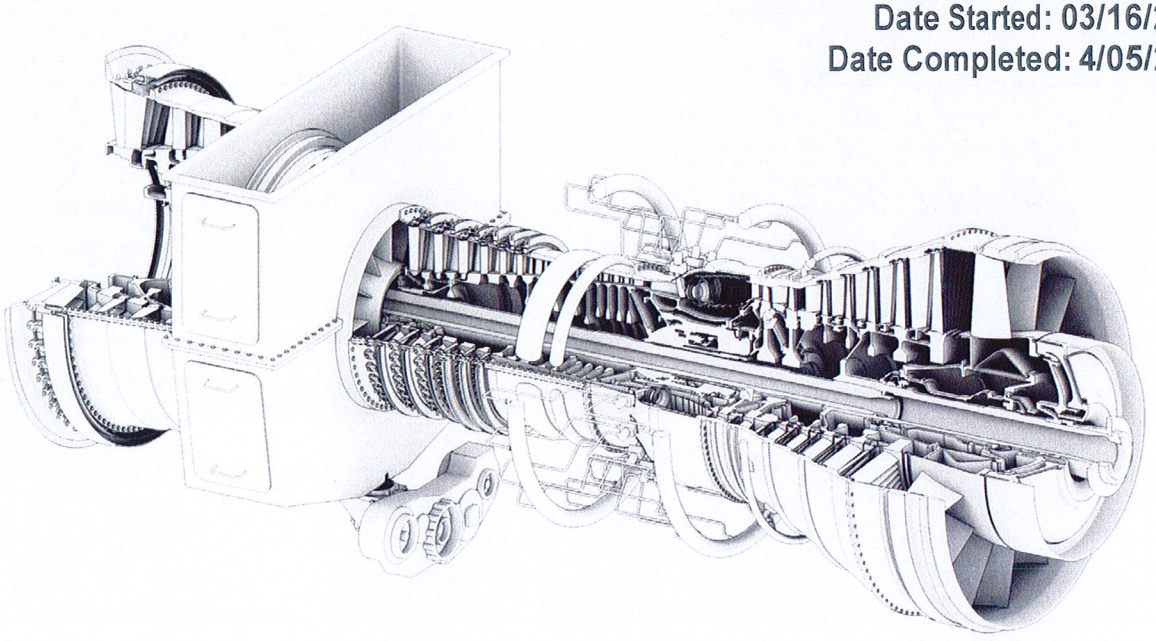
ProEnergy™

Unit 7 LP Vibration Investigation

Depot Report

LS Power Wallingford

Engine Serial Number: 191-346
Engine Model: 7LM6000PC – NGW
Project Number: 1015-5113-346W
Date Started: 03/16/2018
Date Completed: 4/05/2018



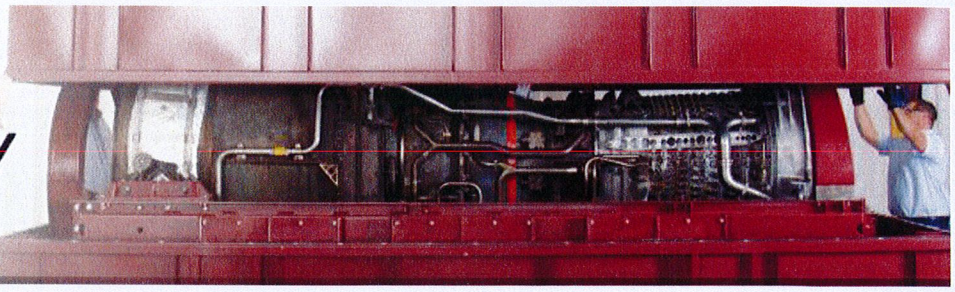


Table of Contents

Introduction 2

Executive Summary 3

Induction & Incoming Inspection 5

LPCS Assembly 6

LPCR Assembly 7

CFF assembly 9

LP shaft assembly 10

Combustor Assembly 12

HPT S1N Assembly 13

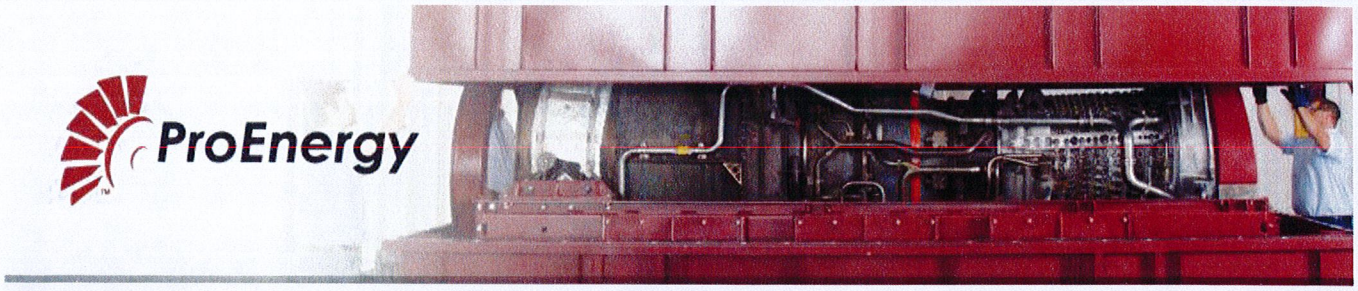
HPT S2N Assembly 15

HPTR Assembly 16

LPT Assembly 20

TRF Assembly 21

Final Engine Assembly 22



Introduction

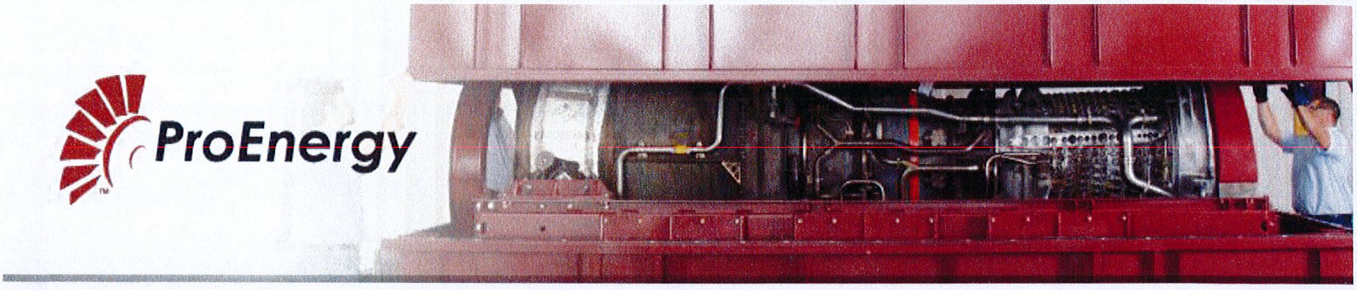
This is an Aero Depot report concerning LM6000 PC S/N: 191-346. During the start-up and commissioning of the unit in Wallingford, the unit experienced an unusual 1X LP Vibration on the CRF Accelerometer during the hot restart of the engine. After performing a variety of troubleshooting steps on site to resolve the unusual vibration, the decision was made to remove the engine from the package and transport it back to the Pro Energy Aero Depot for further inspection.

Unit 191-346	
Total Fired Hours	13,609
Total Fired Starts	529
Total LP Sprint Hours	N/A
Total HP Sprint Hours	N/A

An executive summary on the following page identifies the primary reason for the visit with a brief list of secondary items accomplished during the visit. The remainder of the report focuses on the findings discovered during the disassembly and inspection phase of repair and highlights the work scope required to address the findings and achieve the desired outcome.

Parts identified in the report are primarily non-consumable parts and are presented in part-tracking logs for each module that parts were replaced. Each part-tracking log will name the parts removed and the parts installed by part number and serial number if applicable. A bill of materials has also been included to indicate new, serviceable or overhauled parts installed during the visit or parts repaired and reinstalled.

All work is performed in accordance with approved ProEnergy Work Packages and Procedures.

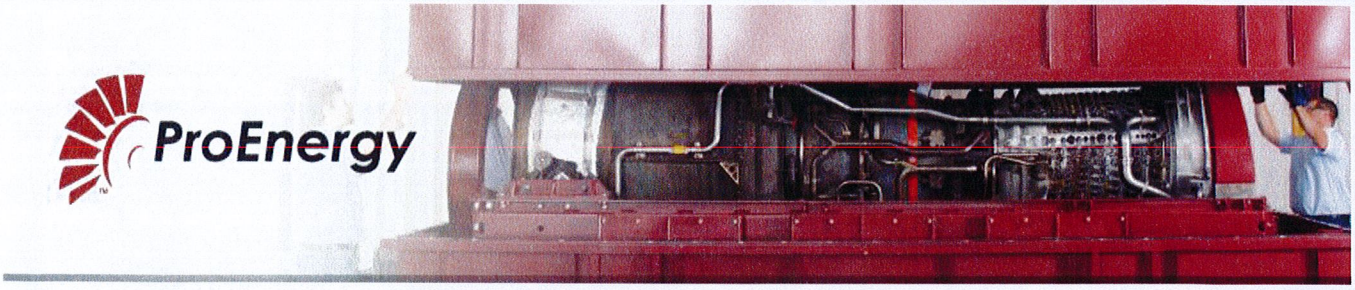


Executive Summary

LM6000PC ESN:191-346 was received in the Pro Energy Aero Depot on March 15, 2018. The engine experienced an unusually high 1X LP Vibration during a Hot Start situation. The below work scope was used to perform the investigation into the LP vibration.

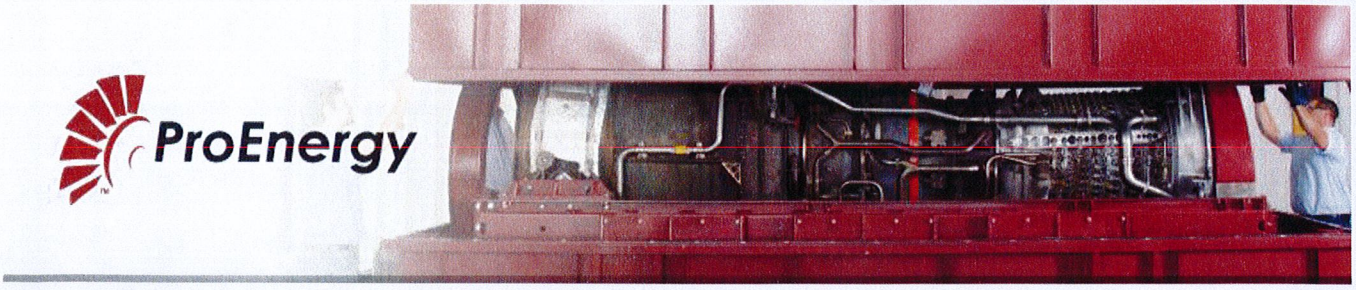
Inspection Work Scope:

- **Engine Induction:**
  - Inspect external condition of engine upon arrival
  - Inspect L/S Pump finger strainers/chip detectors
  - Inspect for missing external parts
- **Engine Disassembly:**
  - Remove Inlet Guide Vanes (IGV's)
  - Remove LPC
  - Remove LPT
  - Remove High Pressure Turbine Rotor (HPTR)
  - Remove 1st Stage HPT Nozzle Assembly
  - Remove 2nd Stage HPT Nozzles Assembly from HPTR
  - Remove LP Mid Shaft
- **Module Disassembly/Assembly:**
  - **LPC Module**
    - **LPC Stator Cases:**
      - Remove LPC Stator Cases from LPC Rotor
      - Visually inspect cases and vanes
      - Reinstall Cases
    - **LPC Rotor:**
      - Visually Inspect Rotor and blades
      - Perform runout checks
      - Balance LPC Rotor
    - **Re-assemble LPC Module**



- **1st Stage HPT Nozzle Assembly:**
  - Disassemble to Piece Parts
  - Visually Inspect parts
  - Route removed nozzle segments to OSV for inspection/repair
  - Assemble 1st Stage HPT Nozzle Assembly with OH'd Nozzle Segments from inventory

