



Best Practice

SABP-K-100

4 November 2007

Heavy Duty Gas Turbines Inspections

Document Responsibility: Gas Turbines & Diesel Engines Standards Committee

Saudi Aramco DeskTop Standards

Table of Contents

1	Introduction.....	2
2	References.....	3
3	General.....	3
4	Types of Shutdown Inspections.....	4
5	Maintenance Interval/Equivalent Operating Hours (EOH).....	4
6	Inspections Best Practices.....	6
6.1	PRE-Inspection (applicable on all inspections).....	6
6.2	POST- Inspection (applicable on all inspections).....	8
6.3	Borescoping Inspection.....	9
6.4	Combustion Inspection.....	11
6.5	Hot Gas Path Inspection.....	20
6.6	Extended Hot Gas Path Inspection.....	26
6.7	Major Overhaul Inspection.....	27
	Appendix I: Turbine Auxiliaries Maintenance.....	33
	Appendix II: Gas Turbine Compressor Cleaning....	38
	Appendix III: Maintenance Interval Calculation.....	42
	Appendix IV: Template Summary of Gas Turbine Condition and Implemented Work at the Shutdown Inspection.....	50
	Appendix V: Template Summary of Gas Turbine Shutdown Inspection Status Report...	67
	Appendix VI: Typical Inspection Forms.....	71

1 Introduction

1.1 Purpose

The purpose of this Practice is to establish general guidelines for conducting the Shutdown inspections on HEAVY DUTY combustion gas turbines. Inspection guidelines provided in this document may not cover all the recommended inspection activities by the Original Equipment Manufacturer (OEM) and referring to the equipment's inspection and maintenance manual is required. This document also provides the guidelines for reporting the inspection result and consequences corrective actions and recommendations.

***Note:** This document has been developed based on the major gas turbine manufacturers (GE, Mitsubishi Heavy Industry, Siemens/Westinghouse and Hitachi). All figures shown in this document were extracted from GE and MHI manuals since the majority of heavy duty combustion gas turbines installed in Saudi Aramco facilities are GE and MHI units.*

1.2 Scope

This Best Practice gives general guidelines to be followed during Borescope Inspection, Combustions Inspection, Hot Gas Path Inspection and Major Overhaul Inspection. Also, provides a template to be used for reporting the inspection results.

1.3 Disclaimer

This Best Practice is being provided for the general guidance and benefit of Saudi Aramco engineers conducting various inspections on gas turbines. The use of this Best Practice does not relieve the manufacturer from his responsibility or duty to confirm or to verify the accuracy of any information presented or from his contractual liability to expose capability to manufacture rotating equipments with the required safety, quality control, accuracy in meeting delivery dates and filed support aspects that conforms to Mandatory Saudi Aramco Engineering Requirements. The use of the information or material contained herein will not guarantee that the resulting product satisfies the applicable requirements of Saudi Aramco Standards. Saudi Aramco assumes no responsibility or liability whatsoever for any reliance on the information presented herein in accordance with this Best Practice document. Moreover, this Best practice is intended only to provide guidelines for Saudi Aramco engineers conducting various inspections on gas turbines and shall not be considered as a replacement for the Mandatory Saudi Aramco Engineering Requirements. Saudi Aramco® is a registered trademark of the Saudi Arabian Oil Company. Copyright, Saudi Aramco, 2007.

1.4 Conflicts with Mandatory Standards

In the event of a conflict between this Best Practice and other Mandatory Saudi Aramco Engineering Requirement, the Mandatory Saudi Aramco Engineering Requirement shall govern.

2 References

The mandatory engineering requirements of the specific rotating equipment produced by the plant being evaluated shall be considered per the relevant Saudi Aramco and international codes and standards.

- *General Electric (GE) and Mitsubishi Heavy Industries (MHI) Gas Turbines Manuals*
- *ISO-900: 2000, Quality Management System Requirements*

3 General

Combustion gas turbines require a planned inspection (periodic) program including repair and replacement of parts as needed to ensure the maximum availability, reliability and safety of the engine. Several operating factors can affect the maintenance/inspection schedule and these factors must be considered along with the recommended inspection intervals by the OEM prior to the planning of the periodic inspection program. The following factors have the greatest influence:

- 3.1 Type and Quality of Fuel:** The effect of the fuel type on parts life is associated with the radiant energy in combustion process and the contaminants in the fuel. Natural gas has the lowest radiant energy and will contribute to a longer life.
- 3.2 Starting Frequency:** A significant cause of deterioration of the hot gas part's life is due to thermal shock, which occurs during start up and shutdown of the gas turbine. Frequent gas turbines starts and shutdowns subjects the hot gas path components to significant thermal cycles.
- 3.3 Load Cycle:** Usually, gas turbine manufacturers provide peak load mode, increasing the firing temperature above the designed limit, as an option to be used during operation emergencies. Operating on peak load mode will dramatically decrease the hot gas path components life.
- 3.4 Environment:** The condition of the air inlet system can influence the performance of the gas turbine especially when operated in dusty or corrosive atmosphere.
- 3.5 Start Up Time:** The normal programmed starting time is designed to minimize transient thermal stresses and maximize parts lives. If the unit has an emergency

start capability then additional parts life will be expended for each emergency start that is initiated.

3.6 Maintenance Practice: Poor maintenance of parts can cause accelerated deterioration. A good preventive maintenance program will pay dividends in reducing total maintenance cost and produce a high rate of reliability.

3.7 Type of Material: Turbine up-rate (through upgrading the material of the hot gas components to resist higher firing temperature) would result in extending the interval between shutdown inspections.

4 Types of Shutdown Inspections

Typically, most of the heavy duty gas turbine manufacturers identified three main shutdown inspections separated by predefined intervals and these intervals are depending on the components life and the previous field experience. The inspections intervals (time between shutdown inspections in fired hours) recommended by the manufacturer are considered to be the maximum operating hours without conducting a shutdown inspection. The following are the main shutdown inspections:

4.1 Combustion Inspection (CI)

4.2 Hot Gas Path Inspection (HGPI).

4.3 Major Overhaul (MI)

In addition, forth type of inspection is borescope inspection that can be conducted during any shutdown or annually to check specific stages of the compressor and hot gas path components.

5 Maintenance Interval / Equivalent Operating Hours (EOH)

Inspection, maintenance requirements and forecasting of parts life of gas turbine components varies depending upon the operating conditions. Gas turbine manufacturers have developed different formulas to calculate the inspection intervals based on various factors. Appendix III provides the different methods used by some manufacturers. Modification to these intervals can only be made based on actual experience in the site of similar models.

5.1 GE Maintenance Intervals

Table # 1 list the recommended inspection intervals (as maximum intervals) for the GE GT operating under ideal conditions of gas fuel, base load and no water or steam injection. Since most of gas turbines operate on non-ideal condition, using the maintenance factors is required to adjust for these maximum intervals.

Type of inspection	Combustion System	Factored Hours / Factored Starts					
		MS5001PA/ MS5002C,D	MS6B	MS7E/EA	MS6FA	MS7F/FA	MS7FB
Combustion	Non-DLN	12,000/800 ⁽¹⁾⁽³⁾	12,000/1,200 ⁽²⁾⁽³⁾	8,000/900 ⁽³⁾	-	-	-
	DLN	8,000/400	12,000/450	12,000/450	8,000/450	8,000/450	8,000/450
Hot Gas Path		Eliminated/1,200	24,000/1,200	24,000/1,200	24,000/900	24,000/900	24,000/900
Major		48,000/2400	48,000/2,400	48,000/2,400	48,000/2,400	48,000/2,400	48,000/2,400

* Refer to appendix III for table notes & additional information

Table #1: GE Base Line Recommended Inspection Intervals, Base Load-Gas Dry Fuel

5.2 MHI (501F) Maintenance Intervals

Similar to GE, the recommended inspection intervals by Mitsubishi Heavy Industry (MHI) are shown below based on skilled workers engagement:

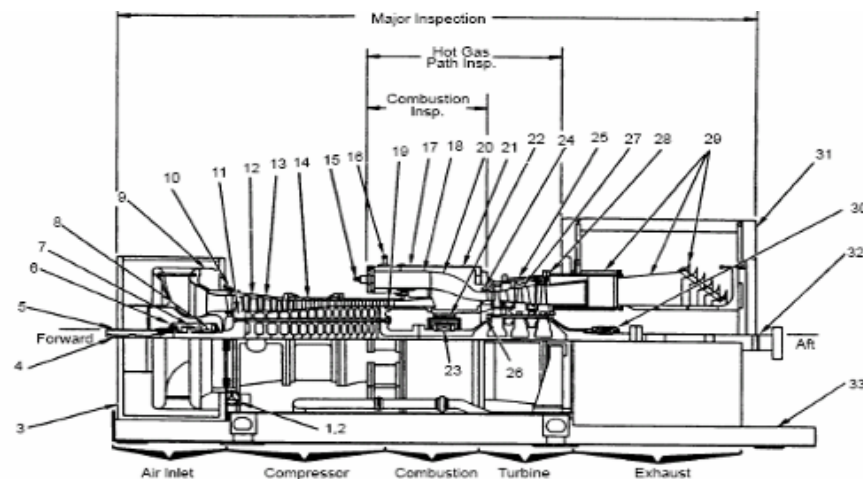
Year (Estimated EOH)	Type of Inspection & Maintenance	Expected Duration (*)
1 st (8,000)	Combustion inspection	12 days
2 nd (16,000)	Turbine Inspection	20 days
3 rd (24,000)	Combustion Inspection	12 days
4 th (32,000)	Turbine Inspection	20 days
5 th (40,000)	Combustion Inspection	12 days
6 th (48,000)	Major Overhaul Inspection	42 days

- (*)
1. Based on 24 hour work, spare parts and consumables available at site, necessary tools and equipment available at site, the lay down area enough for disassembled parts and one overhead crane.
 2. It includes cooling down period and turning operation at the last step of the inspection, but excludes test operation period.

Table #2: MHI Base Line Recommended Inspection Intervals, Base Load- Dry Gas Fuel

6 Inspections Best Practices

Figure # 1 shown below gives a generic idea of the scope involved for each shutdown inspection in terms of hardware.



The following is what is considered as being the best practices of the major activities involved for each inspection type:

6.1 PRE-Inspection (applicable on all inspections)

6.1.1 Long term planning

6.1.1.1 Continuiuos monitoring of the gas turbine operating hour status. (refer to Appendix V for samples).

6.1.1.2 Develop a comprehinsive three year plan for the anticipated shutddown inspection schedule (refer to Appendix V for samples).

6.1.2 Understanding the train

6.1.2.1 Review of alarm lists to correct during inspection.

6.1.2.2 Prior to conduct any shutdown inspection, set of operating parameters/data shall be reviewed and recorded for future record and performance monitoring. Many items status is only found when the unit is running and with periodic checks (e.g., motor noise).

- 6.1.2.3 A thorough review of the train and component history must be conducted to enable proper planning of the inspection and maintenance activities.
 - 6.1.2.4 Review previous inspection report.
 - 6.1.2.5 Combustion tuning may be required if the static data, shown in the control system, is not proper
 - 6.1.3 Activity planning
 - 6.1.3.1 The list of shutdown maintenance items shall be ready and action plan for them prepared. The list should not be generated in the last minute out of memory, but rather through a continuous compilation. Many items status is only found when the unit is running and with periodic checks (e.g., motor noise) and a proper list is generated to allow efficient inspections and overhauls.
 - 6.1.3.2 Qualification and size of gas turbine maintenance crew shall be carefully reviewed to avoid delay and low quality work.
 - 6.1.3.3 Review TIL list for unit for additional work scope and parts requirements.
 - 6.1.4 Hardware Preparation
 - 6.1.4.1 All consumable materials and all parts scheduled for replacement shall be ordered in advance, especially long lead items, to avoid delay in inspection activities
 - 6.1.4.2 All special tools required for the shutdown inspection shall be ready prior to conduct the inspection.
 - 6.1.4.3 Before and after conducting any inspection, perform compressor cleaning/washing.
 - 6.1.4.4 Examine all material (e.g., spare, consumables) for loss or damage.
 - 6.1.5 Site preparation
 - 6.1.5.1 The inspection area must be secured and planned.
 - 6.1.5.2 The lay down area must be secured and cleared.
-

6.1.5.3 Material storage area (new, refurbished, rejected) must be clearly arranged and avoid any mix up

6.1.6 Assembly, Disassembly, & Inspection instructions

6.1.6.1 Each individual component inspection procedure, acceptance criteria, inspection forms, and bolt torquing sequence and values shall be available before conducting the shutdown inspection.

6.1.6.2 Clearance diagrams shall be available for the assembly.

6.1.6.3 Assembly and disassembly instructions shall be obtained from the manufacturer manuals.

6.1.6.4 Remove all items from pockets when entering the inspection area or when being near an opened up gas turbine unit.

6.2 POST-Inspection (applicable on all inspections)

6.2.1 Report details of WORK performed, tests results and recommendations see appendix for samples. The final outage report shall include:

- i. Job summary.
- ii. Inspection summary.
- iii. Recommendations.
- iv. Parts used and recommended.
- v. TIL/ECN activity.
- vi. Combustion section data.
- vii Compressor section data (if applicable).
- viii Turbine section data (if applicable).
- ix. Lube oil system inspection (if applicable).
- x. Coupling inspection (if applicable).
- xi. Enclosures (if applicable).
- xii Alignment and clearance overview (if applicable).
- xiii. Start Up comments.
- xiv. Operating base line data.

6.2.2 Start-up of the unit: monitor unit startup for faults and abnormal sounds and time required for start up.

6.2.3 F.S.N.L. test. Conduct engine health checks at FSNL; record baseline data. Including leak check work areas of turbine.

6.2.4 Load test. Conduct health checks with engine loaded; record baseline data.

6.2.5 Update the filing system.

6.2.5.1 A comprehensive filing system must be maintained for each train (e.g., Inspections, trip reports, failures, repairs).

6.2.5.2 A filing system must be maintained for each rotatable component (i.e., items that are removed for refurbishment and might be installed in any other identical unit such as liners).

6.3 Borescope Inspection (As Required)

The objective of the borescope inspection is to assess the condition of the compressor and turbine rotating and stationary parts, without removing the compressor and turbine casings, using an optical borescoping device via the borescope access locations/borescope plugs.

Heavy duty gas turbines incorporate provisions in both compressor and turbine shells/casings for gas path visual inspection of intermediate compressor rotor stages and turbine (turbine nozzles and buckets) by means of optical borescope.

These provision, consisting of radially aligned holes through the casings and internal stationary turbine shrouds, are designed to allow the penetration of an optical borescope into the gas or air flow path regions of a non-operating gas turbine. Complete inspection can be conducted only on the rotating parts through turning the rotor in slow motion. *Borescope inspection access locations are shown in equipment manuals and marked on compressor and turbine casings. Figure # 2 shows an example for the typical access locations for GE Frame 6B gas turbine. Figure # 3 shows Borescope inspection schematic view.*

Since the displayed picture from the borescoping device sometimes is misleading, the borescoping activities should be conducted by experienced team who can identify actual defects/damages. Video tapping can be used during the inspection to record the findings for consultation purposes and to keep the history. When planning for borescope inspection, it is advisable to arrange for a good quality borescoping device to avoid wrong findings which may lead to extending the inspection scope.

The borescope allows inspection of the following areas:

- i Turbine section:* turbine nozzles and buckets (foreign object damage, corrosion, blocked cooling holes, cracks, trailing edge bowing, erosion, burning and tip clearance).

- ii *Axial flow compressor*: compressor blades (foreign object damage, dirt build up, corrosion, tip erosion, trailing edge thinning, stator blade root erosion and tip clearance).
- iii *Combustion system*: combustors and transition pieces (carbon build up, hot spots, cracking, bulging, wear and missing metal).

After the completion of the borescope inspection, the borescope plugs and bores should be inspected for wear. All borescope plugs should be reinstalled back.

- Inspect the turbine buckets, if possible, for the following defects:
 - Corrosion
 - Erosion
 - Cracks
 - Deposits
 - Oxidation
 - Bulging
 - Missing material
 - Missing/cracked TBC (if applicable)
 - Plugged cooling holes (if applicable)
 - Foreign object damage
 - Tip seals and tip clearances
- Inspect the compressor blades and vanes for the following:
 - Dent
 - Foreign object damage
 - Dust buildup
 - Corrosion
 - Erosion
 - Rubbing tips
 - Sharp edge

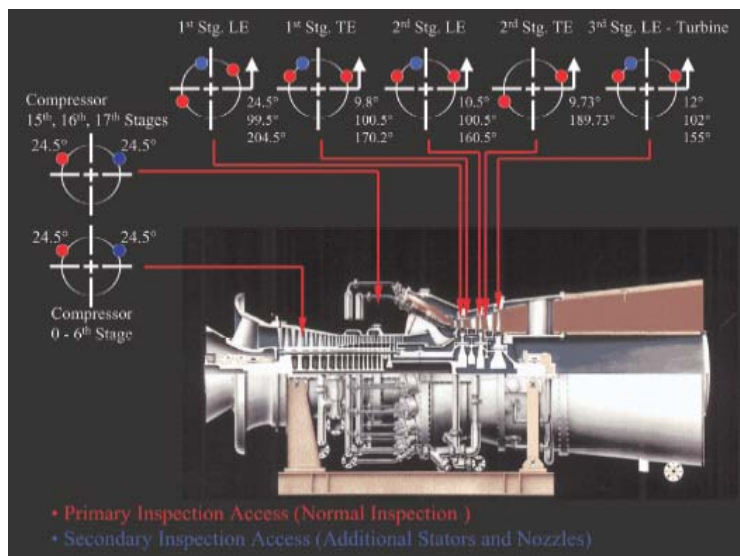


Figure # 2: Typical Borescope Inspection Access Locations for GE Frame 6F

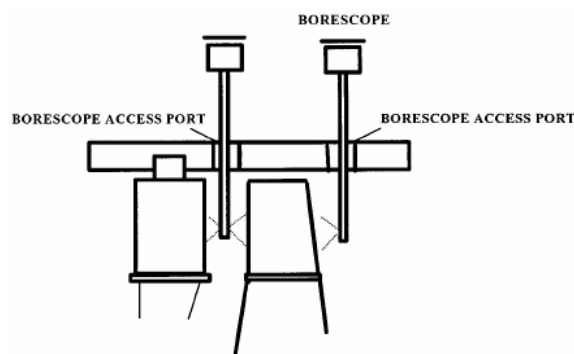


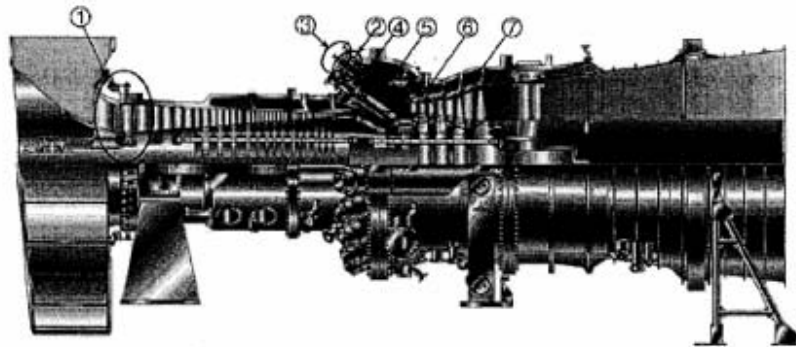
Figure # 3: Borescope inspection schematic view

6.4 Combustion Inspection “CI”

The objective of the combustion inspection is to assess the condition and to do the necessary repair if required of the combustion system components. The inspection concentrates on the combustion liners, transition pieces, fuel nozzles and end caps which are subjected for replacement, to minimize the down time, since these parts will contribute to a longer life of the downstream parts. The replaced parts can be cleaned and repaired to be available for the next combustion inspection.

Typically, it takes from 5 to 12 days to perform the combustion inspection based on an average maintenance crew, 8 to 12 hour shift a day (for MHI 501F units, two 12 hour shifts) and availability of critical spare parts and special tools.

The scope of the CI includes removing combustion system components such as fuel nozzles, combustion liners, transition pieces, and ignitors. Figure # 4 & 5 show the main components to be inspected during the CI.



- No. ① Compressor Inlet ② Flame Detectors and Ignitors ③ Fuel Nozzles
④ Combustor Baskets ⑤ Transition Pieces ⑥ Pressure side of the
1st Raw Turbine Vanes ⑦ Suction Side of the last Turbine Buckets

Figure # 4: Main Components to be Inspected during CI

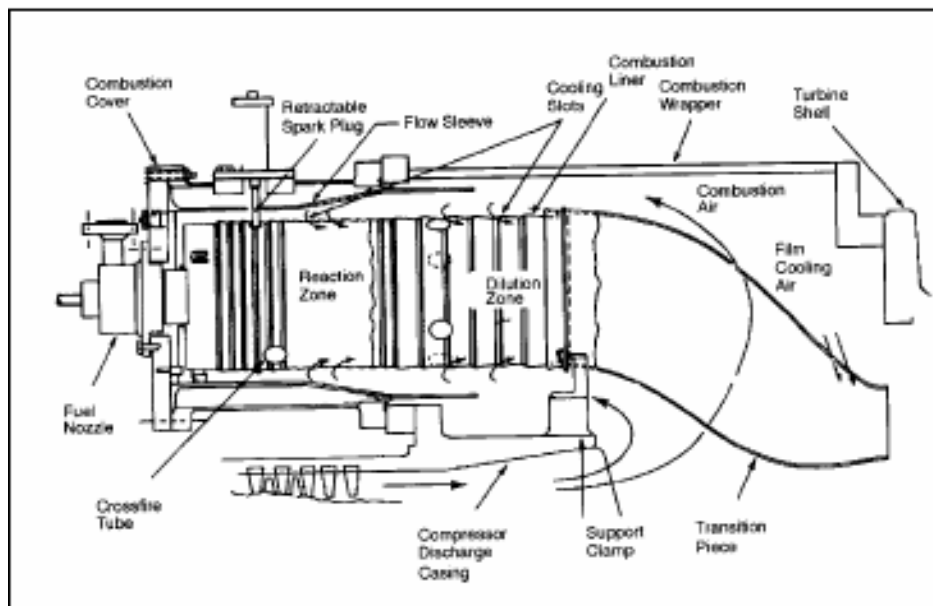


Figure # 5: Main Combustion Components

It should also be noted that GE Frame 5 gas turbines has two different combustion wrapper configuration, short and long wrapper. This difference affects the combustion inspection scope by requiring the removal of the upper

half of the combustion wrapper for the machines with the short wrapper to allow removing the transition pieces.

Typically, the below components are dismantled during the combustion inspection and following inspection activities should be performed:

Note: *Additional CI work scope activities can be found in the Operation & Maintenance manual of the equipment.*

- **Fuel Nozzles:** The following inspections should be carried out on the fuel nozzles:
 - Inspect the fuel nozzles for major carbon build-up, plugged slots or orifices, burns, cracks, erosion and wear/fretting prior to cleaning.
 - Defected/failed fuel nozzles shall be replaced with new or refurbished nozzles.
 - If large and thick carbon deposits found on the fuel nozzles, a sample can be sent to the laboratory for analysis.
 - New and repaired sets should be flow match tested.

Figure # 6 shows one of the fuel nozzles assemblies used by GE for dual fuel system.

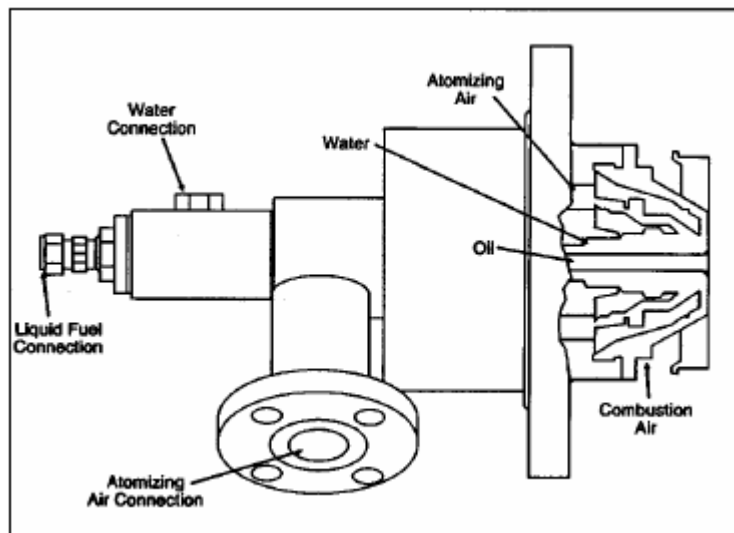


Figure # 6: Typical liquid fuel nozzle assembly

- **Fuel Gas Piping and Manifold (Applicable for Rigid piping manifold):** The fuel gas piping and manifold should be removed and radiographed to check for cracks in welded areas. The welds should be 100% pass the

radiograph test. If defects in welds are found, a weld repair shall be performed and then 100% radiographed again.

- **Flame Detectors:** The flame detectors should be visually inspected, for fretting and erosion, then tested. If the flame detectors during the inspection and sensor testing to be faulty, it should be replaced as a complete assembly. Refer to equipment manual for sensor's testing procedure.
- **Spark Plugs:** The spark plugs (igniters) should be inspected visually for wear between the tip and the hole in the combustion liner and for overheating damage to the tip. Test the spark plugs functionality as per the manufacturer approved procedure.
- **Cross Fire Tubes and Retainers:** The cross fire tubes and retainers (Figure # 7) should be inspected for the following:
 - Burn through
 - missing metal
 - distortion
 - cracks
 - Wear

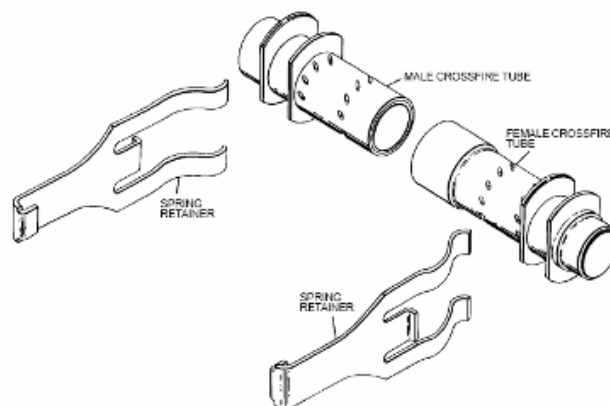


Figure # 7: Cross Fire Tubes and Retainers

- **Combustion Liners:** The inspection of the combustion liner should cover (as applicable) liner sleeve, cooling rings and holes, venture (for DLE machines), nozzles cap, center body, spring seal, cross fire tube collars, stoppers, lovers, Thermal Barrier Coating and rivets.

Visual and dye penetrant inspections of weld joints can be carried out at site. Other inspection methods, such as zygo and magnetic particles, can be

performed only in the repair shop. Refer to manufacturer's inspection procedure and acceptance criteria. Figure # 8 shows the typical combustion liner assembly.

During the inspection, the following defects should be considered:

- Cracks
- Missing metal
- Wear/fretting
- Out of roundness
- Cracked TBC
- Missing/worn TBC
- Local distortion
- Bent
- Open louvers
- Closed louvers
- Hot spot
- Burned
- Corrosion
- Damaged spring seals
- Worn liner stoppers
- oxidization

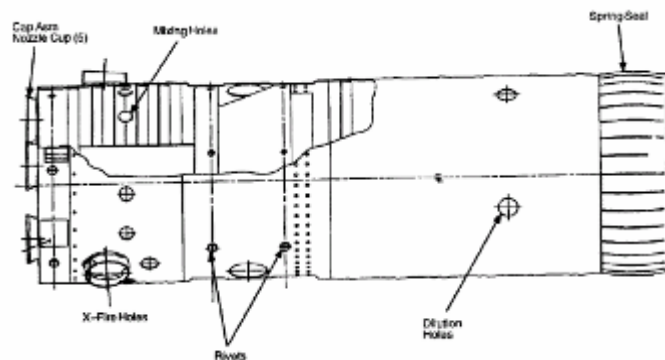


Figure # 8: Combustion Liner Assembly

- **Transition Pieces:** Visually and dye penetrant inspect the transition pieces (figure # 9) for the following:
 - Aft side seal slots for wear cracks and distortion.