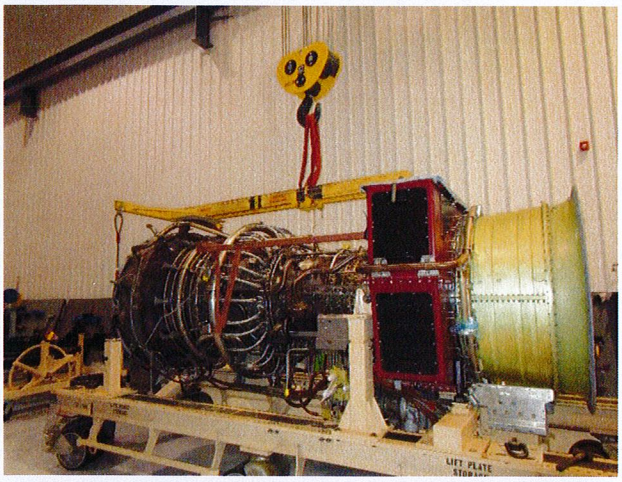
- **2nd Stage HPT Nozzle Assembly:**
  - Remove S2NA from HPTR
  - Perform visual inspection of S2NA
  - Install onto HPTR
- **HPTR:**
  - Disassemble HPT Rotor
  - Visually inspect parts
  - Remove 1st Stage HPT Blades and route to OSV for inspection/repair
  - Replace 1st Stage HPT Disk
  - Assembly HPT Rotor
  - Replace 1st Stage HPT Blades with OH'd blades from inventory
  - Install 2nd Stage HPT Blades
  - Grind 1st Stage HPT Blades to specification
  - Balance HPT Rotor
- **LPT**
  - Visually inspect LPT Assembly
  - Borescope inspection of LPT Assembly
  - Remove TRF
  - Visually inspect 6R and 7R bearings
  - Visually inspect balance piston seal
  - Re-install TRF
- **Final Engine Assembly**

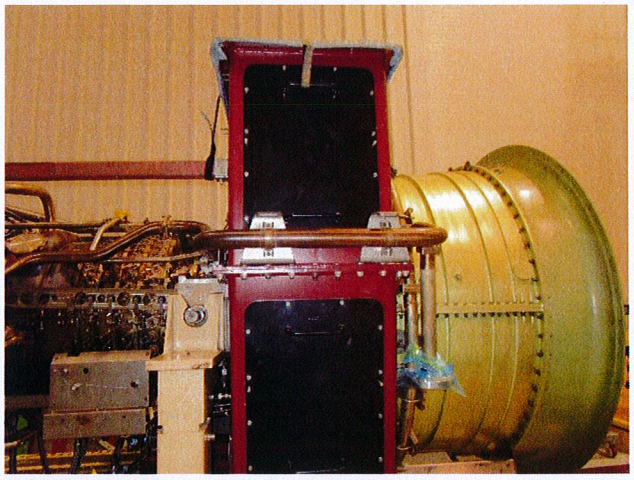


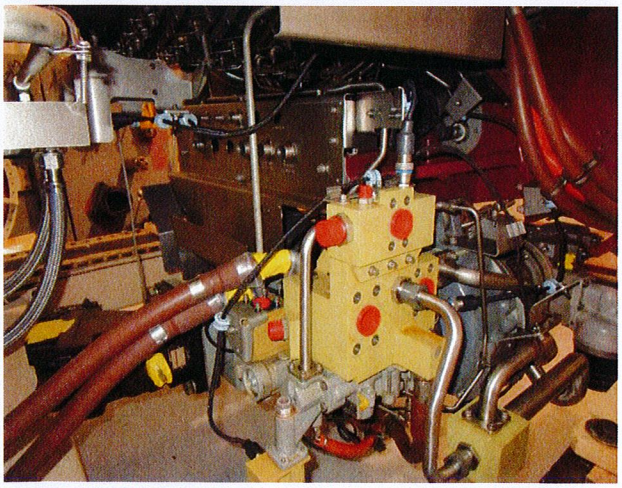
Induction & Incoming Inspection

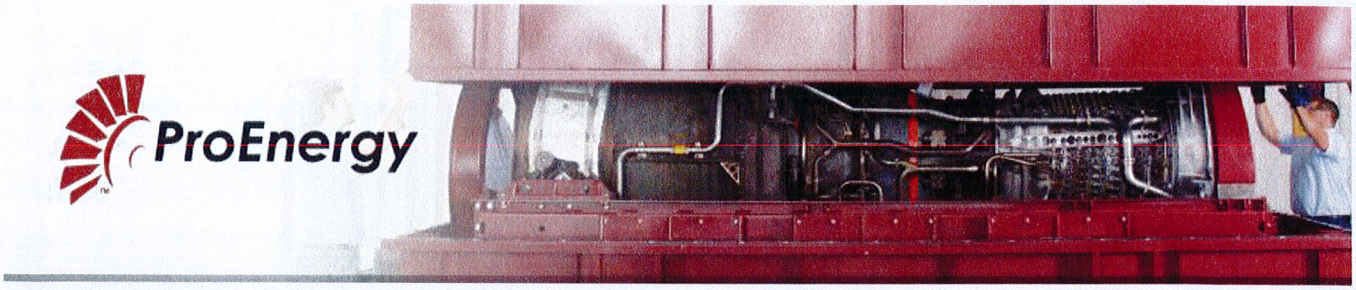
ESN: 191-346 arrived at the Pro Energy Aero Depot on March 15, 2018. The engine was inducted into the Depot and inspected in order to document the as received condition.

Incoming Photos:









LPCS Assembly

The LPC was removed from the engine and the LPC Stator cases were removed for inspection.

Inspection Findings:

- No discrepancies noted

Action/Corrective Action:

- The LPC Stator Cases were found to be in Serviceable condition.
- LPC Stator Case shrouds were found to be in Serviceable condition.
- LPC Stator Cases re-installed on the LPC Rotor.

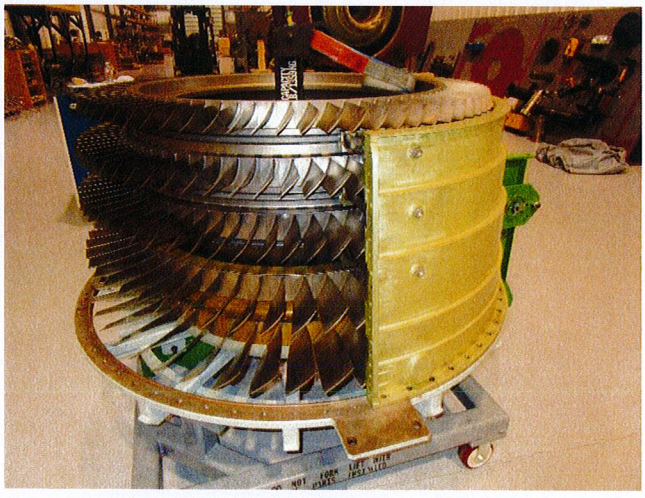
Purchased Parts Installed:

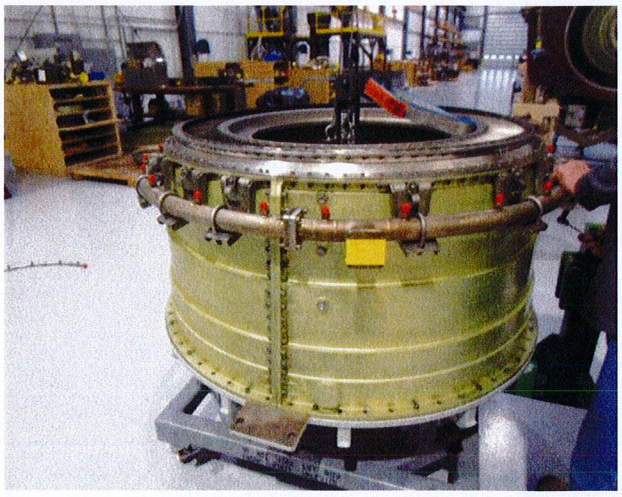
- N/A

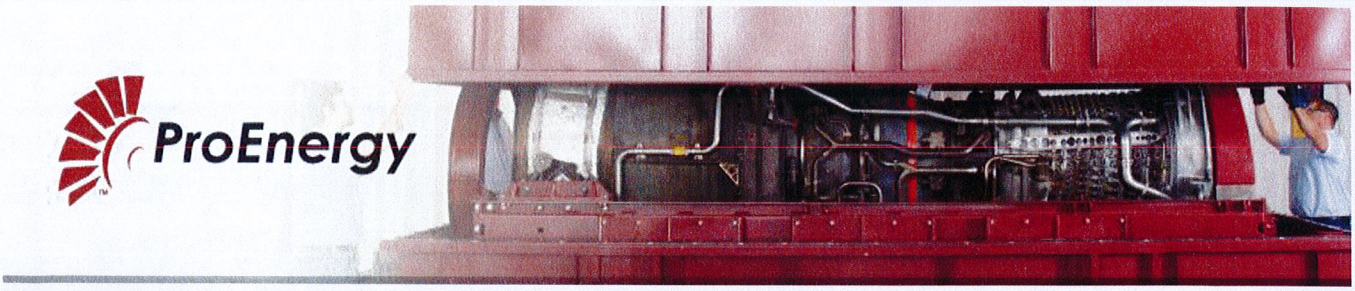
Serviceable parts installed:

- N/A

Photos:







LPCR Assembly

The LPC was removed from the engine and the LPC Rotor was removed for inspection and check balance.

Inspection Findings:

- LPC Rotor was found to be slightly outside desired balance specifications.

Action/Corrective Actions:

- LPC Rotor rebalanced to tighter specifications. Results shown below.

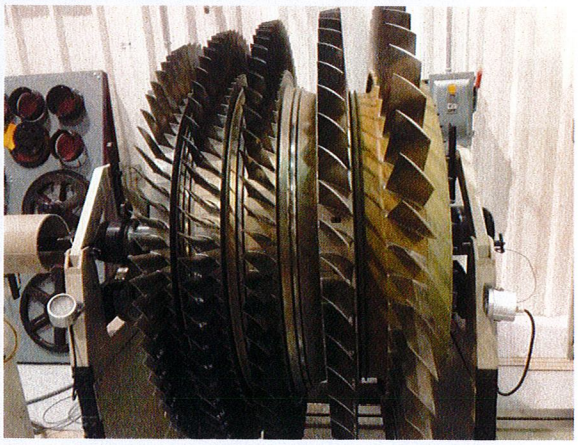
Purchased Parts Installed:

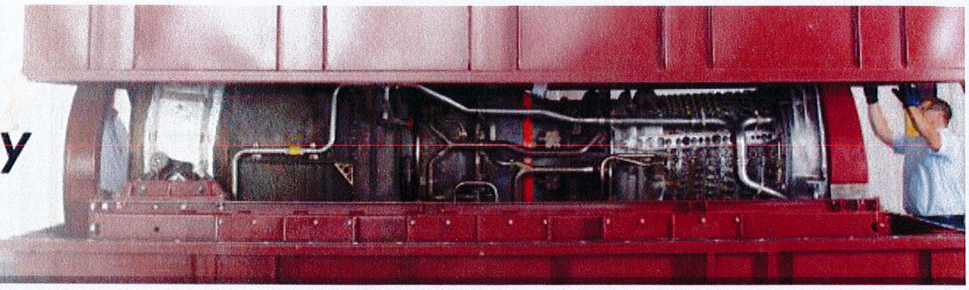
- N/A

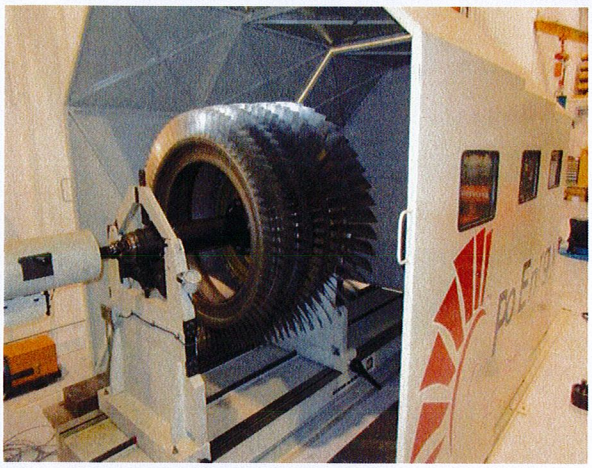
Serviceable Parts installed:

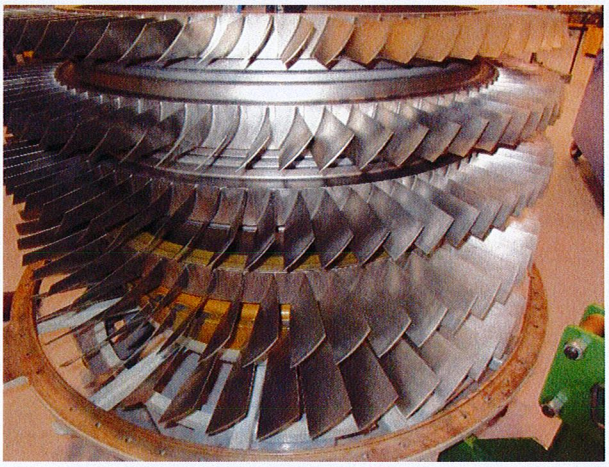
- N/A

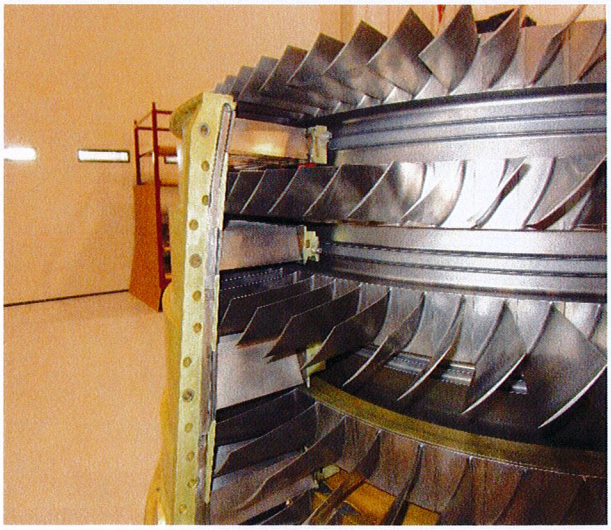
LPCR Pictures:

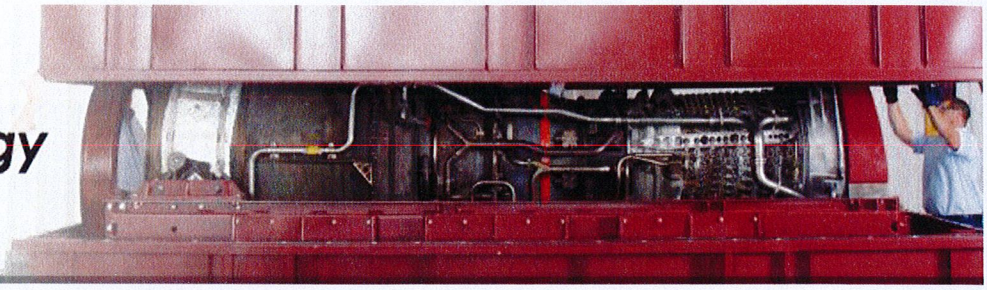












CFF assembly

Upon removal of the LPC, the CFF was visually inspected.

Inspection Findings:

- During the inspection it was noted that SB 181 had not been implemented
- CFF in serviceable condition

Action/Corrective Action:

- SB 181 was implemented to bring the unit into compliance

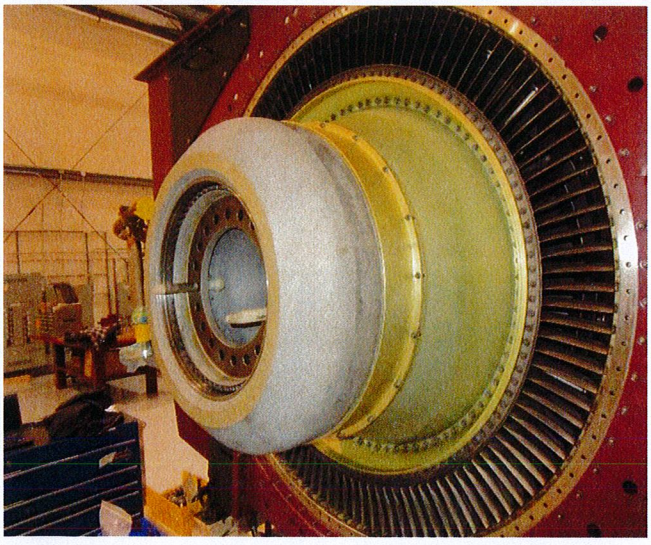
Purchased Parts Installed:

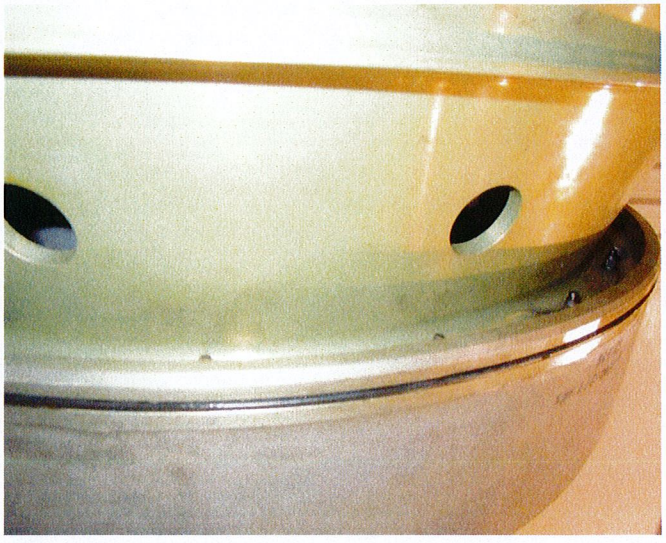
- N/A

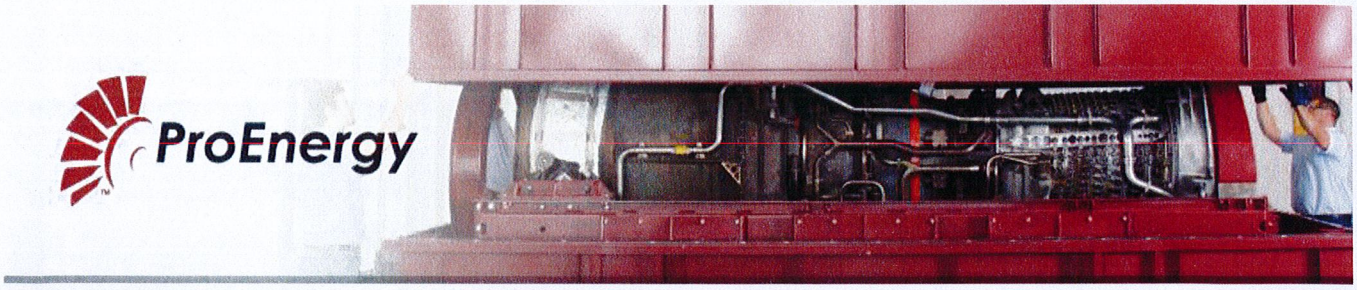
Serviceable parts installed:

- N/A

CFF Photos:







LP shaft assembly

The LP Mid shaft was disassembled, visually inspected, runouts verified between the forward shaft and midshaft.

Inspection Findings:

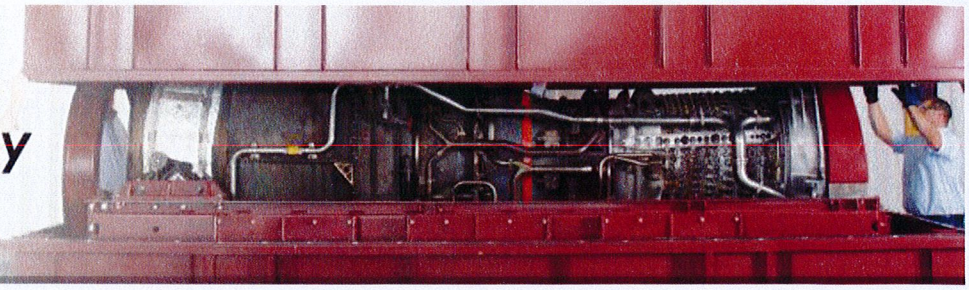
- Performed stack check of the 1B Bearing and found the measurement to be out 0.014" out of specification
- 1B Bearing routed to outside vendor for inspection. Results of inspection indicated galling/scratches on the bearing races, small dents and flat spots on the bearings balls/bearing surface.
- Inspection of the forward shaft bearing journal was found to be in serviceable condition.
- Forward shaft to mid shaft runouts were found to be within specifications. Measurement is as follows:
    - **Runout:** 0.0025

Action/Corrective Action:

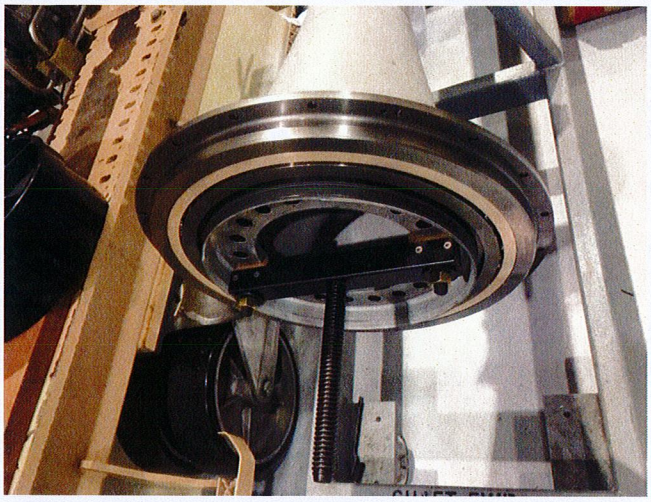
- Routed 1B Bearing to OSV for evaluation
- Referenced original build records and "As Built" stack up was 0.164"
- Reassembly stack check reading of 0.166' was similar to the As Built stack reading, however the disassembly stack check reading was 0.178. This 0.0140" discrepancy was noted and therefore an RCA was performed.
- RCA on the stack check process revealed a miss calibrated micrometer
- Recalculated the stack check measurements using properly calibrated micrometer
- As Found and As Built measurements within specification
- 1B Bearing replaced with OH'd bearing

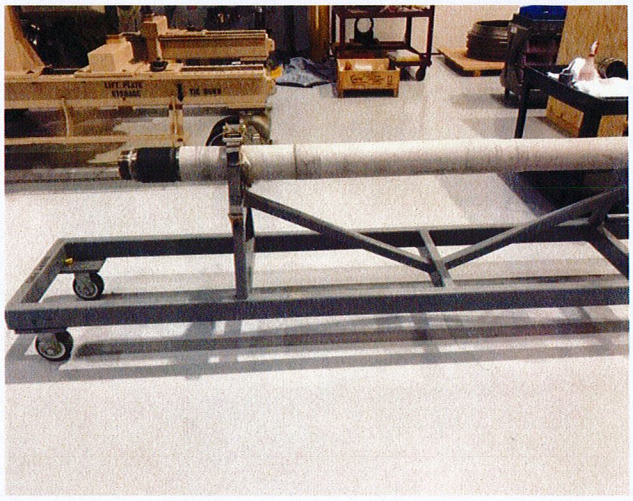
Purchased Parts installed:

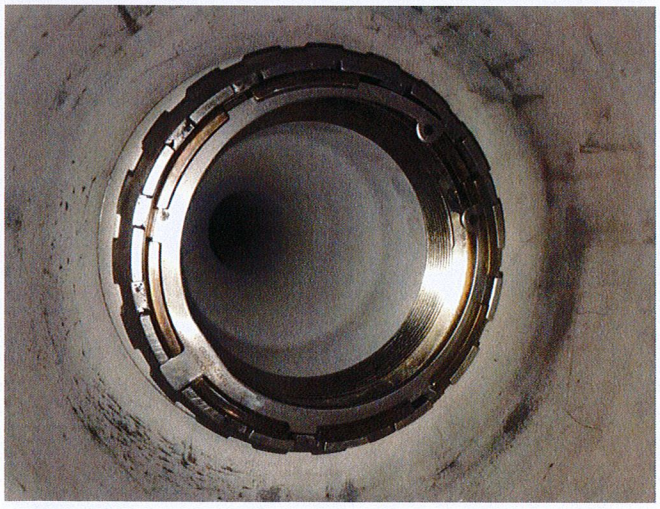
Description	Part Number	Serial Number	Condition	QTY
Bearing, Ball	L43683P01	MDADH176	OH	1

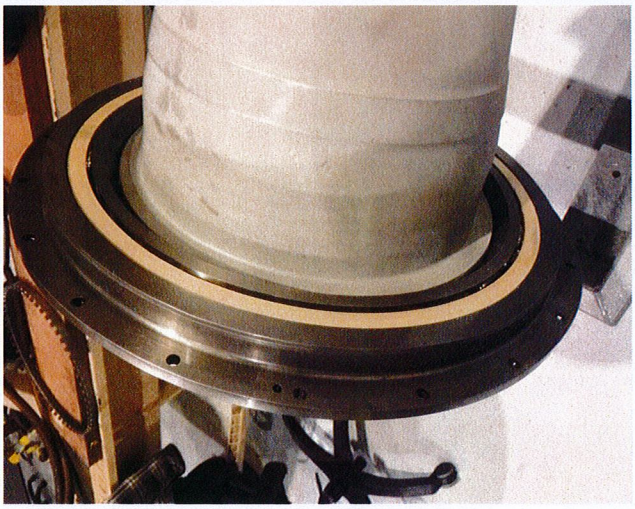


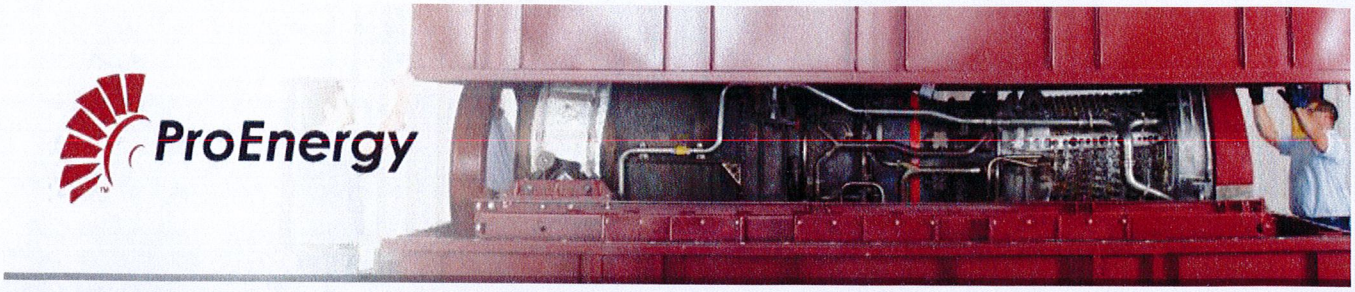
LP shaft Assembly Pictures:











Combustor Assembly

During engine disassembly the combustor was not removed. The exposed part of the combustor was visually inspected upon the removal of the 1st Stage HPT Nozzle Assembly (S1NA). Below are the findings/corrective actions:

Inspection Findings:

- Combustor was in serviceable condition and no deficiencies noted.

Action/Action Taken:

- N/A

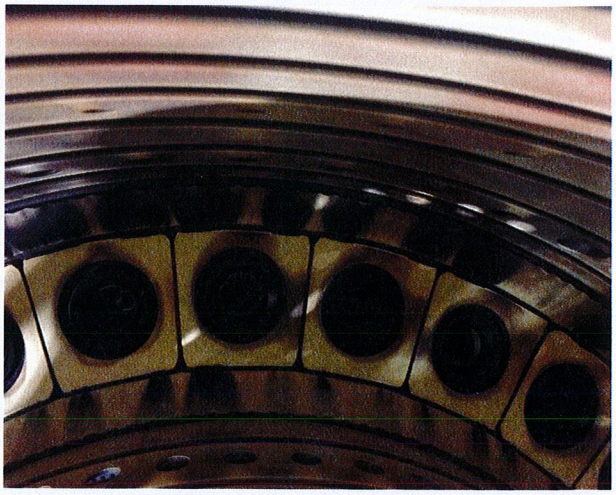
Purchased Parts Installed:

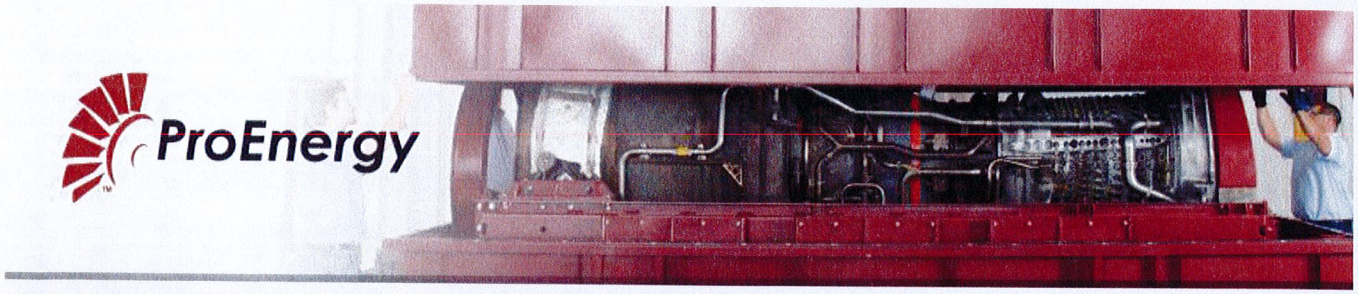
- N/A

Serviceable parts installed:

- N/A

Combustor Pictures:





HPT S1N Assembly

Prior to ESN: 191-346 being removed from the package for shipment back to the Pro Energy Aero Depot, a borescope inspection was performed on the engine. During the borescope of the S1NA spalling of TBC was discovered on the convex side of several nozzle segments. The S1NA was disassembled to piece parts and inspected.

Inspection Findings:

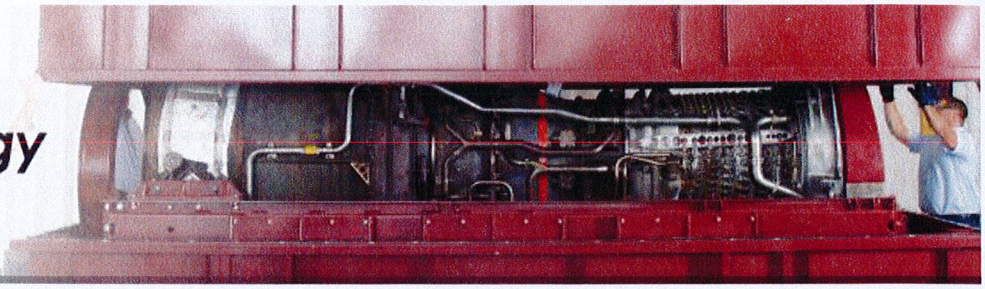
- TBC spalling on several nozzle segments

Action/Action Taken:

- Nozzles segments removed and routed to OSV for inspection/perform a RCA to determine the cause of the TBC spalling on the convex surface of the nozzle segments.
- Replaced all nozzle segments with OH'd nozzles segments from PES inventory
- Assembled S1NA

Purchased Parts Installed:

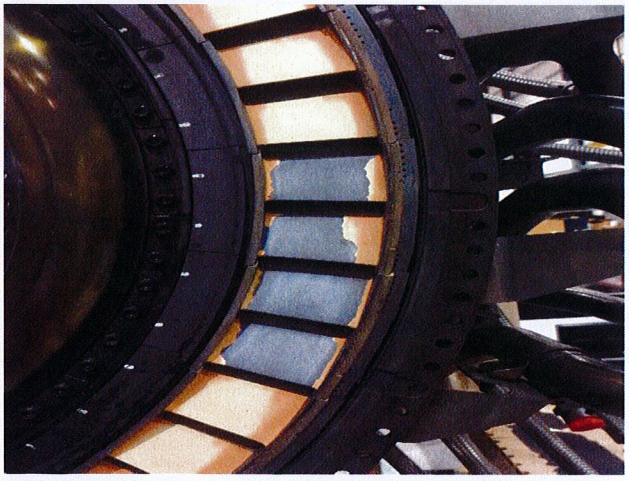
ITEM	QTY	PART NUMBER	DESCRIPTION
		Stg 1 Nzl	
1	23	1539M96P01	Seal
2	23	9395M19P01	Bolt
3	23	9395M19P03	Bolt
4	46	J490P05	Nut
5	23	1288M66P05	Seal
6	23	1304M20P03	Seal
7	23	1288M65P01	Seal
8	23	1288M65P02	Seal
9	23	1304M20P06	Seal (Code CE)
10	36	AN123631	Rivet
11	54	J979P06	Nut
12	132	9186M93G04	Bolt
13	30	J644P09A	Bolt



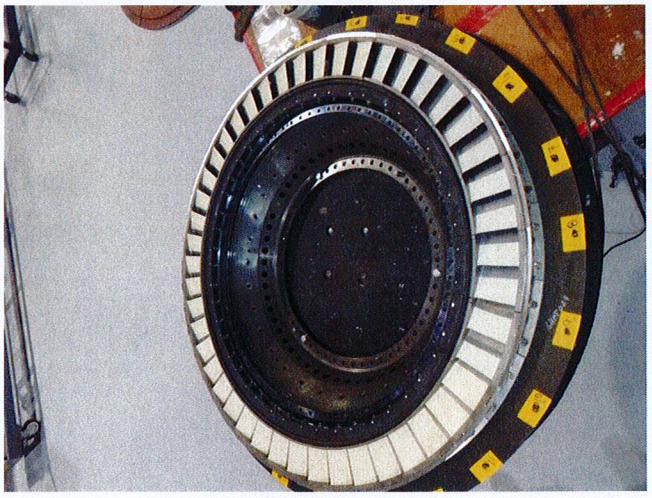
Serviceable OH'd parts installed:

Part Number:			
709034, 709310			
Position	**Serial Number**	**Position**	**Serial Number**
BORO1	MUNCG965	13	MUNNA838
2	MUNNA817	14	MUNNA840
3	MUNNA878	15	MUNNA859
4	MUNNA809	16	MUNNA855
5	MUNNA825	17	MUNNA847
6	MUNNA821	18	MUNNA813
7	MUNNA858	19	MUNNA869
8	MUNNA865	20	MUNNA832
9	MUNNA839	21	MUNNA850
10	MUNNA854	22	MUNNA864
11	MUNNA827	*23	MUNW4568
12	MUNNA846		

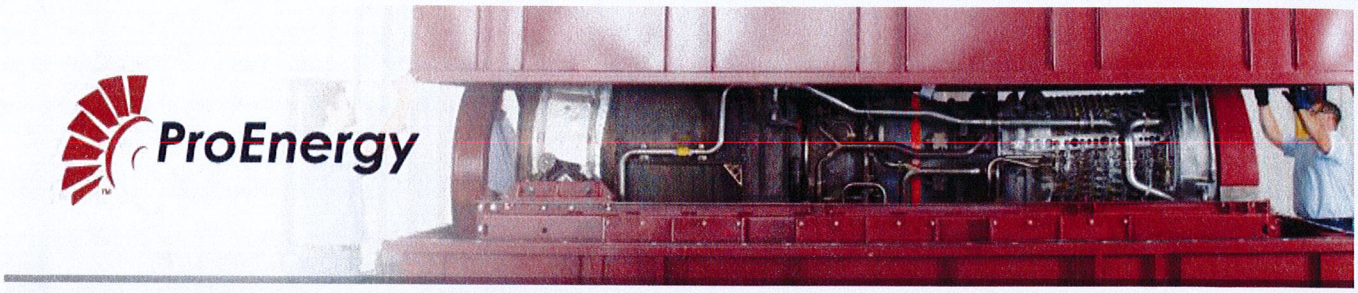
HPT S1N Pictures:



Removed



Installed



HPT S2N Assembly

The S2NA was removed from the HPT Rotor and visually inspected. Based on the inspection the S2NA was not disassembled.