- Body for weld cracks, body cracks, out of roundness, corrosion and deposits.
- Aft bracket for weld and body cracks.
- Aft frame body corners for weld or body cracks.
- Forward support bracket for weld or bod crack and wear.
- Floating seal retainers for weld or retainer cracks and wear.
- Floating seals for wear, cracks and radial movement.
- Brush seals for wear and damage.

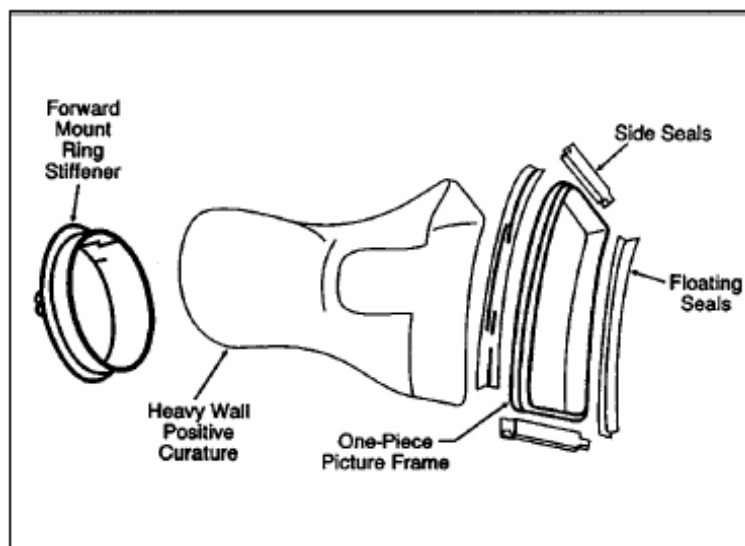


Figure # 9: Typical Transition Piece Assembly

- **Bypass Valve, Murmon Couplings & Elbow:** The following inspections can be performed:
 - Corrosion
 - Erosion
 - Cracks
 - Deposits
- **Support Springs & U-Support:** these parts require visual inspection for deformation and damaged.
- **Combustion Casing:** The following inspections can be performed on the combustion casing:

- Visually inspect inside and outside of lower and upper halves of the combustion casings for cracks, bulging, buckling signs of overhating and corrosion.
 - Visually inspect liner stoppers for wear.
 - Visually inspect all thread inserts in the combustion system.
 - **Turbine Nozzles:** The first stage turbine nozzle (pressure side) can be visually inspected via entering the combustion wrapper. During the CI, the remaining turbine nozzle stages can be only inspected with borescoping device (refer to borescoping inspection). Visual inspection for the remaining turbine nozzles require removing the turbine casing which is not covered in the combustion inspection scope. Inspect the turbine nozzles for the following:
 - Corrosion
 - Erosion
 - Cracks
 - Deposits
 - Oxidization
 - Bulging
 - Missing material
 - Missing/cracked TBC (if applicable)
 - Plugged cooling holes
 - Foreign object damage.
 - **Turbine Buckets:** If required, inspect all turbine bucket stages using borescoping device (refer to borescope inspection). First and last turbine buckets can be visually inspected through combustion wrapper and exhaust diffuser. Inspect the turbine buckets, if possible, for the following defects:
 - Corrosion
 - Erosion
 - Cracks
 - Deposits
 - Oxidization
 - Bulging
 - Missing material
 - Missing/cracked TBC (if applicable)
 - Plugged cooling holes (if applicable)
 - Foreign object damage
-

- Tip seals and tip clearances

In some gas turbines, there are no exhaust defusers which may allow visual inspection on the suction side of the last turbine buckets.

- **Axial Air Compressor:** If required, perform borescope inspection for the axial compressor through access borescope plugs (refer to borescope inspection). Inspect the compressor blades and vanes for the following:
 - Dent
 - Foreign object damage
 - Dust build up
 - Corrosion
 - Erosion
 - Rubbed tips
 - Sharp edge

The first rotating compressor row can be visually inspected through entering the compressor inlet plenum.

- **Inlet Guide Vanes:** Visually inspect (dye penetrant can also be performed) the inlet guide vanes for the following:
 - Corrosion
 - Erosion
 - Distortion
 - Cracks
 - Rubbed tips
 - Foreign object damage
 - Traces of oil deposit
 - Bushing wear
 - Dust build ups
 - Clearances between the inlet guide vanes and inner and outer compressor inlet casing.
 - Control mechanism proper functioning and without signs of wear or damaged lockwires.

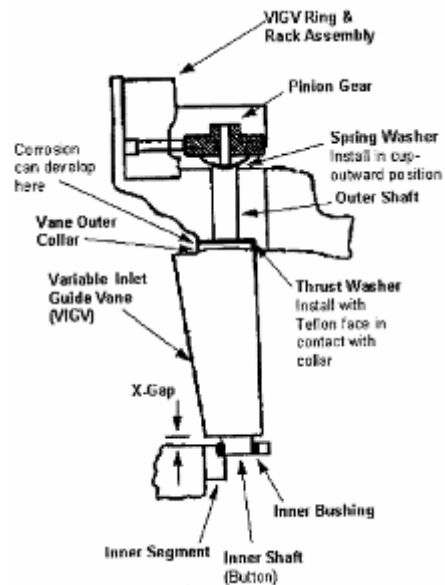


Figure # 10: Typical Variable Inlet Guide Vane assembly

- **Air Filtration System:** Visually inspect air inlet system for the following:
 - Darkness test: ensure no light is passing into the clean area.
 - Plenum's ductwork for defected metal sheet attachments, which may allow dust to enter the plenum
 - Filter elements for looseness and damages
 - Air pulsation cleaning system integrity
 - Venturi tubes damage
 - Debris screen damage
 - Silensor's cracking and wear.
 - Filter element expiration date.

Heavy dust accumulation inside the air plenum could indicate filter element or inlet ductwork problem. Visually inspect air inlet plenum manhole's gaskets for air leakage. Check filter element's screw tightening.

- **Turbine Exhaust System:** Visually inspect the exhaust ductwork integrity. Perform weld repair as required using the approved weld repair procedure. The inspection should include, as a minimum, the following:
 - Exhaust frame/casing bolts for looseness and defected tack welds
 - Exhaust thermocouples for damage
 - Expansion joint integrity

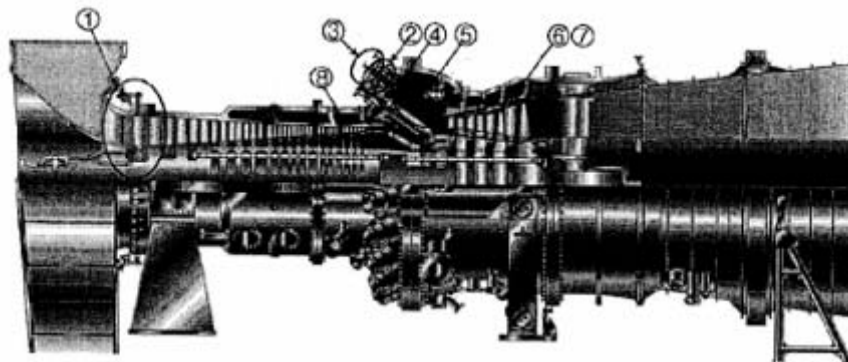
- Insulation material, material loss
 - manhole gasket for damages
 - Exhaust silencers and diffusers for cracking and wear
 - Seal plates around expansion joint for cracks
 - Missing or loss of securing plates/washers
- **Turbine Auxiliaries:** Inspection, repair and part replacement for the auxiliary equipments can be performed as required based on operation and maintenance history (refer to Appendix I).

6.5 Hot Gas Path Inspection “HGPI”

The objective of the Hot Gas Path Inspection is to inspect, evaluate or/and replace the combustion component(s). In addition, thorough inspection of turbine section including repair activities as specified by the OEM instruction manuals shall be carried out.

Typically, it takes from 20 to 25 working days to perform the hot gas path inspection based on an average maintenance crew, 12 hour shift a day (For MHI units two shifts) and availability of critical spare parts and special tools.

The hot gas path inspection includes the combustion inspection scope, as discribed above, and in addition a detailed insepection of the turbine nozzles, turbine buckets, stator shrouds and turbine seals. During the HGP inspection, the upper half of turbine casing shall be removed to provide sufficient access for the required inspections and part replacement as required. Figure # 11 shows the main components covered by the HGPI scope.



- No. ① Compressor Inlet ② Flame Detectors and Ignitors ③ Fuel Nozzles
 ④ Combustor Baskets ⑤ Transition Pieces ⑥ Turbine Vanes
 ⑦ Turbine Buckets ⑧ Compressor Last Row, Exit Guide Vanes and
 Diaphragms

Figure # 11: Main Components to be Inspected during HGPI

A complete set of turbine clearances shall be taken prior to perform the hot gas path inspection according to the clearance drawings specified by the manufacturer.

Additional to the scope of the combustion inspection, the following are main activities to be performed during the HGPI. Detailed HGPI work scope activities can be found in the manufacturer Operation & Maintenance manuals:

- **Turbine Nozzles:** Turbine nozzles should be visually inspected prior to conducting cleaning. The intent of the initial visual inspection is to predict dust accumulation on vanes, inner and outer shrouds.

The dust accumulation can be heavy as thick layers in certain areas of the nozzles which may plug cooling holes. Thick dust deposits are sometimes dangerous when they disintegrate and move in high speed with hot gases, causing foreign object damages to the downstream hot gas path components. Heavy deposits may indicate low air filtration performance due to inadequate filtration capability, damaged filter elements or air leakages through inlet air ductwork. Effective online axial air compressor cleaning could remove deposits from compressor blades and vanes. Figure # 12 shows two turbine nozzles stages.

Thorough visual and dye penetrant inspections (if applicable due to the TBC application) should be carried out on turbine nozzles considering the following:

- Cracks in leading edge, trailing edge, pressure side, suction side, inner shrouds and outer shrouds.
 - Cracked TBC, if applicable
 - Missing TBC, if applicable
 - TBC thinning, if applicable
 - Missing metal
 - Bulging
 - Erosion
 - Corrosion
 - Oxidization
 - Foreign object damage
 - Distortion and bent
 - Local overheating
 - Plugged cooling holes
 - Deposits
-

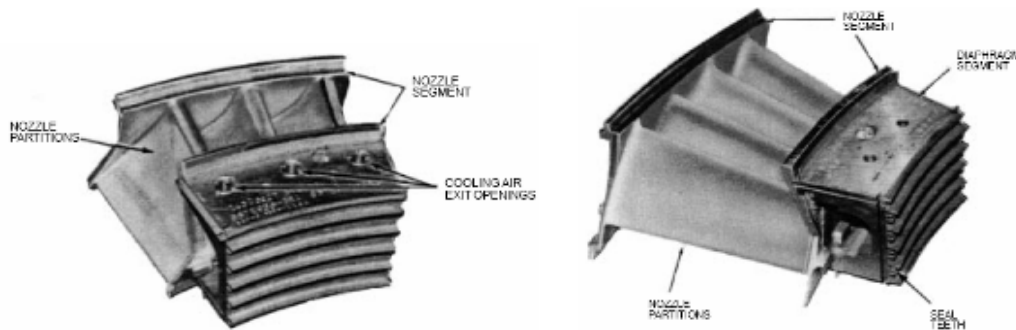


Figure 12: Typical Gas Turbine Nozzle Segments

***Note:** First stage nozzles could be replaced during the hot gas path inspection if required according to the inspection.*

- **Turbine Buckets:** Initial visual inspection to turbine buckets should be carried out to predict dust accumulation for the above mentioned reason.

Thorough visual and dye penetrant inspections (if applicable due to the TBC application) should be carried out on turbine buckets considering the following:

- Cracks in leading edge, trailing edge, pressure side, suction side and tip seals.
- Rubbing sings against shroud blocks
- Cracked TBC, if applicable
- Missing TBC, if applicable
- TBC thinning, if applicable
- Missing metal
- Erosion
- Corrosion
- Oxidization
- Foreign object damage
- Distortion and bent
- Local overheating
- Plugged cooling holes
- Deposits

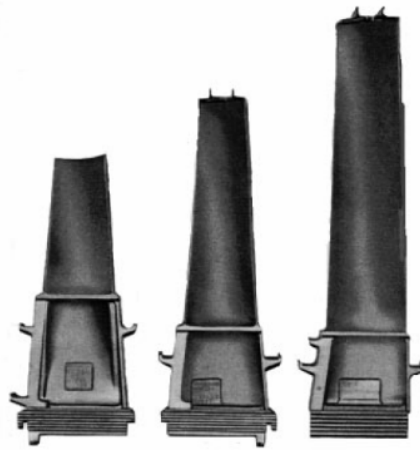


Figure # 13: Typical Turbine Buckets

- **Turbine Shroud Blocks:** visually inspect shroud blocks for the following:
 - Burns
 - Cracks
 - Deposits
 - Erosion
 - Wear
 - Missing material
 - Rubbing signs

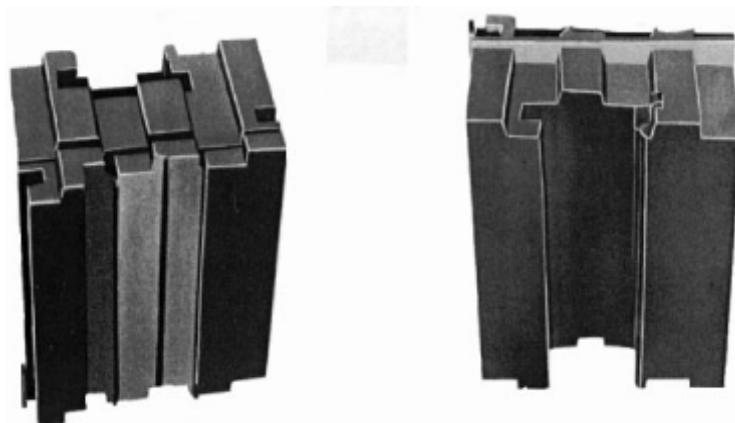


Figure # 14: Turbine Shroud Blocks

- **Turbine Bucket Cover-plates:** visually inspect the exposed face areas, dovetails area, and the inner and outer seal areas of the forward and aft cover

plates (Figure # 15) for cracks, seal damages, corrosion and looseness. Check cover-plates for free movement.

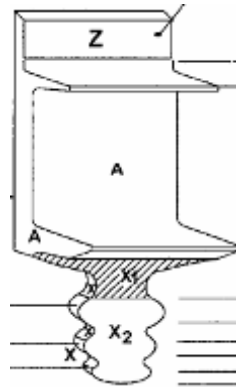


Figure # 15: Turbine Bucket Cover-plates

- **Turbine Bucket Cover-plate Twist Locks:** Visually inspect (dye penetrant inspection can be applicable) the exposed face areas of cover-plates twist locks (Figure # 16) for the following:
 - Cracks
 - Fretting
 - Corrosion
 - Foreign object damage
 - Hot spots
 - Wear
 - Seal rubs
 - Locking/stack twist lock head
 - Distortion
 - Bent.

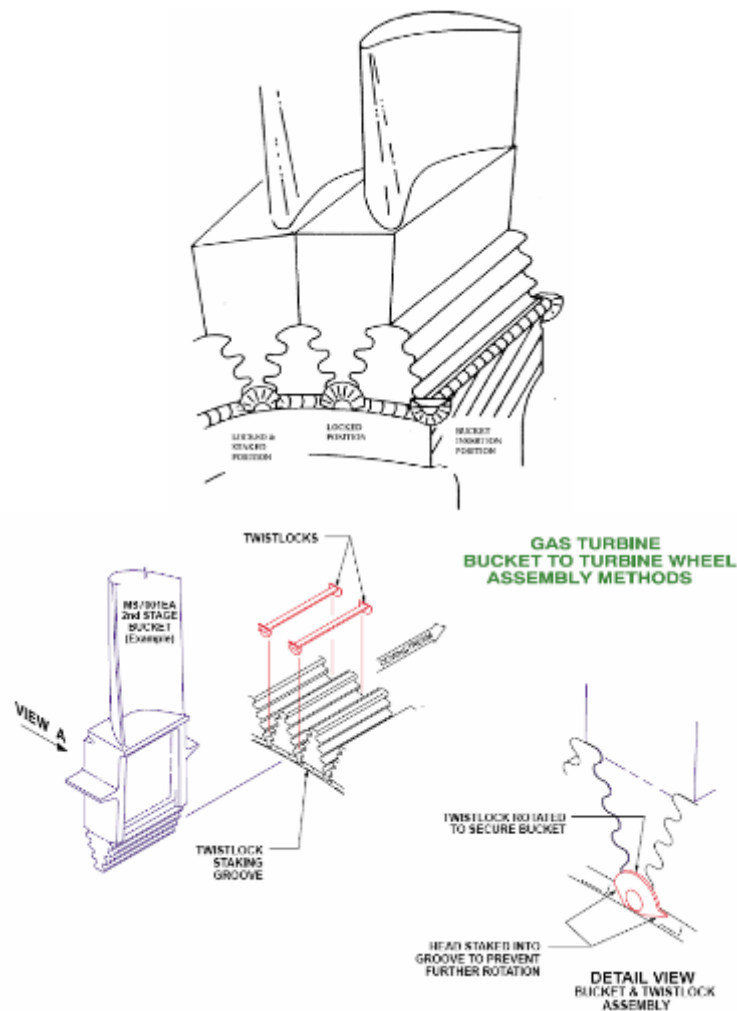


Figure # 16: Twist Locks Assembly

- **Diaphragm, Deflector and Wheel Space Thermocouples:** Visual inspection (dye penetrant inspection can be applicable) should be carried out to diaphragm seal segments and deflector to detect the following:
 - Cracks
 - Distortion
 - Fretting
 - Corrosion
 - Foreign object damage
 - Hot spot
 - Missing material
 - Seal damages

Based on the operation history, the wheel space thermocouples can be replaced.

- **Turbine Wheel Dovetails:** Visual and dye penetrant inspections should be carried out to turbine wheel dovetails to detect the following:
 - Cracks
 - Distortion
 - Fretting
 - Corrosion
 - Hot spot
 - Missing material
- **Seal Pins:** Visual inspection should be carried out to seal pins to detect the following:
 - Cracks
 - Distortion
 - Fretting
 - Corrosion
 - Missing material
- **Diaphragm Support Pins:** Visual and dye penetrant inspections should be carried out to 2nd stage diaphragm support pins to detect the following:
 - Cracks
 - Distortion
 - Fretting
 - Corrosion
 - Foreign object damage
 - Hot spot
 - Missing material

6.6 Extended Hot Gas Path Inspection “EHGPI” (As Required)

The objective of the Extended Hot Gas Path Inspection is to remove axial compressor rotor due to reported problem or refurbishment due to component life. During the EHGPI, the axial air compressor casings should be removed to allow the visual inspection to the compressor stages, compressor rotor bearings and compressor air seals.

The scope of the EHGPI include the HGPI scope and in addition the axial air compressor casings should be removed for thorough inspection and refurbishment, if required.

Typically, it takes from 25 to 30 working days to perform the extended hot gas path inspection based on an average maintenance crew, 12 hour shift a day and availability of critical spare parts and special tools.

6.7 Major Overhaul Inspection “MI”

The objective of the Major Overhaul Inspection is to conduct thorough inspection through out the gas turbine and its auxiliaries to assess the condition of each part and to replace the parts that reached life limits as per OEM recommendations.

Typically, it takes from 35 to 45 working days to perform the major overhaul inspection based on an average maintenance crew, 12 hour shift (two shifts for MHI 501F units) a day and availability of critical spare parts and special tools.

The major overhaul inspection scope involves all components within gas turbine flange-to-flange and auxiliary systems which are subjected to wear during normal operation. This inspection includes elements of the Combustion and Hot Gas Path Inspection. Removal of the upper half casings for axial air compressor, combustion section, turbine section and exhaust frame allows access to open bearings and removal of the rotor assembly. Figure # 25 shows the main CGT flange-to-flange components to be inspected during MI. Prior to removing casings, the unit must be properly supported using mechanical jacks and jacking sequence procedures to assure proper alignment of rotor and stator components.

Set of clearances and/or alignment figures shall be taken during assembly and disassembly activities for the following components:

***Note:** Refer to the manufacturer alignment and clearance drawings for the recommended values.*

- Accessory coupling alignment
 - Load coupling alignment
 - Compressor blades tip clearances
 - Compressor blades axial clearances
 - Turbine buckets tip clearances
 - 2nd Stage variable nozzle clearances (for two shaft machine)
 - Rotor position and float
 - Journal sleeve/tilting pad oil clearances
 - Bearing housing crush
-

- Rotor journal diameters
- Labyrinth seal clearances
- Air seals clearances

Note: *Refer to equipment manual for additional readings.*

In addition to the HGPI scope, the following main components shall be inspected as per the following. Detailed scope of work can be found in the manufacturer O&M manuals:

- **Journal and thrust bearings and seals**

Inspect journal bearing surface for the following:

- Cracked and chipped babbitt (caused by either excessive machine vibration or misalignment)
- Wiped/smeared babbitt (some typical cases could create large wiped areas, such as oil supply blockage, inadequate oil flow, tight journal clearances and shaft alignment)
- Scoring
- Foreign material
- Pitting/scratches (caused by impurities which accumulate in the lubricating oil system)
- Excessive or abnormal wear pattern
- Varnish
- Indication of overheating

Inspect thrust bearing surface for the following:

- Cracked and chipped babbitt
 - Wiped/smeared babbitt (some typical cases could create large wiped areas, such as oil supply blockage, inadequate oil flow or pressure, excessive thrust load, tight axial clearances between active and inactive thrust bearings and misalignment between the bearing and the thrust collar)
 - Scoring
 - Foreign material
 - Pitting/scratches (caused by impurities which accumulate in the lubricating oil system)
 - Excessive or abnormal wear pattern
-

- Varnish
- Indictation of overheating

Inspect labyrinth and knife seals for wear, rubbing, excessive clearances and sealing air feed holes blockage. Inspect labyrinth seal drain holes for blockage.

- **Axial Air Compressor Blading and Casing and Inlet Guide Vanes**

The inspection required for the axial air compressor section should cover the following:

- **Inlet Guide Vanes:** Inspect Inlet Guide Vanes (fixed and variable) for the following:
 - Actual angle vs. command (calibration)
 - Deposits
 - Foreign object damage
 - Distortion
 - Cracks (dye penetrant can be used)
 - Rubbing signs for the variable inlet guide vanes
 - Erosion (thinning of trailing edges and rounding of leading and trailing tip corners)
 - Corrosion pitting
 - Bushing wear (for the variable inlet Guide vanes)
 - Clearances between the inlet guide vanes and inner and outer compressor inlet casing

Sample of deposits from variable inlet guide vanes can be collected and sent to laboratory for analysis. If oil traces found on the guide vanes or any part of the casing, this could indicate leakage in the bearing housing/accessory compartment near to the inlet guide vanes area.

- **Axial Air Compressor Blading:** Visually inspect the compressor blades for the following:
 - Tip rubs
 - Bents (blades bent, tips bent and airfoil bent)
 - Cracks (blade fatigue cracks and blade cracks due to foreign object damage)
-

- Corrosion (blade pitting and sharp edges in leading and trailing edges)
- Deposits
- Erosion (loss of blade contour and sharp edge conditions)
- Foreign object damage (small nicks or dents around leading edge)
- Dents (areas around leading and trailing edges and vane section of blade)
- Clearances during assembly and disassembly
- **Axial Air Compressor Casing:** Visually inspect the compressor casing for the following:
 - Cracks
 - Erosion
 - Corrosion
 - Deposits
 - Wear
 - Missing material
 - Rubbing signs in the inlet guide vane area and other stages
- **Turbine Wheel Dovetails**

Turbine wheel dovetails can be only inspected when the turbine buckets are removed. Wheel dovetails can be visually and dye penetrant inspected for cracks, wear, deposits and excessive dovetail clearances.
- **First Stage Nozzle Support Ring:** Visual and dye penetrant inspection can be performed to the 1st stage nozzle support ring to detect the following:
 - Cracks
 - Fretting
 - Erosion
 - Corrosion
 - Deposits
 - Wear
 - Missing material
- **HP Rotor:** The HP rotor should be inspected in three locations; turbine wheel dovetails, rotor journals and axial compressor balding.

The turbine wheel can be visually and dye penetrant inspected for the following defects:

- Cracks
- Distortion
- Fretting
- Corrosion
- Hot spot
- Missing material
- Out of spec dimensions
- Dovetail slots deformation and/or damage (e.g., fretting, angle, corrosion)

The LP rotor journals should be visually inspected and measured for the following defects:

- Worn out
- Scratches
- Out of spec's dimension

The axial compressor balding should be visually inspected for the following defects:

- Cracks
- Distortion
- Fretting
- Erosion
- Corrosion
- Rapping signs
- Missing material
- Sharp edges
- Deposits

- **LP Rotor:** The LP rotor should be inspected in two locations; turbine wheel dovetails and rotor journals. The turbine wheel can be visually and dye penetrant inspected for the following defects:

- Cracks
- Distortion
- Fretting
- Corrosion

- Hot spot
- Missing material
- Out of spec dimensions
- Dovetail slots deformation and/or damage (e.g., fretting, angle, corrosion)

The LP rotor journals should be visually inspected and measured for the following defects:

- Worn out
 - Scratches
 - Out of spec's dimension
- **Exhaust Diffuser:** Visually inspect the exhaust diffuser for the following defects:
- Cracks
 - Erosion
 - Corrosion
 - Deposits
 - Missing material

4 November 2007

Revision Summary
New Saudi Aramco Best Practice.

Appendix I: Turbine Auxiliaries Maintenance

- **General**

Visually inspect gears for teeth conditions, bearings conditions and clearances, alignment contact, Babbitt and seal ring wear condition.

- **Lube Oil and Hydraulic Supply Filter Elements:** The lube oil and hydraulic filters in the heavy duty gas turbines are usually dual filter arrangements with transfer valve to allow replacing these filters while the gas turbine in operation. The lube oil filters should be replaced based on high differential pressure or every shutdown inspection. The filters are usually equipped with a differential pressure indicator where alarm and trip signals incorporated in the control system. Filter element should be replaced when differential pressure increases to high levels specified by the manufacturer. Exceptionally low reading may be an indication of a passing filter.
- **Fuel Filters Elements:** Fuel gas (sales gas) and diesel are the common fuels used in Saudi Aramco for heavy duty gas turbines. Regardless to the difference in fuel filtration system configuration between gas and liquid fuels, filter elements should be replaced every shutdown inspection or when differential pressure reaches high levels. Alarm and shutdown settings are usually incorporated in the control system.
- **Air Filters Elements:** Air filter elements replacement should not be attempted while the gas turbine is in operation. High differential pressure through filtration system and/or filter elements life are considered to be the main factors for filter elements replacement. Refer to filter element manufacturer to obtain component life. The air pulse system is used to keep low differential pressure reading. The integrity of the air filtration system should be checked. The filtration housing should be checked for any gaps. The integrity of the debris screen should be checked.
- **Lube Oil Tank:** During major maintenance activities which require gas turbine shutdown, the lube oil tank should be opened to check internal tubing and piping condition and loose fittings. Also, check each oil pump intake screen for foreign material and loose hardware. Remove sludge from the tank bottom. Sample of sludge can be sent to laboratory for analysis. Make sure the inside of the tanks is thoroughly clean before refilling.
- **Cooling Water System:** For units cooled with water Cooling system fouling with its consequent performance degradation should be periodically checked even with the system is properly rust inhibited. Thorough inspection during the shutdown inspection should be planned and this can be done through removing the water side head of the lube oil heat exchanger.