Inspection Findings:

- S2NA found in serviceable condition

Action/Action Taken:

- N/A

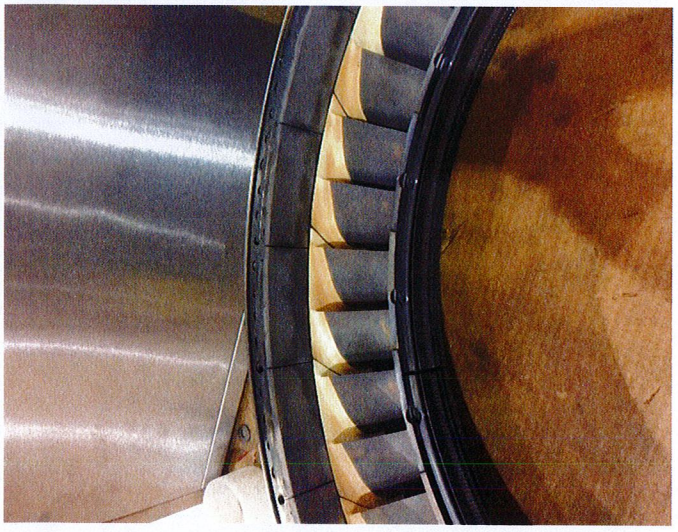
Purchased Parts Installed:

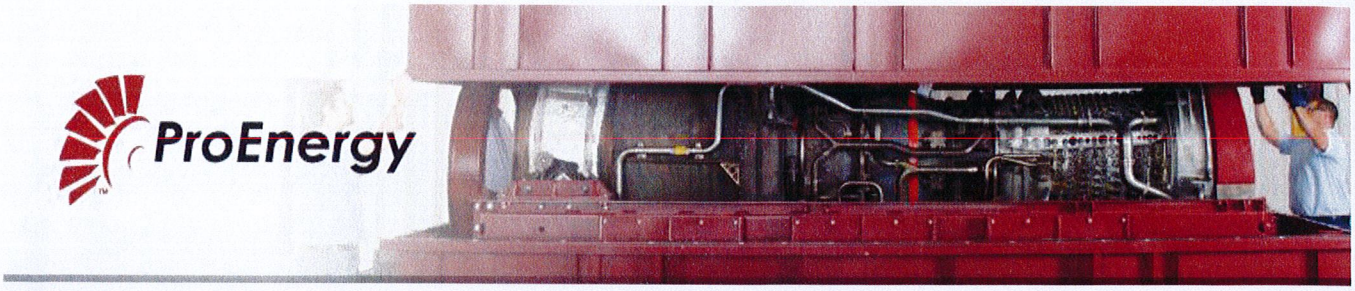
- N/A

Serviceable parts installed:

- N/A

S2NA Pictures:





HPTR Assembly

Prior to ESN: 191-346 being removed from the package for shipment back to the Pro Energy Aero Depot, a borescope inspection was performed on the engine. During the borescope of the HPT Rotor, TBC chipping was noted on the leading edges of the 1st Stage HPT Blades. The HPT Rotor was removed, disassembled to piece parts, and visually inspected.

Inspection Findings:

- All 1st Stage HPT Blades exhibited TBC chipping
- 1st Stage HPT Disk exhibited signs of minor coating spalling on the pilot surface

Action/Action Taken:

- Removed 1st Stage HPT Blades and routed to OSV for inspection and repair
- Changed out 1st Stage HPT Disk with OH'd disk from PES inventory
- Installed complete set of OH'd 1st Stage HPT Blades
- Performed tip grind on 1st Stage HPT Blades to match 1st Stage Shrouds
- Balanced HPT Rotor

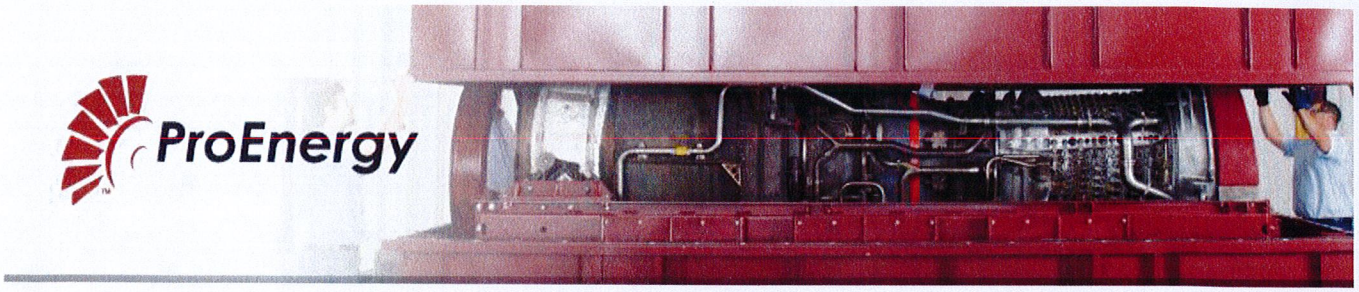
Purchased Parts Installed:

Description	Part Number	Serial Number	Condition	QTY
Disk, 1st Stage HPT	1531M84G12	GWN08GRA	OH	1

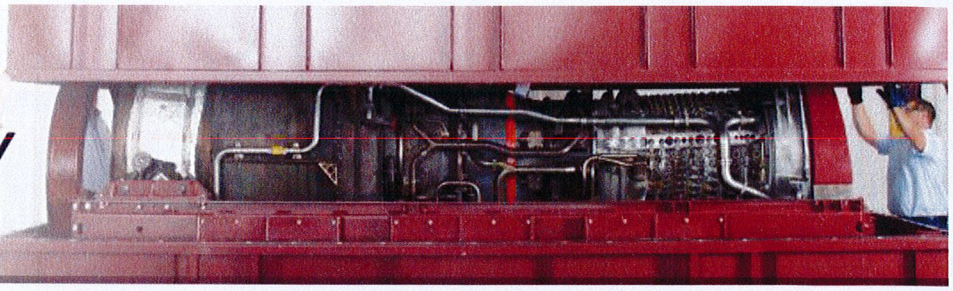
Serviceable OH'ed parts installed:

Part Number: 739012

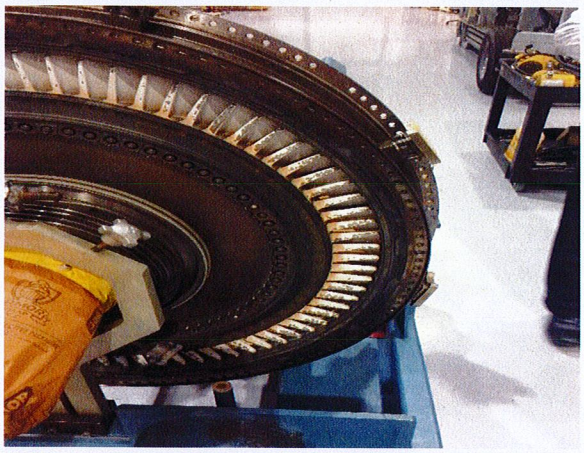
Position	Serial Number	POS	SERIAL NUMBER	POS	SERIAL NUMBER
1	FEL4H438	29	PCMLTAKF	55	FELR8942
2	FEL5H017	30	PCMUD1WJ	56	FELJ6192
3	FEL5H029	31	PCMYS6JA	57	FEL8F379
4	FEL5H025	32	PCMFG7VL	58	FEL1G170
5	FEL4H985	33	PCMWM3TU	59	FELP2046

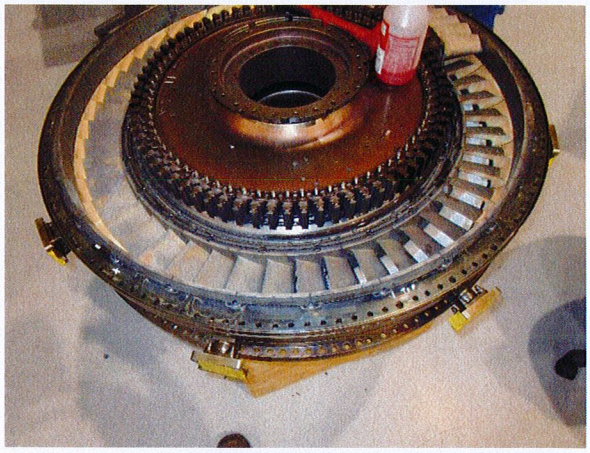


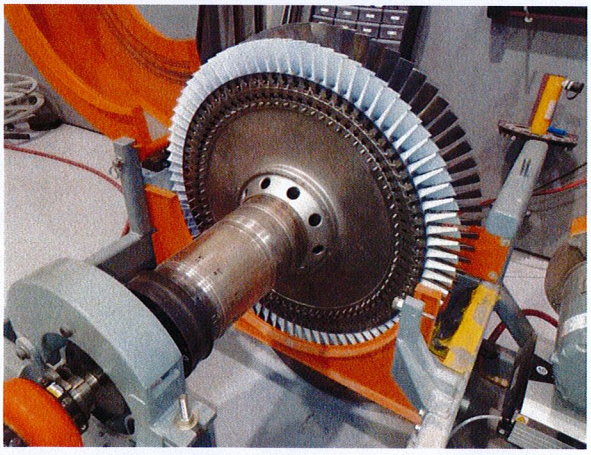
6	FELW3454	34	PCMYK8LS	60	FEL8A538
7	FEL4945B	35	PCMAPNAM	61	FELC8700
8	BWH723ML	36	PCMWF1DH	62	FELR1455
9	BWH565ML	37	PCMVD1YS	63	FELU0228
10	PCMAPTUU	38	PCMATHGE	64	FEL8F370
11	PCMLPGHP	39	PCMYM7EA	65	FELP2042
12	PCMFL1JR	40	PCMAMJLG	66	FEL6G410
13	PCMFP2RV	41	PCMYN2CF	67	FELR1460
14	PCMFE4TK	42	PCMATCYM	68	FELU7041
15	PCMLWMVK	43	PCMATBFP	69	FELU0738
16	PCMFM2TH	44	FELU0212	70	FELP2051
17	PCMAAPFP	45	FEL0A875	71	FEL3G114
18	PCMWG2AK	46	FEL8F375	72	FELR8932
19	PCMALTYC	47	FELR9029	73	FELP2151
20	PCMASDMC	48	FEL0A860	74	FEL1G167
21	PCMAYALN	49	FEL2C079	75	FELR8937
22	PCMAWEMF	50	FEL1C374	76	FELT0981
23	PCMAPFKC	51	FELR8952	77	FELT9609
24	PCMAKTAV	52	FEL1C485	78	FEL0A874
25	PCMYM9GU	53	FEL8A874	79	FEL8F380
26	PCMATULF	54	FELR8990	80	FELU0201
27	PCMTF7KM				
28	PCMLLHKJ				

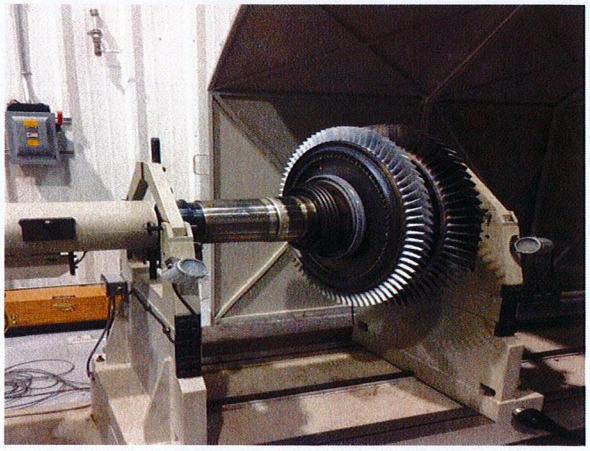


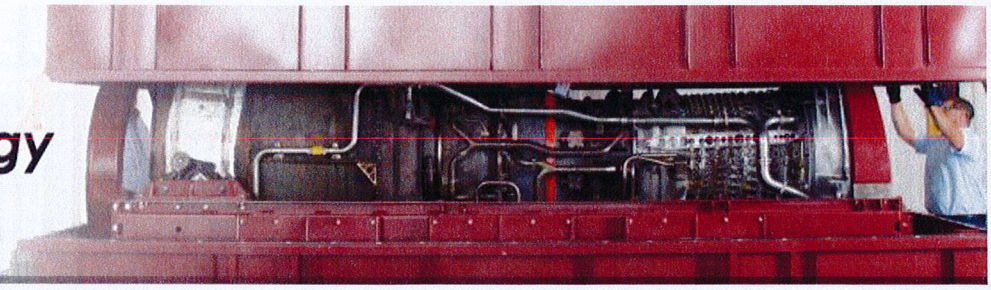
HPTR Pictures:











LPT Assembly

During the disassembly process of the engine, the LPT was removed to allow access for the removal of the hot section. While LPT was in the maintenance stand, the TRF was removed to inspect the 6R/7R Bearings along with the balance piston seal.

Inspection Findings:

- LPT in Serviceable Condition

Action/Action Taken:

- N/A

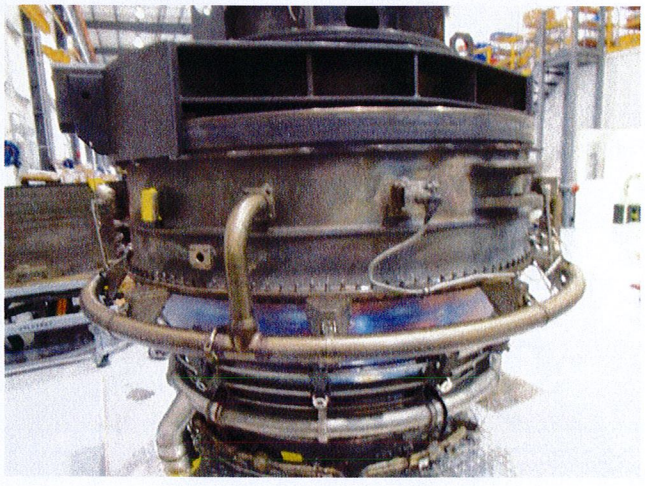
Purchased Parts Installed:

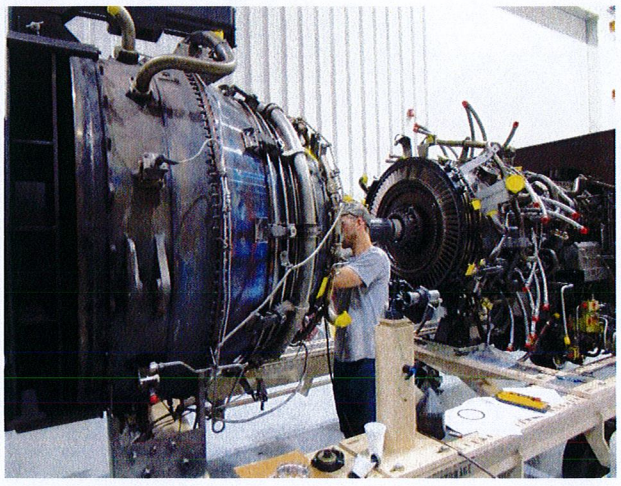
- N/A

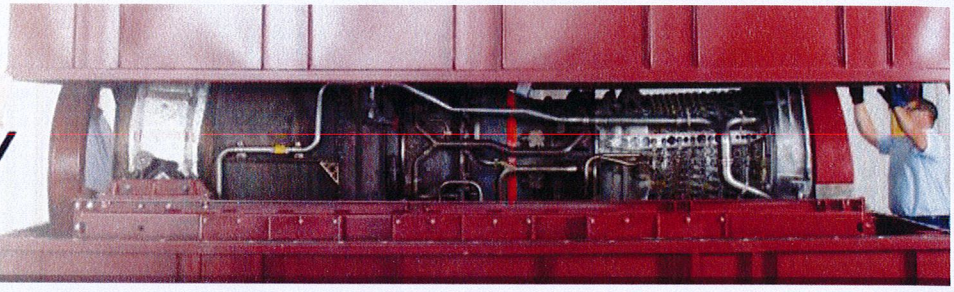
Serviceable parts installed:

- **N/A**

LPT Photos:







TRF Assembly

The TRF was removed from the LPT so that the 6R/7R Bearings could be inspected. Along with the bearings, the balance piston seals were inspected including FPI.

Inspection Findings:

- 6R/7R Bearing found to be in serviceable condition. No deficiencies noted
- Balance piston seals in serviceable condition. No deficiencies noted

Action/Action Taken:

- N/A

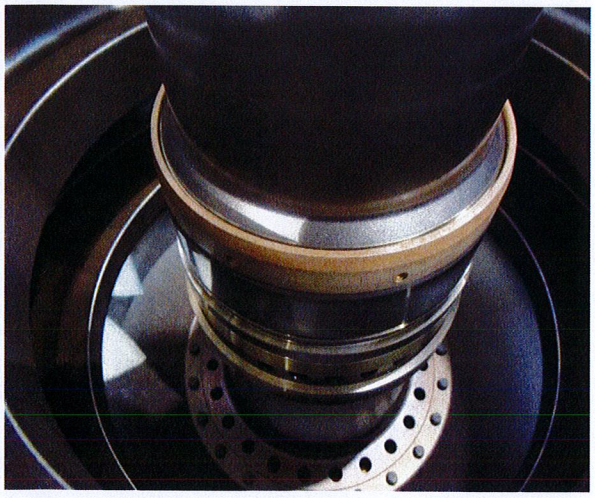
Purchased Parts Installed:

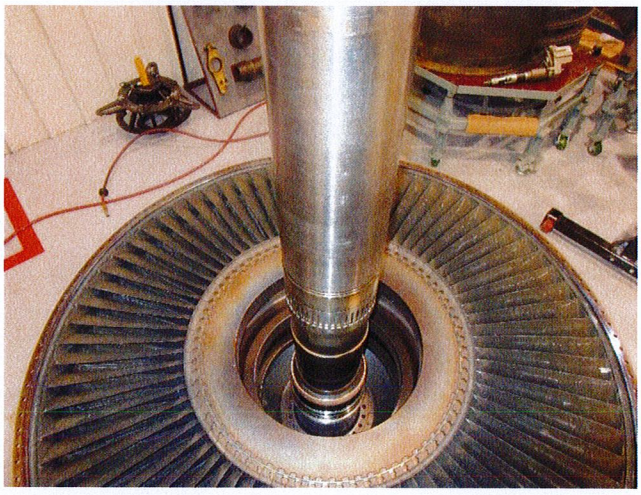
- N/A

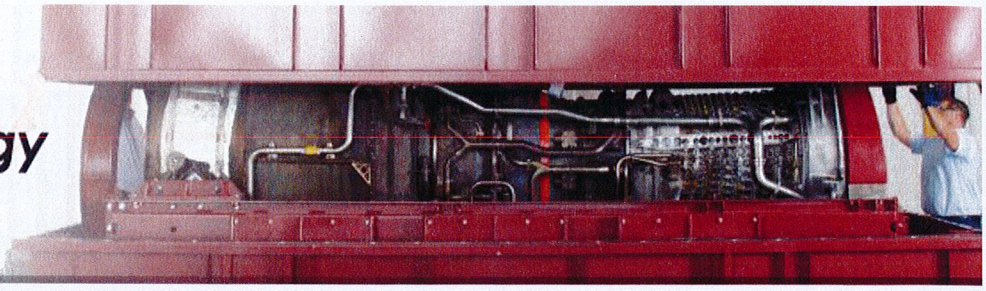
Serviceable parts installed:

- N/A

TRF Photos:

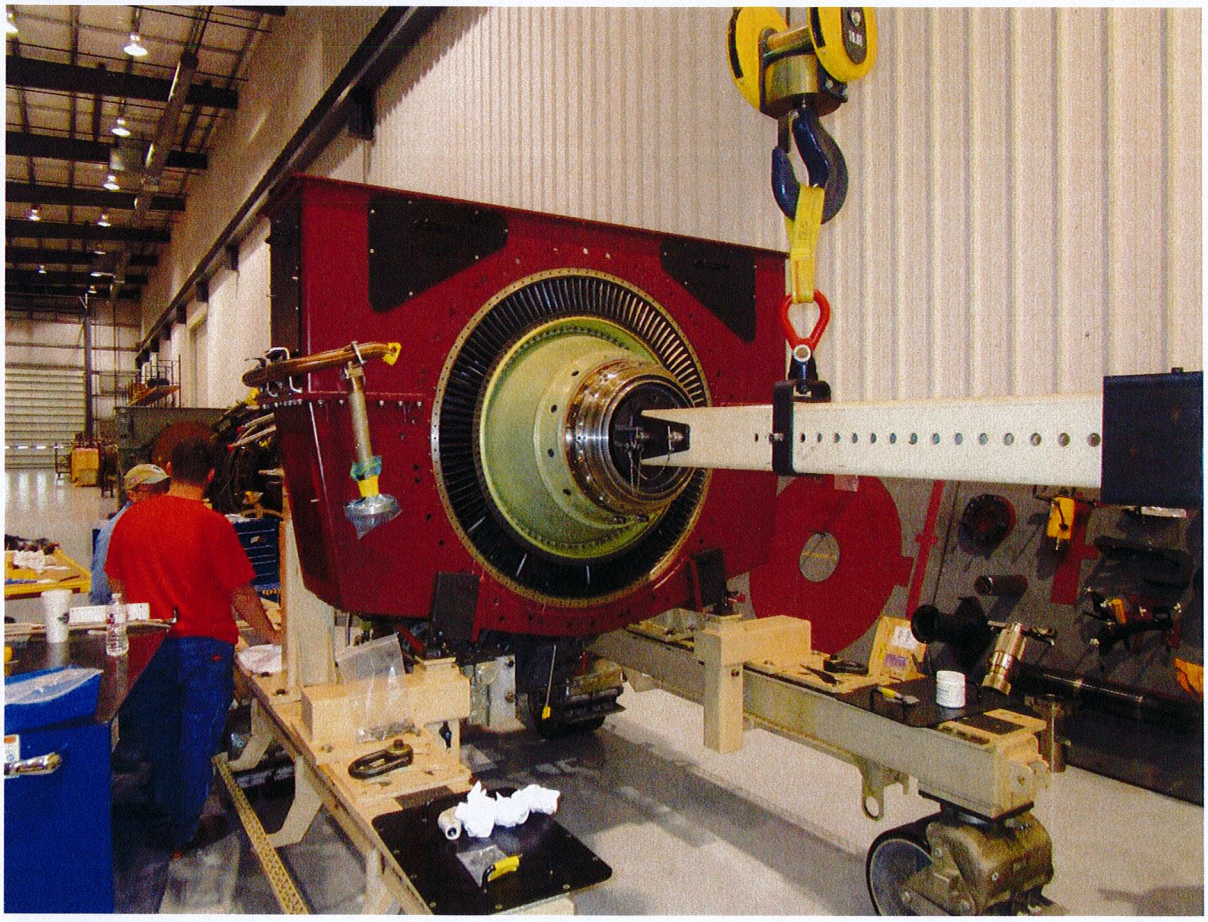


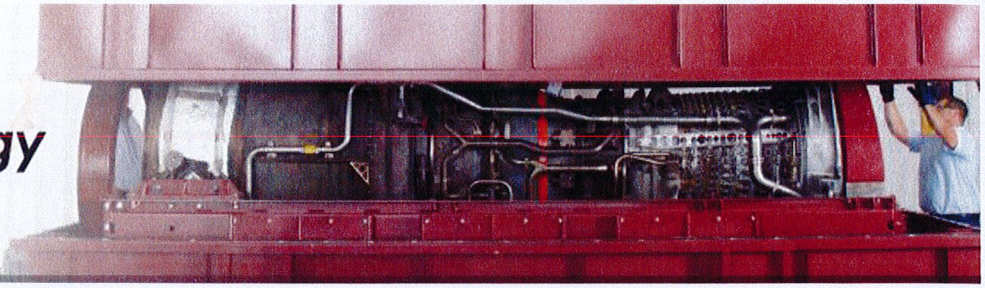




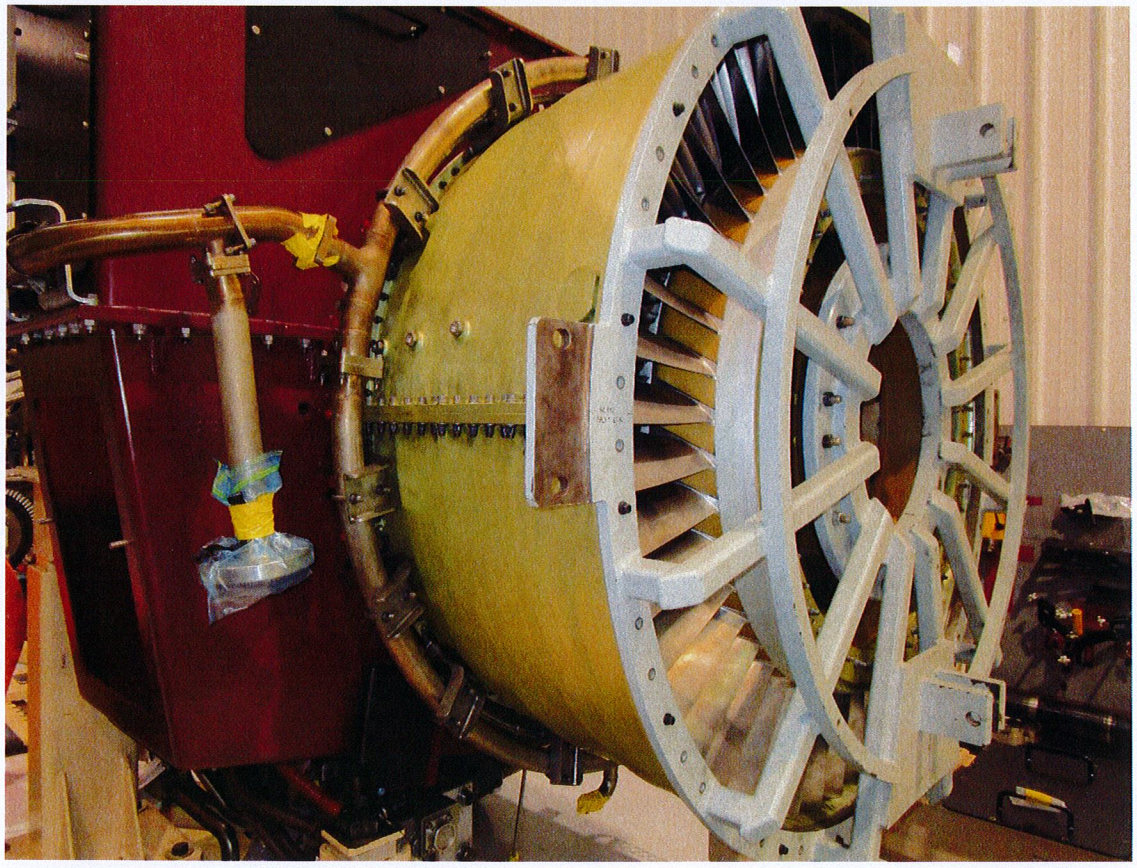
Final Engine Assembly

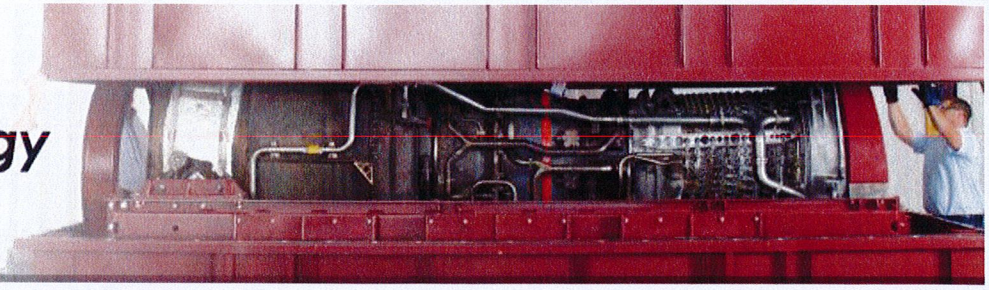
- Install LP shaft



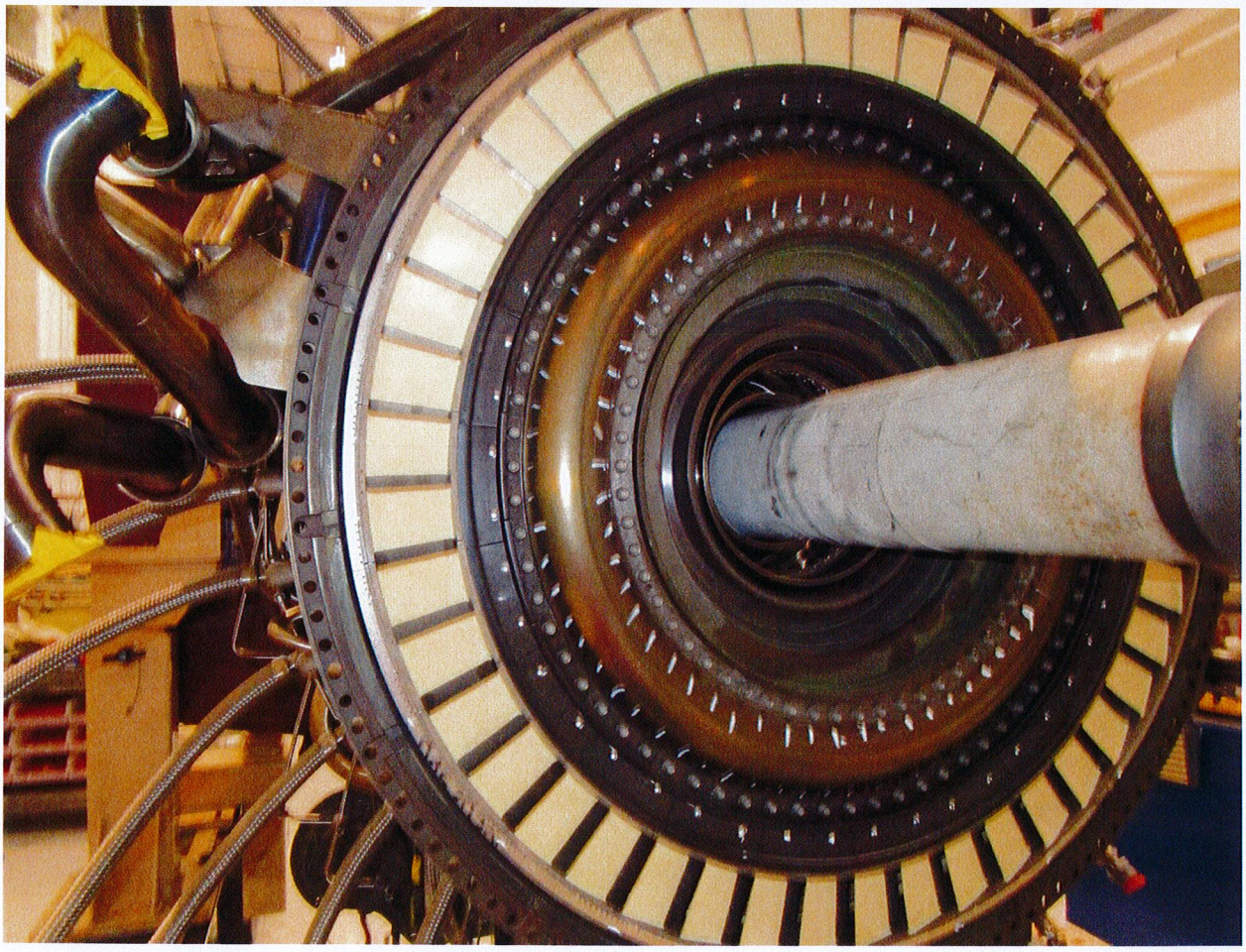


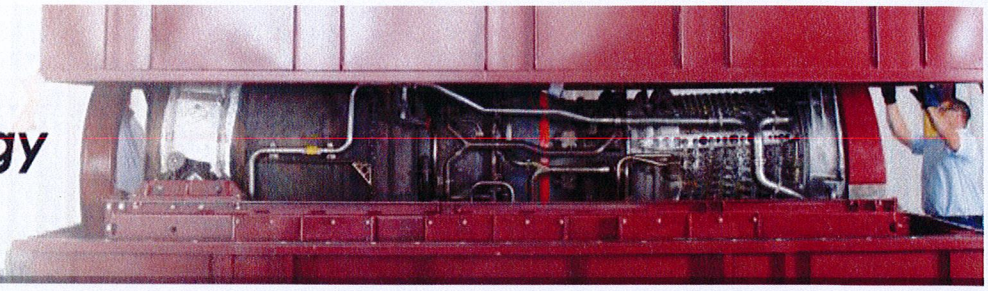
- Install LPC



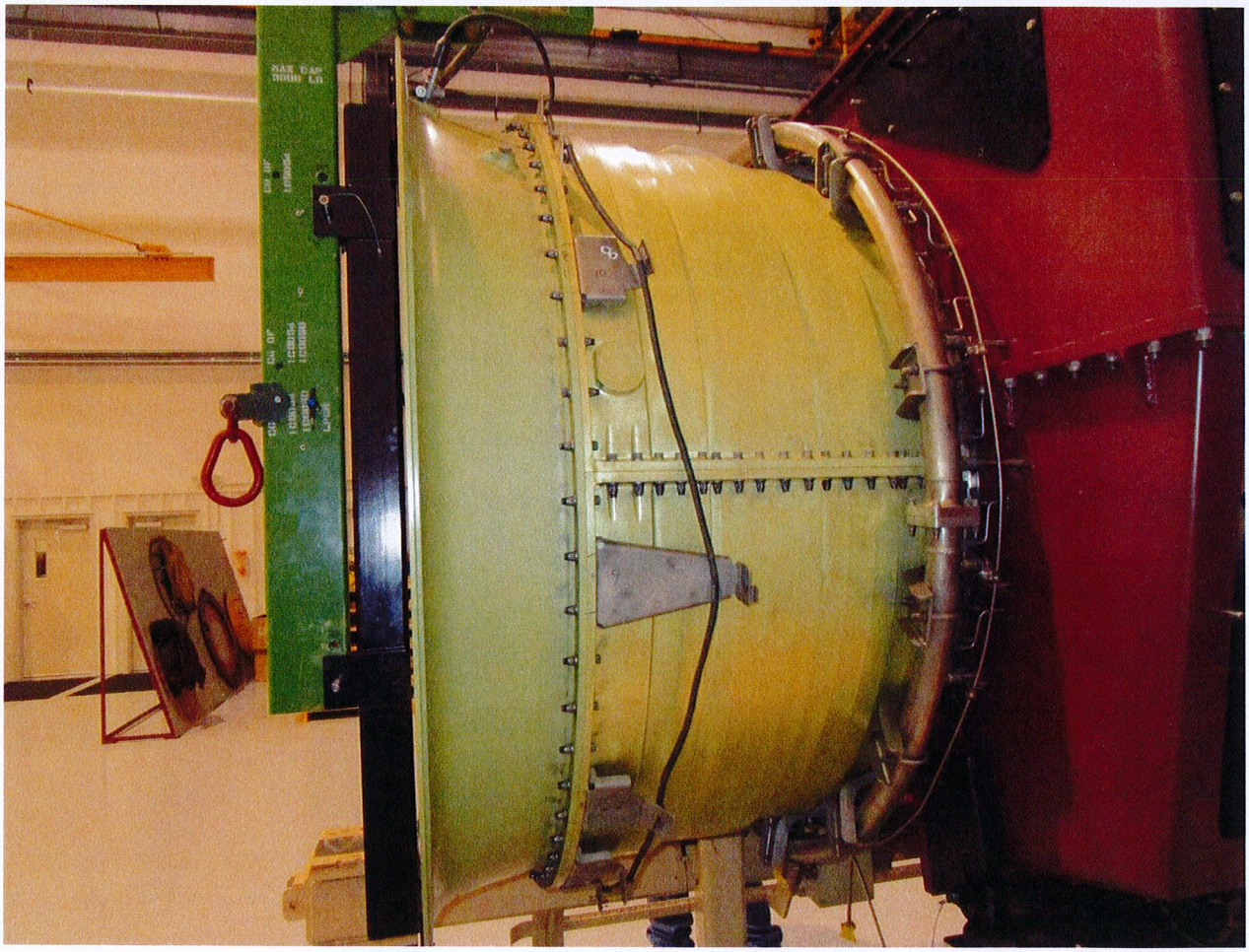