- **Mian and Auxiliary Cooling Water Pumps:** Check the cooling water pumps for seal leakage either when running or stopped. Check the internal cleanliness of the mechanical seal cooling water circulating line. Whenever the pump is disassembled for any reason, the impeller to wear ring clearance should be checked for excessive clearances. Also, the impeller, shaft sleeve, and wearing wring parts of the mechanical seal should be checked and replaced, if worn.
 - **Lube Oil Heat Exchangers:** Check the heat exchangers for leakage, efficient operation and foreign material contamination. Heat Exchangers are subjected to fouling (scale, sludge, deposits, etc.) and should be cleaned periodically depending on specific conditions, since they generally reduces heat exchangers effectiveness. Pressure drop and/or reduction in performance usually indicates cleaning is necessary.
 - **Fin Fan (Radiator) Coolers:** Maximum effetiveness of the fin fan coolers can be achived when the fin-tube radiator assemblies are clean and free of any kind of debris. The fin fan coolers should be cleaned perodically using washing water or washing water mixed with a suitable fins chemical cleaner to remove oil film and debris. The fins should be cleaned in the direction opposite to normal flow. Check fin fan coolers for leakage, corrosion, erosion, or damage of the fins or tubes. The fan and motor should checked for cleanliness, vibration, noise, blade damage, rust and corrosion and mounting bolet security.
 - **Liquid Fuel Forwarding System**
 - **Centrifugal Pump:** The discharge pressure of the pump should be checked against the specified figure on the P&ID's prior to start up of gas turbine. Check the pump for unusal or excessive noise and mechanical shaft seals for leakage while operation.
 - **Fuel Oil Heaters:** Check to assure that the fuel oil is being maintained within the temperature limits specified on the P&ID's. If not, check the power and control circuits.
 - **Fuel Oil System**
 - **Main Fuel Pump:** Check the shaft of the main fuel pump for leakage of the seal. Check the fuel pump bypass vlave calibration.
 - **Flow Divider:** Check the flow divider for unusal noises and external leaks. Check output pressure of the flow divider in accordance with the insturctions in the control specifications.
 - **Fuel Gas control Valves Block:** Check for excessive gas leakage at the valve stems, packing leakoff and vent lines. Check the zero effective stroke position of the control valve. If leakage noticed from valve, check the seating surfaces for damage or foreign material. Check rod seals and hydraulic cyliners for leakage. Check spendle clerances to ensure it is within required range. Calibrate and strok the valves prior to machine start up. Typically stroke position is set at a negative value to ensure proper closure and off-set due to hydraulic system.
-

- **Hydraulic Supply System**

- **Main Hydraulic Pump:** Check the shaft of the main hydraulic pump for leakage of the seal. Check the hydraulic pump for noise and vibration. Check the inlet and discharge connections for leakage and/or loose connections. Check the pump coupling for wear or damages.
 - **Auxiliary Hydraulic Supply Pump:** Check the auxiliary hydraulic supply pump for vibration, noise and leakage. Check the discharge pressure against the specified value in the P&ID's.
 - **Hydraulic Supply Piping:** All tubing connections and device connections should be checked for leakage.
- **Unit Piping Systems (Fuel, Oil, Water and Air):** Visual inspection should be carried out to check piping systems for leaks, loose hardware, loose hangers/supporters, leaky gaskets, valve packing leaks, vibration of piping, excessive piping stresses and vents functionality.
 - **2nd Stage Nozzle Control System (for two-shaft mechanical drivers):** Check the pressure of the accumulator to be within the specified values in the control specifications. Check the nozzle hydraulic cylinder for excessive leakage. Calibrate and stroke the nozzles prior to machine start up.
 - **Cooling and Sealing Air System:** Check piping for air leakage. Using the Cooling and Sealing Air Piping Schematic as a guide, check that all orifice-flange-plates are in their respective locations. Verify the orifice size stamped on the plate against the P&ID's. Check the Compressor Bleed Valves to be operated freely with no evidence of sticking. Check that the compressor discharge pressure transmitter is calibrated within the control specification.
 - **Atomizing Air System:** The atomizing air compressor should be checked for overheating, low pressure ratio and excessive gear or rotor noise.
- **Starting System**
 - **Starting Motor:** Check the starting motor for dirt, oil and grease/oily surfaces. Check ventilation channels to be free of oily vapor, debris, metal particles, dust or other contaminants.
 - **Starting Clutch:** Check the clutch jaws for signs of uneven wear, nicks or other physical damage. Check the hydraulic cylinders for leakage. Check the clearances of the clutch jaws in the engaged and disengaged positions.
 - **Torque Converter:** Check torque converter for oil leakage, vibration and noise.
-

- **Ratchet System:** Check ratchet pump motor for cleanliness. Check relief valve setting and oil leakage of external piping. Check ratchet pump for noise, high vibration and overheating.
 - **Accessory Gear Box:** Check gears for pitting, scoring and broken teeth. Check the condition of the gears and bearings.
 - **Electronic Overspeed Protection System:** The clearance between the out side diameter of the toothed wheel and the tip of the magnetic pickup should be checked. Calibration checks can be performed after each major inspection or at any time wiring has been disconnected or when a replacement overspeed card has been installed.
 - **Overspeed Bolt Assembly (for unit with mechanical overspeed protection):** Check the overspeed trip assembly for quick and positive trip action and reset capability. Check the overspeed trip assembly functionality after the completion of Major Overhaul and 30,000 fired hours after Major Overhaul. Compare the recorded value with the value specified in the control specifications in the service manual.
 - **Main, AC and DC Lube Oil Pumps:** Check the lube oil pumps for excessive vibration and leakage. Check the thrust bearings and bearing seals for wear. Check the clearances of the wear ring. If the wear exceed the recommended limit, replace the wear ring. Check the oil pumps for unusual noise.
 - **CO₂ Fire Protection System:** The system shall be checked for proper functioning (solenoid, etc). cylinders weights must be checked for appropriate values. Fire detectors shall be checked for soundness (dents, twist, distortion) and calibration. Check the dampers for obstruction and tightness. Check the compartments for tight joints especially at the doors.
 - **Accessory and Load Couplings:** The accessory and load couplings should be visually inspected for wear or other physical damage. Complete dimension check should be made (as recommended by the dedicated inspection sheet) to verify the end float, radial clearance, coupling runout, midspan, tooth condition and lubricant condition.
 - **Auxiliary Generator Coupling:** Check the auxiliary generator coupling for cracks, wear, deposits, erosion, missing metal and scratches. Clean and repack with the correct grease.
 - **Control System and Instruments:** The control system and instruments should be checked and calibrated, as specified in the service manuals, after each major overhaul inspection. The following are some of the main activities:
 - Conduct control system simulation test.
 - Combustion tuning may be required if the static data is not proper
 - Update control system with OEM configuration updates.
-

- All pressure switches, temperature switches solenoids and gauges will be checked and set to specifications.
- Control system tune-up would involve checking of present control settings and adjusting where necessary.
- Identify unit of all grounds, repair low voltage terminations to clear grounds where possible.
- CO₂ system puff test, detector and solenoid test.
- Trial run after inspection for twenty-four (24) hours without trips or unit instability.

- **Electrical**

- Remove, clean, inspect and re-install all on base AC/DC motors. Check, and clean MCC breakers.
 - Megger and inspect all on-base motor windings.
 - Inspect generator breaker and clean.
 - Check, clean and re-install leads between generator and GAC, all busbars and lagging.
 - Check, clean, test all breakers inside GAC and inspect cable jacks.
 - Calibrate all protective devices, located in generator control panel.
 - Minimum P.U.
 - Visual inspection.
 - Minimum pick-up instantaneous and time elements.
 - Two (2) point multiple check of characteristic.
 - Check current transformers operating protective devices, wired to relays located in generator control panel.
 - Loose connections.
 - Secondary injection test.
 - Resistance (burden).
 - Check the Generator Auxiliary Compartment and the Excitation system.
 - Perform insulation P.I. test to generator.
 - Seal all compartment joints to atmosphere.
-

Appendix II: Gas Turbine Compressor Cleaning

General:

Gas Turbine performance may decline as a result of deposits on compressor blades during operation. A decline in performance is indicated by a gradual loss of power output and an increase in fuel consumption. Many of the problems are a direct result of dirt or fouled axial flow compressors. Fouled compressors result in reduced air flow, lower compressor efficiency, and lower compressor pressure ratio.

Types of Fouling:

There are many types of compressor fouling. The type and rate of fouling depend on the environment in which the gas turbine operates and the type of inlet filtration. Among the most common types of contaminants are:

1. Salt water.
2. Sand and dust.
3. Hydrocarbons and general chemical products.
4. Specific products typical for the site.
5. Insects.
6. Oil, oil vapours.
7. Turbine exhaust gases.

Usually, dust and sand, as well as all the other solid contaminants are removed by the filtration system. Some of the solid particles may succeed in passing the filtration system and can result in a source of fouling together with other components, such as oil vapours. Salt causes corrosion when it deposits on blading and shall be immediately removed. The greatest fouling problems are caused by liquid mixtures, usually hydrocarbons, that deposit on blading and form a base for solid deposits. Oil vapours coming from compressor's upstream bearing can be entrained by airflow and deposit on the compressor surfaces with similar consequences as for hydrocarbons.

Method of Detection:

Two basic methods are used to determine the cleanliness of the compressor. Visual inspection and performance monitoring are described below:

Visual Inspection:

The best method for detecting a fouled compressor is to inspect it visually. This involves shutting the unit down, removing the inlet plenum inspection manhole, and

visually inspecting compressor inlet, bellmouth, inlet guide vanes and early stage compressor blading.

If any deposits, including dust or deposits, can be wiped or scraped off these areas, the compressor is fouled sufficiently to affect performance. The initial inspection also reveals whether the deposits are oily or dry. Location of the source of the oil and corrective action should be accomplished before cleaning the compressor to prevent recurrence of the fouling.

Performance Monitoring:

The second method for detecting a fouled compressor is performance monitoring. Performance monitoring involves obtaining gas turbine data on a routine basis which in turn is compared to base line data to monitor trends in the performance of the gas turbine.

The performance data is obtained by running the gas turbine at steady state BASE LOAD and recording output, exhaust temperature, inlet air temperature, barometric pressure, compressor discharge pressure and temperature, and fuel consumption. The data should be taken carefully with the unit warmed up.

The OEM's Field Performance Testing Procedure can be used as a guide for assessing machine performance both before and after cleaning the compressor.

Output and heat rate can be corrected to a standard condition using the turbine performance curves and an analysis can be made of compressor pressure ratio and efficiency. The current performance levels can be compared to baseline data and will aid in determining the problem area.

If performance analysis indicates compressor fouling, it should be verified by a visual inspection.

The compressor efficiency can be determined by the following formula:

$$\eta = \frac{T_2 - T_1}{T'_2 - T_1}$$

Where:

η = Compressor efficiency

T_1 = Ambient absolute temperature

T'_2 = Axial compressor discharge absolute temperature

T_2 = Adiabatic compressor discharge temperature, where:

$$T_2 = T_1 \left(\frac{P_2}{P_1} \right)^{\frac{K-1}{K}}$$

Where:

$$K = \frac{C_p}{C_v} = 1.4$$

Cleaning and Restoration of Performance:

The compressor may be cleaned in place through the use of cleaning agents which are introduced into the compressor. The liquid cleaning involves washing the compressor with water and detergents. Deposits, such as salt, may be removed with potable water. Oily or varnished oil deposits require detergent solutions. Refer to OEM for the recommended/approved detergents and water quality.

Generally, there are four types of washing/cleaning methods as well as different types of agents. These types are the following:

- On-line (running) with liquids.
- Off-line (crank) with liquid.
- Off-line (crank) with solids.
- Compressor cleaning during overhaul (disassembly)

The on-line and off-line compressor washing with liquids are the common methods used nowadays. On-line washing is made with the machine at rated speed and under load, while the off-line washing is made at lower speed than the rated one. The on-line washing is less efficient compared to the off-line and it is not recommended to use it alone, but it shall be considered as a support of the off-line washing. It is recommended to use on-line washing on regular bases to extend the time between off-line washings and therefore to minimize shutdowns. Long and repeated compressor washings may result in damages of high technology hot parts, such as combustion chambers, turbine buckets and nozzles.

Off-Line Washing

Off-line washing is made with the gas turbine at the speed of the starting system (cranking speed). Compressor washing happens in two stages, agent injection/soak deposits stage and rinsing with demineralized water stage. The injection of both agent and water is made by means of many nozzles located in the compressor inlet area. These nozzles are sized and positioned to inject the liquids directly into the axial compressor

suction port with the required quantity. The efficiency of this type of washing can be determined by examining the liquids drained from the compressor casing. The washing cycle should go on until rinsing water becomes clean.

On-Line Washing

On-line washing is carried out when the gas turbine is running at the rated speed and under load. This washing is carried out together with off-line washing in order to extend the machine stop times as long as possible. The frequency and quantities to be used should be fixed during operation. To fix washing times and intervals, it is important to have a proper and continuous monitoring of performances and a continuous record of parameters after each washing.

Washing with Solids

This type of washing is not recommended for up-to-date machines for which this method can cause the damage of hot gas path parts, such as turbine buckets and nozzles. Washing with solids can be carried out at intervals when other systems can not restore the performance. This type of washing can be performed only on-line with machine at steady speed and under load in order to assure a sufficient air flow and a high temperature to burn washing residues. Washing compounds can be both organic and inorganic.

Washing Procedure:

Refer to equipment manual to obtain the on-line and off-line washing procedure, the recommended detergent and water specification and mixing ratio for the specific GT model number.

Appendix III: Maintenance Interval Calculation

Inspection, maintenance requirements and forecasting of parts life of gas turbine components varies depending upon the operating conditions. Therefore, the inspection intervals should be calculated taking in consideration the following factors:

1. Operating/fired hours (part load, base load and peak load).
2. Number of Starts and Stops (including emergency starts).
3. Fast load starts.
4. Part load starts.
5. Trips history (part and full load).
6. Type of fuel (gas, diesel, heavy fuel).
7. Water and steam injections, if applicable.

Gas turbine manufacturers have developed different formulas to calculate the inspection intervals based on various factors. In principle, these formulas are similar and the difference in inspections intervals among manufacturers and gas turbines models are due to the variation in firing temperature, material of the hot gas path components and developed experience by manufacturers over time. The following calculation techniques show how to calculate the maintenance intervals and accordingly estimate the remaining life for parts which have been developed by General Electric (GE) and Mitsubishi Heavy Industry (MHI) for different frame sizes.

4.1 GE approach to calculate the Maintenance Intervals

Table # 3 list the recommended combustion, hot gas path and major inspection intervals (as maximum intervals) for the GE gas turbines operating under ideal conditions of gas fuel, base load and no water or steam injection. Since most of gas turbines operate on non-ideal condition, using the maintenance factors is required to adjust for these maximum intervals.

Type of inspection	Combustion System	Factored Hours / Factored Starts					
		MS5001PA/ MS5002C,D	MS6B	MS7E/EA	MS6FA	MS7F/FA	MS7FB
Combustion	Non-DLN	12,000/800 ⁽¹⁾⁽³⁾	12,000/1,200 ⁽²⁾⁽³⁾	8,000/900 ⁽³⁾	-	-	-
	DLN	8,000/400	12,000/450	12,000/450	8,000/450	8,000/450	8,000/450
Hot Gas Path		Eliminated/1,200	24,000/1,200	24,000/1,200	24,000/900	24,000/900	24,000/900
Major		48,000/2400	48,000/2,400	48,000/2,400	48,000/2,400	48,000/2,400	48,000/2,400

Table #3: Base Line Recommended Inspection Intervals, Base Load-Gas Fuel-Dry

Factors that can reduce maintenance intervals:

- Fuel
- Load setting
- Steam/water injection
- Peak load TF operation
- Trips
- Start cycle
- Hardware design

- Notes:** (1) Units with lean head end liners have a 400 starts combustion inspection interval.
(2) Machines with 6581 and 6BeV combustion hardware have a 12,000/600 combustion inspection interval.
(3) Multiple Non-DLN configurations exist (standard, MNQC, IGCC).
(4) Units equipped with extender kits may have different combustion and HGPI intervals

Starts and Hours Criteria:

Gas turbine wears in different ways for different service duties. Thermal mechanical fatigue is the dominant limiting factor of life for peaking machines, while creep, oxidation and corrosion are the dominant limiting factors of life for continuous duty machines. For that reason, gas turbine maintenance requirements based on independent counts of starts and hours. Whichever criteria limit is first reached determines the maintenance interval.

An alternative to GE approach, which is sometimes used by other manufacturer such as MHI, converts each start cycle to an equivalent number of operating hours with inspection intervals based on the equivalent hours count.

4.1.1 Combustion Inspection Interval

The combustion inspection interval can be determined by knowing two factors which are the hours-based and start-based combustion maintenance factors. Maintenance factors greater than one reduces the recommended combustion inspection intervals from those shown in Table -1 representing baseline operating condition. The following calculation methods are used to determine these factors.

A. Hours-Based Maintenance factor:

$$\text{Maintenance Factor} = \frac{\text{Factored Hours}}{\text{Actual Hours}}$$

$$\text{Factored Hours} = \sum (K_i \times Af_i \times Ap_i \times t_i), i = 1 \text{ to } n \text{ operation modes}$$

$$\text{Actual Hours} = \sum (t_i), i = 1 \text{ to } n \text{ operation modes}$$

Where:

I = Discrete operating mode (or operating practice of time interval)

t_i = Operating hours at load in a given operating mode

Ap_i = Load severity factor

Af_i = Fuel Severity Factor

K_i = Water/Steam injection severity factor

B. Starts-Based Maintenance factor:

$$\text{Maintenance Factor} = \frac{\text{Factored Starts}}{\text{Actual Starts}}$$

$$\text{Factored Starts} = \sum (K_i \times Af_i \times At_i \times Api \times Asi \times N_i), i = 1 \text{ to } n \text{ start/stop cycles}$$

$$\text{Actual Starts} = \sum (N_i), i = 1 \text{ to } n \text{ start/stop cycles}$$

Where:

i = Discrete start/stop cycle (or operating practice)

N_i = Start/stop cycles in a given operating mode

A_{si} = Start type severity factor

A_{pi} = Load severity factor

A_{ti} = Trip severity factor

A_{fi} = Fuel Severity Factor

K_i = Water/Steam in

4.1.2 Hot Gas Path Inspection Interval

Two criteria are used by GE to calculate the actual hot gas path (HGP) interval, versus the recommended intervals listed in the previous table, are based on fired hours and number of starts. The actual HGP intervals are mainly used to estimate the remaining life of the hot gas path components. *Since there are several frame sizes of GE gas turbines, users should refer to the equipment manual, CSD's experts, local GE representatives and GE TIL's to find the recommended parts replacement intervals.*

A. Hours-Based Maintenance factor:

$$\text{Maintenance Interval (Hours)} = \frac{24,000}{\text{Maintenance Factor}}$$

Where:

$$\text{Maintenance Factor} = \frac{\text{Factored Hours}}{\text{Actual Hours}}$$

$$\text{Factored Hours} = (K + M \times I) \times (G + 1.5 D + AfH + 6P)$$

$$\text{Actual Hours} = (G + D + H + P)$$

G = Annual base load operating hours on gas fuel

D = Annual base load operating hours on Distillate fuel

H = Annual operating hours on heavy fuel

Af = Heavy fuel severity factor (Residual Af = 3 to 4, crude Af = 2 to 3)

P = Annual peak load operating hours

I = Percent water/steam injection referenced to inlet air flow

M&K = water/steam injection constants

M	K	Control	Steam Injection	N2/N3 Material
0	1	Dry	< 2.2%	GTD-222/FSX-414
0	1	Dry	> 2.2%	GTD-222
0.18	0.6	Dry	> 2.2%	FSX-414
0.18	1	Wet	> 0%	GTD-222
0.55	1	Wet	> 0%	FSX-414

B. Starts-Based Maintenance factor:

$$\text{Maintenance Interval (Starts)} = \frac{S}{\text{Maintenance Factor}}$$

Where:

$$\text{Maintenance Factor} = \frac{\text{Factored Starts}}{\text{Actual Starts}}$$

$$\text{Factored Starts} = 0.5NA + NB + 1.3NP + 20E +$$

$$2F + \sum_{i=1}^{\eta} (a_i T_i - 1) T_i$$

$$\text{Actual Starts} = (NA + NB + H + NP)$$

Where:

S = Maximum starts/based maintenance interval (model size dependent)

NA = Annual number of part load start/stop cycles (<60% load)

NB = Annual number of base load start/stop cycles

NP = Annual number of peak load start/stop cycles (>100% load)

E = Annual number of emergency starts

F = Annual number of fast load start

T = Annual number of trips

a_T = Trip severity factor = $f(\text{load})$ (see figure – 5)

η = Number of trip categories (i.e., full load, part load, etc.)

Model Series	S	Model Series	S
MS6B/MS7EA	1,200	MS9E	900
MSFA	900	7/9 F Class	900

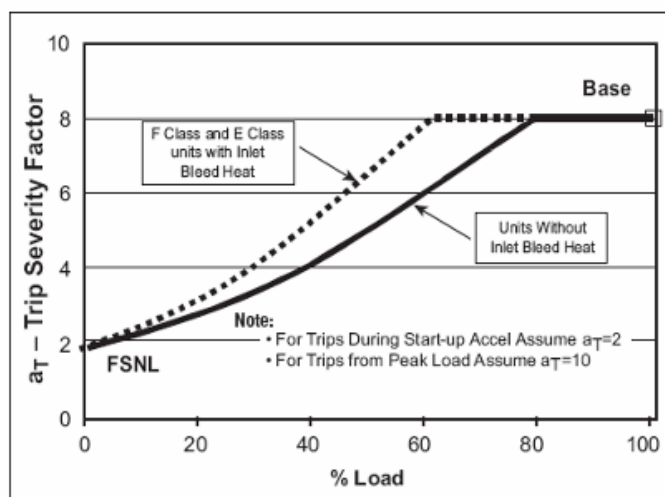


Figure # 17: Maintenance Factor, Trips from Loads

4.1.3 Major Overhaul Interval

There is no direct formula provided by GE to calculate the complete inspection interval of MI. Therefore, the previous formula provided in paragraph # 4.1.2 can be used to estimate another HGPI interval.

4.2 MHI approach to calculate the Equivalent Operating Hours

The recommended inspection intervals by Mitsubishi Heavy Industry (MHI) are shown in table 4 below.

Year (Estimated EOH)	Type of Inspection & Maintenance	Expected Duration (*)
1 st (8,000)	Combustion inspection	12 days
2 nd (16,000)	Turbine Inspection	20 days
3 rd (24,000)	Combustion Inspection	12 days
4 th (32,000)	Turbine Inspection	20 days
5 th (40,000)	Combustion Inspection	12 days
6 th (48,000)	Major Overhaul Inspection	42 days

- (*)
1. The expected duration is for one gas turbine unit.
 2. Based on one day work, skilled workers engagement through the duration, spare parts and consumables available at site, necessary tools and equipment available at site, the lay down area enough for disassembled parts and one overhead crane.
 3. It includes cooling down period and turning operation at the last step of the inspection, but excludes test operation period.

Table # 4: The Recommended Inspection Intervals by MHI

The equivalent operating hours, defined as EOH, can be calculated using the following formulas:

4.2.1 The Equivalent Operating Hours

$$EOH = \sum_{Ni} Hi + So \times A$$

Where:

EOH: Equivalent operating hours (Hr) =

Hi: Actual operating hours (Hr) =

So: Number of equivalent starts & stops =

A: Correction factor for number of equivalent start & stop
(Refer to Table-2)

4.2.2 The Equivalent Number of Starts & Stops

$$So = \sum_{Ni} (Ni) + \sum_{Ni} (Bi \times L Ri) + \sum_{Ni} (Ci \times Ti) + \sum_{Ni} (Di \times LCi)$$

Where:

Ni: Actual number of starts & stops

Bi: Number of load rejections

LRi: Correction factor for number of load rejection (Refer to Table # 5)

Ci: Number of trips

Ti: Correction factor for number of trip (Refer to Figure # 18)

Di: Number of rapid load changes

LCi: Correction factor for rapid load changes (Refer to Figure # 6)

Hot Parts		Correction Factor		
		A: for Number of Equivalent Start & Stop	LRi: for Number of Load Rejection	Ti: for Number of Trip
Combustor Basket		20	6	10
Transition Piece		20	6	10
Cross Flame Tube		20	6	10
Fuel Nozzle		20	6	10
Turbine Vane	Row 1	20	6	10
	Row 2	10	6	10
	Row 3	10	6	10
	Row 4	10	6	10
Turbine Blade	Row 1	20	6	10
	Row 2	10	6	10
	Row 3	10	6	10
	Row 4	10	6	10
Ring Segment	Row 1	20	6	10
	Row 2	10	6	10
	Row 3	10	6	10
	Row 4	10	6	10

Table # 5: MHI Correction Factor for Actual Number of Starts & Stops (Si)

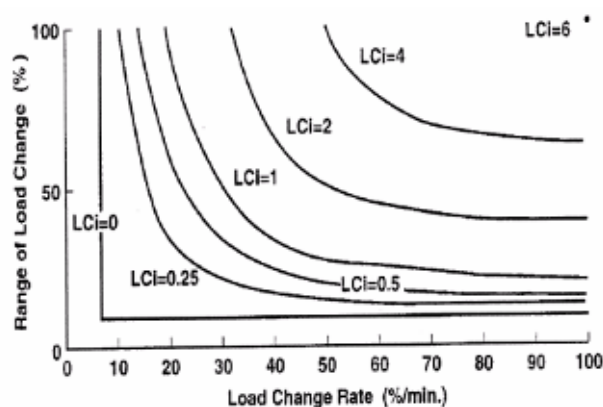


Figure # 18: MHI Correction Factor for Rapid Load Change (LCi)

Appendix IV: Sample/Template Summary of Gas Turbine Condition and Implemented Work at the Shutdown Inspection

Note 1: Below table, which have been extracted from the Seawater Injection Departement/SWED/TSU database, can be considered as a sample document to be used by the engineering team after the completion of the shutdown inspection to reflect the condition of the gas turbine as found, the implemented work based on the shutdown inspection scope, and the recommendations for future actions.

Note 2: Component list mentioned in the below table is suitable for GE Frame 5002 Type A, B and C . Additional components can be added to suit other GT brandnames and models.

Equipment Data:

Date: _____ **Plant No.:** _____ **Turbine Type:** _____

Turbine Serial No.: _____ **Type of Shutdown Inspection:** _____

Total Fired Hours Since Installation: _____ **Total Fired Hours Since Last Inspection:** _____

Total Number of Starts Since Installation: _____ **Total Number of Starts Since Last Inspection:** _____

Activity Start Date: _____ **Activity End Date:** _____

UWIP-4 GT-4 MAJOR OVERHAUL, OCTOBER 15, 2001 TO DECEMBER 10, 2001, AT 96,791 FIRED HOURS & 551 FIRED STARTS:

SUMMARY OF TURBINE CONDITION AND IMPLEMENTED WORK AT THE OVERHAUL:

A. FUEL GAS SYSTEM

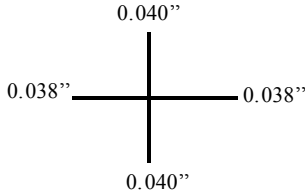
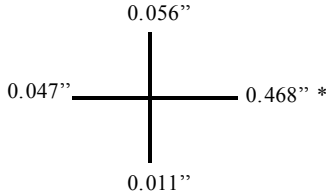
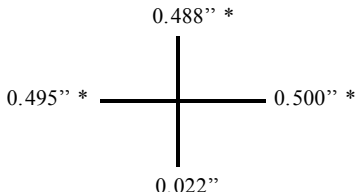
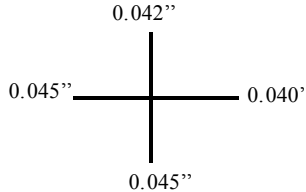
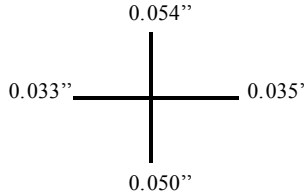
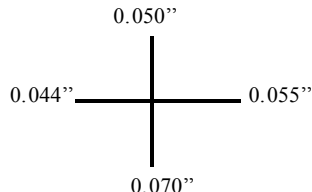
TURBINE COMPONENT	CONDITION AS FOUND	IMPLEMENTED WORK	RECOMMENDATIONS
1) Fuel Gas Piping & Nozzles	Light carbon deposits on the nozzle faces with no blockage on the orifice, slight to medium wear on the nozzles tips.	- A previously cleaned and flow matched fuel nozzle set was installed. - The manifold and pigtails were 50% radiographed in the following locations: <u>Manifold:</u> Locations # 2, 4, 6, 8, 10 and 12 <u>Pigtails:</u> Locations # 1, 3, 5, 7, 9 and 11 - No obvious defects were found. - Gas manifold and pigtails were returned to service.	Clean and flow match the removed fuel nozzle set to within 0.2" water gauge before being installed at another inspection.
2) Fuel Gas / Stop Ratio (SSRV) & Control valves (GCV)	The spindle clearances before assembly were 0.027" for SSRV and 0.071" for GCV.	A previously overhauled gas valve was installed. The valves were inspected and found in good condition. The spindle clearances were 0.035" for SSRV and 0.040" for GCV.	
3) Y Strainer	Dirty, not plugged.	New strainer was installed.	