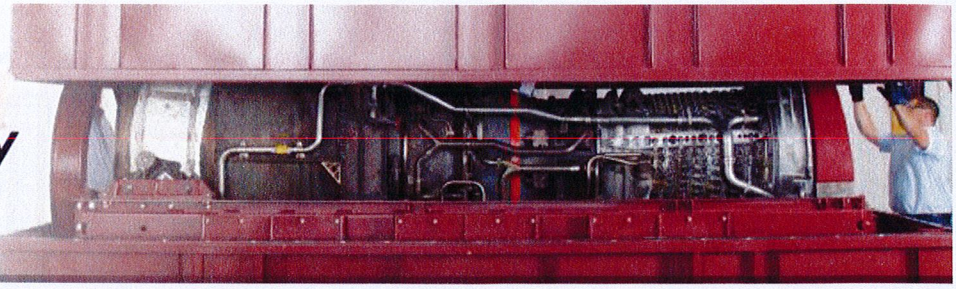
- Install HPT stage 1 nozzle



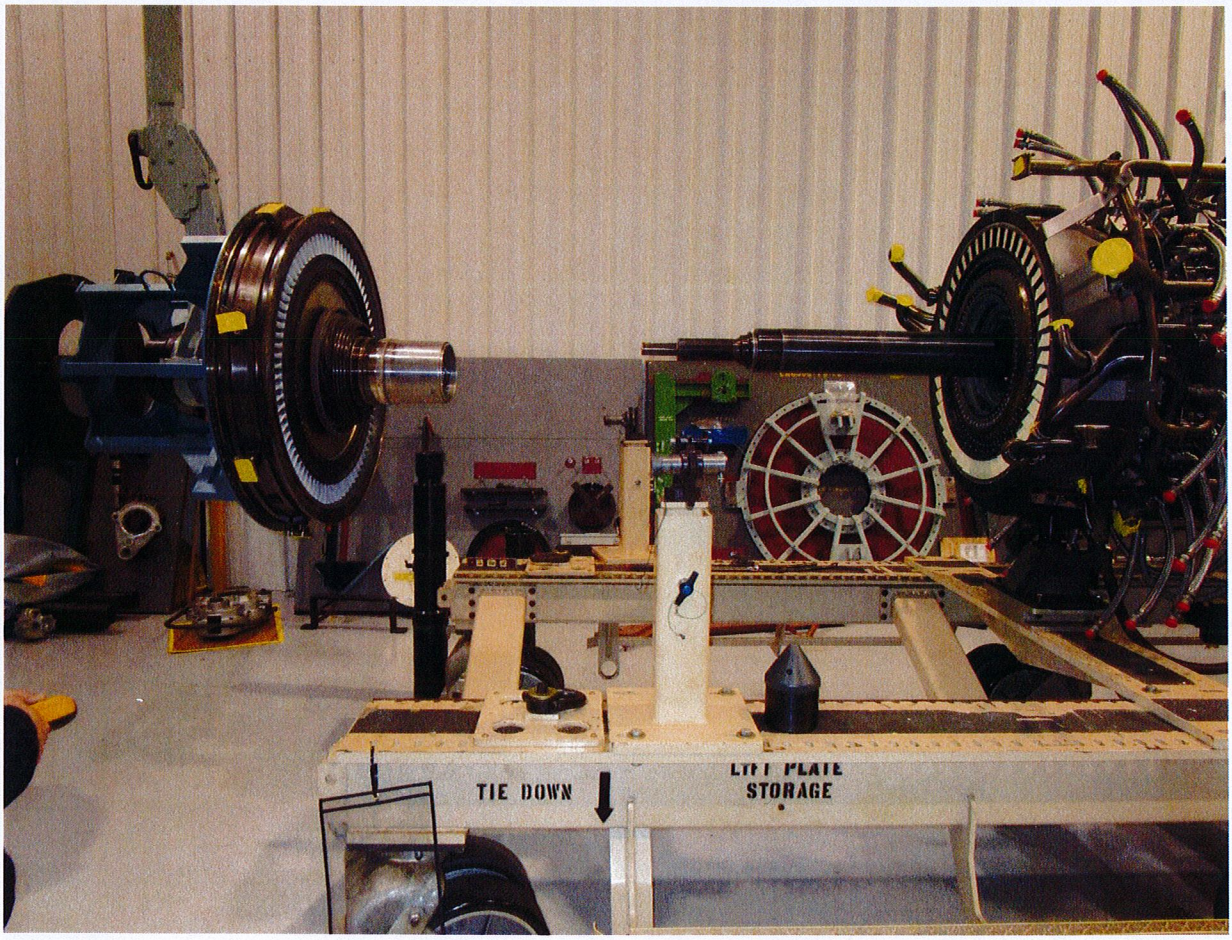


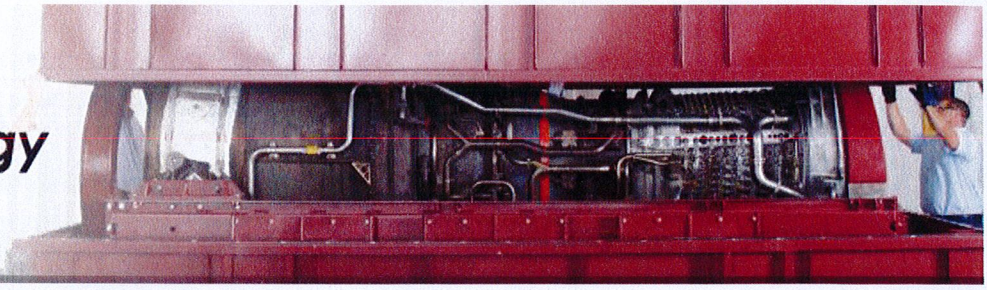
- Install IGV



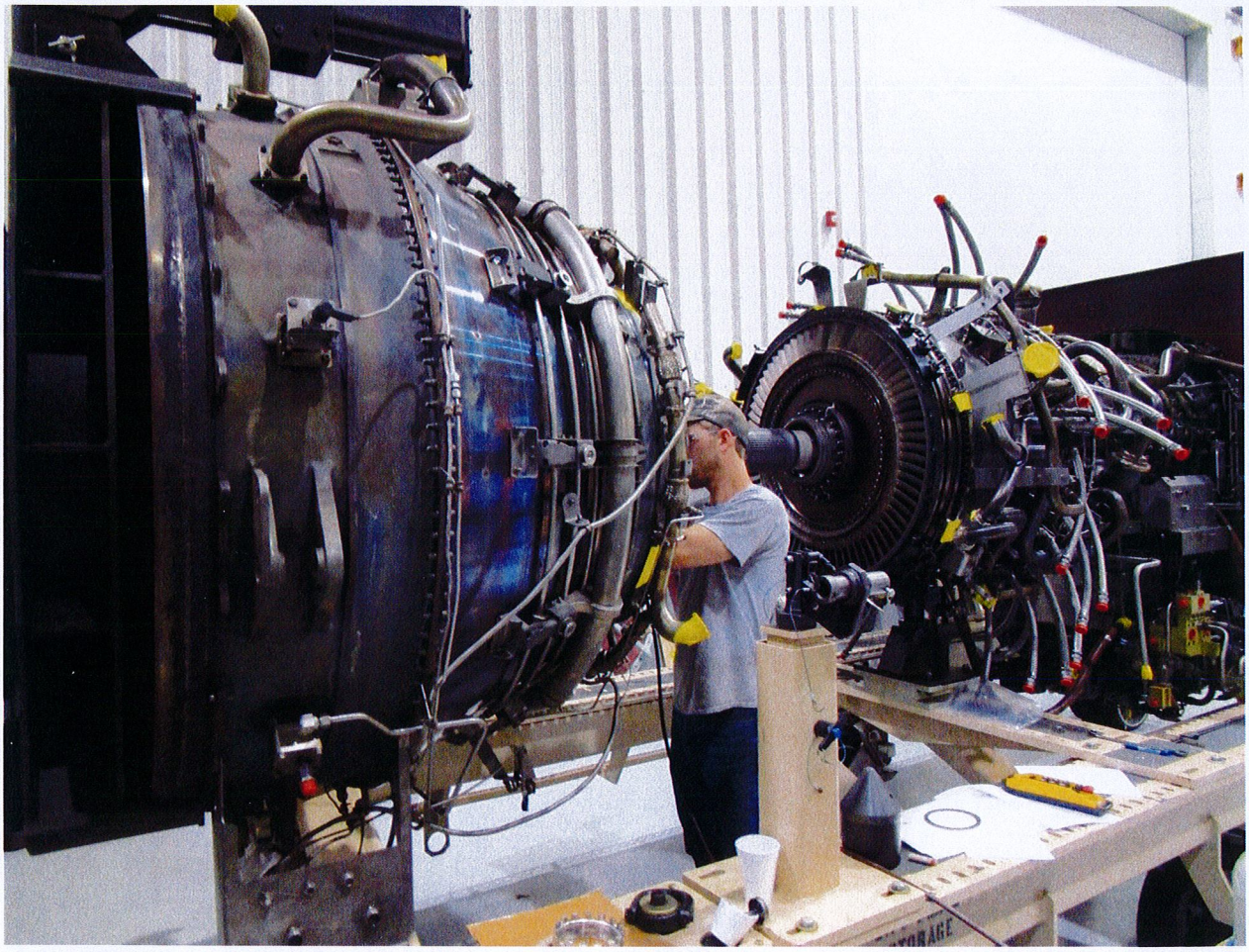


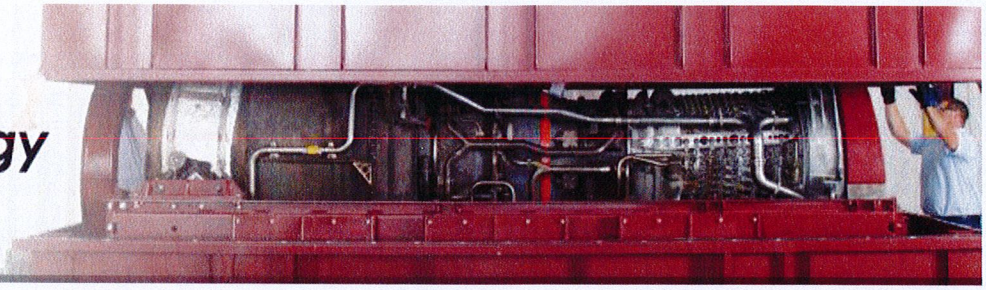
- Install HPTR





- Install LPT module





- Install External Piping