COMBUSTION SYSTEM

TURBINE COMPONENT	CONDITION AS FOUND	IMPLEMENTED WORK	RECOMMENDATIONS
1) Crossfire Tubes and Retainers	Most of crossfire tubes and retainers were in good condition with slight to moderate wear. Three crossfire tubes and two retainers had excessive wear.	Three crossfire tubes and two retainer plates were replaced.	
2) Combustion Liners	Three combustion liners had defects as follows: • Liner no. 5 had 0.25" long crack on the holder. • Liner no. 7 had excessive wear on the crossfire tube collar. • Liner no. 8 had damaged crossfire tube collar. The remaining combustion liners were found in good condition.	Three liners were replaced. The remaining liners were cleaned and returned to service.	
3) Transition pieces: Floating seal Hastalloy X standard.	The transition pieces have accumulated 74628 fired hours since installed in 1982. All transition pieces were found in good condition without cracking or distortion.	Cleaned and returned to service.	

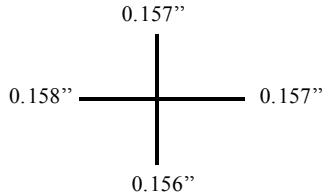
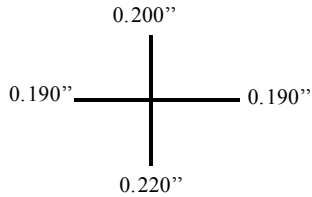
HP COMPRESSOR

TURBINE COMPONENT	CONDITION AS FOUND	IMPLEMENTED WORK	RECOMMENDATIONS
1) Inlet Guide Vanes (IGV's):	The Inlet Guide Vanes were moderately coated with black deposits.	Cleaned, dye checked and found cracks free.	
2) Stator Vanes:	Generally, most of stator blades for both top and bottom halves had signs of slight thinning and erosion. Few stator blades had minor impact damage. The first six stages were coated with moderate to heavy black deposit. The top half stator blades from stage five through fifteen (only the blades at the center of the top half casing) had minor rubbing. They were checked and found in good condition without cracking.	Cleaned, smoothened the sharp edges, dye checked and found in good condition without cracking.	
3) Compressor Casing	Both top and bottom halves were checked and found in good condition.	Cleaned.	
4) Compressor Rotor Blades:	Generally, the rotor blades were found to be in good condition. There is no major defect except light impact defect on few blades. <u>The tip clearances at opening were:</u> <u>1st stage (desired 0.035"-0.055")</u>	The HP rotor was sent to MEELSA Shop for inspection and balancing. Several rotor blades, which had minor impact damage and not dressed at MEELSA, were dressed, dye checked, inspected and found cracks free. <u>The tip clearances at closing were:</u> <u>1st stage (desired 0.035"-0.055")</u>	

TURBINE COMPONENT	CONDITION AS FOUND	IMPLEMENTED WORK	RECOMMENDATIONS
	 <u>7th stage (desired 0.035"-0.060")</u>  <u>15th stage (desired 0.055"-0.075")</u>  * Tip clearance plus casing thickness. * Casing thickness was not stamped.	 <u>7th stage (desired 0.035"-0.060")</u>  <u>15th stage (desired 0.055"-0.075")</u> 	

HP Turbine

TURBINE COMPONENT	CONDITION AS FOUND	IMPLEMENTED WORK	RECOMMENDATIONS
1) No.1 &2 Bearing Journals	Both bearing journals were in good condition.	The no. 1&2 bearing journals were cleaned and polished by MEELSA and the journal size for both bearings were found as follows: No. 1 bearing journal size was 7.9990”. No. 2 bearing journal size was 9.9992”.	
2) No. 1 & 2 Bearings and Labyrinth Seals	Signs of light wear, minor scratches and dints were observed in the bottom half for both bearing liners. No. 1&2 bearings had accumulated 48,402 fired hours. The labyrinth seals for bearing no. 1 were found in good condition. A coked oil deposit was observed in bearing no. 2 labyrinth seals <u>Oil and nip clearances during disassembly for bearing #1&2 were found as follows:</u> • Oil clearances were 0.014” & 0.016” respectively. • Nip clearances were 0.000”nip & 0.001” nip respectively.	Both bearings no. 1 & 2 were replaced No. 1 bearing oil clearance was 0.012” and the crush was 0.002” with a 0.002” shim between no. 1 bearing and its housing. No. 2 bearing oil clearance was 0.014” and the crush was 0.003”. One labyrinth seal in bearing no. 1 was replaced at the accessory coupling side due to high labyrinth clearances. New set of labyrinth seals for bearing no. 2 was installed.	

TURBINE COMPONENT	CONDITION AS FOUND	IMPLEMENTED WORK	RECOMMENDATIONS
3) Thrust Bearing	The disc and bearings were found in good condition and within GE tolerances. The rotor position found 0.207" RHS and 0.197" LHS. The float found 0.019".	Thrust bearings were cleaned and reused. The rotor position found 0.200" RHS and 0.195" LHS. The float found 0.0185".	
4) Rotor wheel	The turbine wheel was inspected and found in good condition. The wheel was magnetic M152 material and had accumulated 48,402 fired hours and 141 starts. The coverplates material was U-500. The twist locks material was magnetic, matching the HP turbine wheel.	The wheel was dimensionally and dye penetrant tested at MEELSA Shop and found within acceptable condition.	
5) HP Buckets	Heavy wall standard buckets had accumulated 48,402 fired hours. The HP buckets were in good condition with minor impact damages on several buckets. Bucket tip clearances (desired 0.174"-0.192") with old buckets 	The buckets were replaced in MEELSA Shop using refurbished heavy wall buckets and retained with refurbished U-500 coverplates. Both HP buckets and coverplates were found free in the wheel. The twist locks were magnetic similar to the wheel. <u>Bucket tip clearances (desired 0.174"-0.192") with refurbished buckets</u> 	Send old buckets for refurbishment.

TURBINE COMPONENT	CONDITION AS FOUND	IMPLEMENTED WORK	RECOMMENDATIONS
6) HP Bucket Shrouds	Most shroud blocks had light to moderate erosion. However, one shroud block, in the right hand side of the bottom half, had previous minor damage from a fire occurred in 1979.	Generally, the HP shroud blocks were in satisfactory condition and did not justify blocks replacement. Also, keeping the existing blocks will not affect turbine performance.	
7) Turbine Casing "Shell"	The turbine casing was checked and found in good condition without sign of erosion.	Cleaned.	
8) HP Nozzle	3-vane segment, serial no. 31598, was installed in 1994. The nozzle was found with substantial cracks after 33,945 fired hours in service. The nozzle bridge clamp clearance was found as follows: RHS = 0.015" & LHS = 0.015"	- A refurbished 2-vane segment nozzle, serial no. SN1G1297, was installed. This nozzle was removed from HAWIPS GT-4. - The nozzle bridge clamp clearance was set as follows: RHS = 0.012" & LHS = 0.011" Note: The desired HP nozzle bridge clamp clearance is from 0.010" to 0.017".	Scrap the 3-vane segment nozzle.
9) HP Nozzle Support Ring	The seal segments on the HP nozzle support ring were cleaned, dye checked and found in good condition without cracking.	No maintenance work was required.	

LP Turbine

TURBINE COMPONENT	CONDITION AS FOUND	IMPLEMENTED WORK	RECOMMENDATIONS
1) No.3&4 Bearing Journals	The journals of no. 3&4 bearings found in good condition within GE tolerance.	The LP rotor was sent to MEELSA Shop for inspection and balancing. The no. 3&4 bearing journals were cleaned and polished by MEELSA. The journal size for both bearings were found as follows: No. 3 bearing journal size is 8.9983”. No. 4 bearing journal size is 8.9980”.	
2) No. 3&4 Bearings & Labyrinth Seals	The journals of no. 3&4 bearings were found in good condition. Surface scratches were observed in journal liners. Both bearings can be reused. The labyrinth seals for bearing no. 3&4 were cleaned and found in good condition. <u>Oil and nip clearances during disassembly for bearing # 3&4 were found as follows:</u> - Oil clearances were 0.013” & 0.014” respectively. - Nip clearances were 0.002” crush & 0.005” nip respectively.	Light polished, cleaned and returned to service. <u>Oil clearances for bearing # 3&4 were found as follows:</u> - Oil and nip clearances for bearing # 3 were 0.013” & 0.002” crush respectively. - Oil and nip clearances for bearing # 4 were not recorded by maintenance.	

TURBINE COMPONENT	CONDITION AS FOUND	IMPLEMENTED WORK	RECOMMENDATIONS
3) Thrust Bearings	The disc and bearings were found in good condition with surface scratches. The axial float during disassembly was 0.022" and rotor position was 0.212" RHS and 0.204" LHS	Thrust bearings were cleaned and reused. The axial float during assembly was 0.016" and rotor position was 0.223" RHS and 0.215" LHS.	
4) Rotor wheel	The wheel was non-magnetic A-286 material and had accumulated 96,412 fired hours and 551 starts.	The wheel was dimensionally and dye penetrant tested in MEELSA Shop and found within acceptable condition. The wheel together with the twist locks were non-magnetic.	
5) LP Buckets	The LP buckets had minor impact defect. The tip clearances of the LP buckets during disassembly were not recorded by maintenance.	The buckets were replaced with a new set at MEELSA Shop. The buckets were retained with refurbished U-500 coverplates. The tip clearances of the LP buckets during assembly were not recorded by maintenance.	Send the old buckets for refurbishment.
6) LP Bucket Shrouds	The LP bucket shrouds were in satisfactory condition and did not require replacement.	Cleaned.	
7) LP Nozzle	The 2nd Stage Nozzle shroud partitions were inspected. The top half casing had one loose lock washer and 11 bushings with cracks in the tack weld area. The lower half casing had 8 bushings with cracks in tack weld. Generally, the LP Nozzle found in good condition.	The remaining weld at the existing bushings was enough to support the bushings. Therefore, no repair was required at this time.	

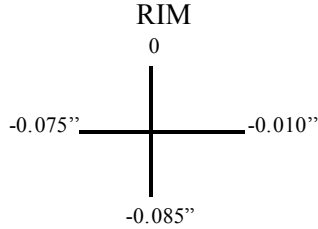
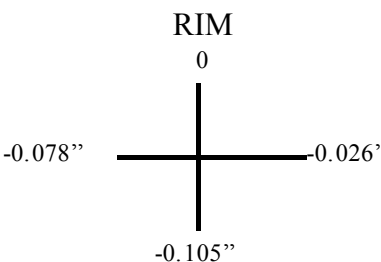
TURBINE COMPONENT	CONDITION AS FOUND	IMPLEMENTED WORK	RECOMMENDATIONS
8) Second Stage Diaphragm	The Second Stage Diaphragm was checked and found in good condition. All inner and outer seals of the diaphragm were in good condition without cracking.	The Second Stage Diaphragm was reused.	
9) Second Stage Diaphragm Support pins	Dye penetrant tested and found one support pin had minor cracks. The remaining support pins were found in good condition without cracking except for minor impact damages.	The cracks found in one support pin were not critical to reduce the strength of the support pin. These cracks will be monitored during coming overhaul. The pins were reused.	

TURBINE AIR INLET & EXHAUST SYSTEM

TURBINE COMPONENT	CONDITION AS FOUND	IMPLEMENTED WORK	RECOMMENDATIONS
1) Air Inlet & Filter Plenums	Minor oil leak coming from the accessory compartment and no. 1 bearing housing split joint. The air inlet screen was in good condition without cracking. The filter plenum together with the debris screen was in good condition. No venture tubes were broken or down.	The plenums were cleaned and all air gaps were sealed. All internal bolts were tightened properly and tack welded.	
2) Exhaust Diffuser Casing	Three one-inch long cracks were found on the top diffuser support struts.	All cracks were weld repaired using welding rod E8018-B2 with a preheat of 250°F. No post heat treatment was required.	

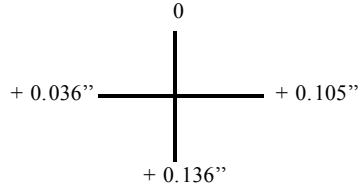
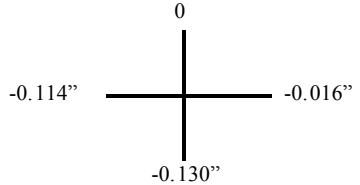
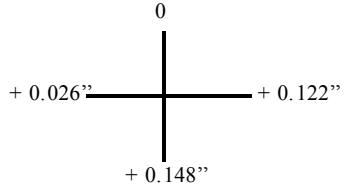
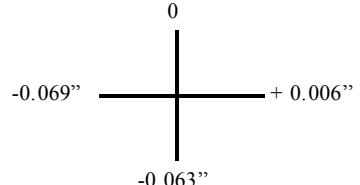
TURBINE COMPONENT	CONDITION AS FOUND	IMPLEMENTED WORK	RECOMMENDATIONS
3) Exhaust Plenum	Generally, the exhaust plenum was in good condition. Twenty-six securing plates were missing. The insulation panels were in position with little signs of distortion.	All missing exhaust insulating panel securing plates were replaced. All securing plate bolts were tack welded to the plates and the plates were tack welded to the panels.	

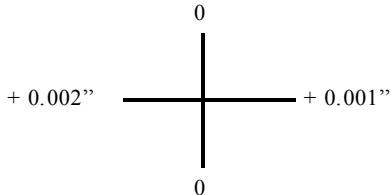
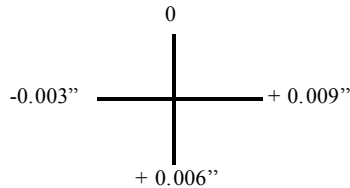
Accessory & Auxiliary Equipment

TURBINE COMPONENT	CONDITION AS FOUND	IMPLEMENTED WORK	RECOMMENDATIONS
1) Accessory Coupling	The float, lift and alignment readings during disassembly were as follows: Float: 0.970" Lift: 0.002" The alignment readings were as follows: 	The float and lift during assembly were not recorded by maintenance. After assembly, the turbine to the accessory gearbox was found misaligned. The readings were found as follows: 	

TURBINE COMPONENT	CONDITION AS FOUND	IMPLEMENTED WORK	RECOMMENDATIONS
	FACE 0 + 0.002" 0 + 0.002"	FACE 0 + 0.003" + 0.001" + 0.004" The accessory compartment was raised to correct the misalignment. The final alignment readings were as follows: RIM 0 + 0.007" + 0.013" + 0.019"	

TURBINE COMPONENT	CONDITION AS FOUND	IMPLEMENTED WORK	RECOMMENDATIONS								
		FACE 0									
2) Main Lube Oil Pump	The gears were found in good condition without damages. The inner and outer bearings had erosion pitting. Main lube oil pump bearing clearances were as follows: Float = 0.010" Oil clearance for inner bearings: Top = 0.002" Bottom = 0.006" Oil clearance for outer bearings: Top = 0.005" Bottom = 0.003"	The gears were cleaned and both inner and outer bearings were replaced. The float on both shafts during assembly was 0.012". Oil clearance for inner bearings: Top = 0.002" Bottom = 0.006" Oil clearance for outer bearings: Top = 0.005" Bottom = 0.003"									
3) Lube Oil Tank & Filters	A sample of lube oil was sent to the laboratory for analysis. The lube oil was in good condition and can be used.	New lube oil filters, hydraulic oil filters & coupling oil filters were installed. Lube oil was added to the required level.									
4) Accessory Gears	- Gears found in good condition with slight wear in the gear teeth. - All bearings were found to be worn.	- New bearings were installed. - The bearing clearances were as follows: <table style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th><u>Shaft #</u></th><th><u>I/B</u></th><th><u>O/B</u></th><th><u>Float</u></th></tr> </thead> <tbody> <tr> <td>#1</td><td>0.007"</td><td>0.008"</td><td>0.030"</td></tr> </tbody> </table>	<u>Shaft #</u>	<u>I/B</u>	<u>O/B</u>	<u>Float</u>	#1	0.007"	0.008"	0.030"	
<u>Shaft #</u>	<u>I/B</u>	<u>O/B</u>	<u>Float</u>								
#1	0.007"	0.008"	0.030"								

TURBINE COMPONENT	CONDITION AS FOUND	IMPLEMENTED WORK	RECOMMENDATIONS
		#2 0.008" 0.008" 0.012" #3 0.007" 0.007" 0.012"	
5) Starting Clutch	The key was found sheared off causing damage to clutch hub at the keyway location.	- The shaft together with a new clutch hub (gear type) was sent to Shedgum Shop for cleaning and polishing the shaft, making a new key and modifying the hub to a sleeve type as the original one. - The clutch was adjusted to the desired tolerances.	
6) Load Coupling	Disassembly Alignment Readings: G/B – Turbine  Turbine – G/B 	Assembly Alignment Reading: G/B - Turbine  Turbine - G/B 	

TURBINE COMPONENT	CONDITION AS FOUND	IMPLEMENTED WORK	RECOMMENDATIONS
7) Auxiliary Generator Coupling	The coupling was in good condition with acceptable wear on the gear teeth. The alignment readings were not recorded by maintenance during disassembly.	The coupling was cleaned and repacked with polyethylene grease. The final alignment readings were as follows: Gearbox  Generator 	The desired alignment readings are zeros.
8) Others: Ratchet Mechanism, Clutch & Torque Converter		- The ratchet was checked and adjusted to the desired clearances. It was cleaned & returned to service. - The torque converter bearing at the clutch hub side had severe wear and was replaced.	

III. HP AND LP OVERSPEED TESTS:

The overspeed test on both HP and LP rotors were carried out successfully on December 10, 2001.

The test results were:

ROTOR	THIS TRIP	LAST TRIP	TRIP RANGE
HP	5616 RPM	5632 RPM	5560-5660 RPM
LP	5218 RPM	5218 RPM	5087-5187 RPM

IV. Conclusion and Recommendation

The turbine was generally in good condition. The turbine was reassembled using a refurbished 2-vane segment HP nozzle, refurbished heavy wall HP buckets, new LP buckets and new no. 1&2 bearings. Three combustion liners, three crossfire tubes and two retainers were replaced due to severe wear and cracking.

Based on the activities carried out during this overhaul, the future overhaul schedule will be as follows:

1. A combustion inspection 15,000 fired hours from this overhaul when the turbine will have accumulated 111,791 fired hours.
2. A hot gas path inspection 30,000 fired hours from this overhaul when the turbine will have accumulated 126,791 fired hours. This is to evaluate the rejuvenated HP buckets installed at this overhaul.
3. A combustion inspection 45,000 fired hours from this overhaul when the turbine will have accumulated 141,791 fired hours.
4. A major overhaul 60,000 hours from this overhaul when the turbine will have accumulated 156,791 fired hours.

Saleh Al-Thanyan, Turbine Engineer
SWID/SWIEU

Appendix V: Template Summary of Gas Turbine Shutdown Inspection Status Report

The attached tables in Appendix IV, which have been extracted from the Seawater Injection Departement/SWED/TSU database, can be considered as samples for reporting the gas turbine operation status (on monthly bases). These tables are comprehensive and contain the required information for calculating the remaining parts life and inspection due dates, planning the future shutdown inspection activities and keeping the record. Overview of the attachment is, as per the following:

Table # 1: Turbine Operating Hours Status: This table provides the turbine operation up-to-date status on each gas turbine which consolidates the required information based on fired hours and number of starts to estimate the upcoming shutdown inspection.

Table # 2: Next Turbine Activity: This table provides the upcoming turbine inspection activity versus the current turbine status.

Table # 3: Three Year Plan for The Anticipated Shutdown Inspection Schedule: This table provides the three year look ahead plan which is required to plan for the inspection activities in terms of budget, manpower, spare parts and operation availability.

TABLE – 1
TURBINE OPERATING HOURS STATUS
3/31/2007

PLANT	NEXT O/HAUL	REQ. AT FIRED HOURS	CURRENT HOURS 3/31/2007	REMAINING HOURS	TOTAL HOURS 2/28/2007	HOURS IN 2/28/2007 3/31/2007	FIRED STARTS	ANTICIPATED DATE FOR OVERHAUL
UWSP GT-1	MAJOR	202516	187296	15220	186552	744	1125	24-Dec-2008
GT-2	MAJOR	191876	192101	-225	191357	744	1123	21-Mar-2007
GT-3	MAJOR	232073	180803	51270	180078	725	1350	2-Feb-2013
GT-4	MAJOR	168056	159656	8400	158912	744	581	14-Mar-2008
GT-5	MAJOR	170700	124017	46683	123273	744	793	26-Jul-2012
UWIP-1 GT-1	MAJOR	228100	177044	51056	176335	709	1917	1-Jan-2015
GT-2	MAJOR	227,145	173765	53,380	173030	735	1984	10-May-2015
UWIP-3 GT-1	MAJOR	223641	199145	24496	198500	645	1552	14-Jan-2010
GT-2	MAJOR	241665	185938	55727	185206	732	1528	7-Aug-2013
GT-4	MAJOR	207807	186439	21368	185698	741	1712	6-Sep-2009
UWIP-4 GT-1	MAJOR	192097	156612	35485	156503	109	1326	20-Aug-2012
GT-2	MAJOR	204840	162764	42076	162112	652	1282	20-Aug-2013
GT-3	MAJOR	146000	143852	2148	143140	712	718	28-Jul-2007
GT-4	MAJOR	156791	133754	23,037	133135	619	648	29-Sep-2010
UWIP-5 GT-1	MAJOR	192000	186975	5025	186292	683	1489	24-Nov-2007
GT-2	MAJOR	192696	189592	3104	188915	677	1610	25-Aug-2007
GT-3	MAJOR	198443	156706	41737	156001	705	725	3-Sep-2012
GT-4	MAJOR	162130	152348	9782	151631	717	736	7-Jul-2008
HAWIP GT-1	MAJOR	116000	81277	34723	80538	739	223	12-Mar-2012
GT-2	MAJOR	120000	89630	30370	88892	738	191	29-Jul-2011
GT-3	MAJOR	118000	88739	29261	88253	486	178	1-Jun-2011
GT-4	MAJOR	110450	91425	19025	90685	740	205	15-Dec-2009
GT-5	MAJOR	107453	89058	18395	88786	272	219	12-Nov-2009
ADWIP GT-1	MAJOR	312787	252787	60,000	252787	0	998	2-Jul-2017
GT-111	MAJOR	145342	89722	55620	89012	710	433	2-Oct-2016
GT-211	MAJOR	217412	186726	30686	186017	709	593	28-Jun-2012
SHWIP-2 GT-1	MAJOR	227488	203488	24000	202754	734	2187	24-Dec-2009
HDGOSP-2 GT-1	MAJOR	48,000	25874	22,126	25706	168	189	2-Jan-2011
GT-2	MAJOR	48,000	19688	28,312	18987	701	210	21-Jan-2012
GT-3	MAJOR	48,000	9803	38,197	9199	604	76	25-Sep-2013

EHGP: Extended Hot Gas Path Inspection (HP Major Overhaul Only)

TABLE-2
NEXT TURBINE ACTIVITY
3/31/2007

PLANT	NEXT TURBINE ACTIVITY	AT FIRED HOURS	CURRENT HOURS 3/31/2007	HOURS TO NEXT TURBINE ACTIVITY	ANTICIPATED DATE FOR TURBINE ACTIVITY
UWSP GT-1	CI	187516	187296	220	9-Apr-2007
GT-2	MAJOR	191876	192101	-225	21-Mar-2007
GT-3	CI	187073	180803	6270	17-Dec-2007
GT-4	CI	158056	159656	-1600	23-Jan-2007
GT-5	CI	125700	124017	1683	9-Jun-2007
UWIP-1 GT-1	CI	183100	177044	6056	1-Mar-2008
GT-2	CI	182145	173765	8380	8-Jul-2008
UWIP-3 GT-1	CI	210,000	199145	10855	25-Jun-2008
GT-2	CI	196665	185938	10727	19-Jun-2008
GT-4	CI	192807	186439	6368	21-Dec-2007
UWIP-4 GT-1	CI	172097	156612	15485	6-Aug-2009
GT-2	CI	174840	162764	12076	29-Jan-2009
GT-3	MAJOR	146000	143852	2148	28-Jul-2007
GT-4	CI	146448	133754	12694	4-Mar-2009
UWIP-5 GT-1	MAJOR	192000	186975	5025	24-Nov-2007
GT-2	MAJOR	192696	189592	3104	25-Aug-2007
GT-3	CI	168448	156706	11742	8-Oct-2008
GT-4	MAJOR	162130	152348	9782	7-Jul-2008
HAWIP GT-1	CI	86600	81277	5323	2-Jan-2008
GT-2	CI	90355	89630	725	7-May-2007
GT-3	CI	88000	88739	-739	20-Feb-2007
GT-4	CI	95450	91425	4025	26-Oct-2007
GT-5	CI	99453	89058	10395	22-Sep-2008
ADWIP GT-1	CI	267787	252787	15000	22-Oct-2009
GT-111	CI	100342	89722	10620	22-Jan-2009
GT-211	CI	187412	186726	686	12-May-2007
SHWIP-2 GT-1	CI	218488	203488	15000	14-Dec-2008
HDGOSP-2 GT-1	CI	35000	25874	9126	17-Oct-2008
GT-2	CI	22000	19688	2312	21-Aug-2007
GT-3	CI	23000	9803	13197	27-Jun-2009

CI = Combustion Inspection

HGP = Hot Gas Path Inspection for HP nozzle change-out

Shaded Boxes = Inspections are due or anticipated due in the next three months

Table # 3

THE ANTICIPATED OVERHAUL SCHEDULE FOR 2007-2009 (As of March 31, 2007 Operating Hours)

	2007												2008												2009												
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
UWSP GT-1				CI																						MJR											
GT-2			MJR																				CI														
GT-3												CI																									
GT-4	CI													MJR																							CI
GT-5							CI																				CI										
UWMP-1 GT-1															CI																						
(*) GT-2																					CI																
UWMP-3 GT-1																					CI																
GT-2																					CI																
GT-4												CI																									MJR
UWMP-4 GT-1																																					
GT-2																																					
GT-3																																					
GT-4																																					
UWMP-5 GT-1																																					
GT-2																																					
GT-3																																					
GT-4																																					
UWMP-6 GT-1																																					
GT-2																																					
GT-3																																					
GT-4																																					
HAWMP GT-1																																					
GT-2																																					
GT-3																																					
GT-4																																					
GT-5																																					
(*) ADMP GT-1																																					
GT-11																																					
GT-211																																					
SHWMP-2 GT-1																																					
HEGOSP-2 GT-1																																					
GT-2																																					
GT-3																																					

 Inspection was completed
  Inspection is in progress
  Over due
 CI=12 HGP=1 EHGP=0 MAJ=4 CI=9 HGP=0 EHGP=0 MAJ=3 CI=16 HGP=0 EHGP=0 MAJ=3
 CI= COMBUSTION INSPECTION, EHGP= EXTENDED HOT GAS PATH INSPECTION, HGP= HOT GAS PATH INSPECTION, MAJ= MAJOR OVERHAUL

(*) Note: ADWIP GT-1 MJR was a remaining activity from 2006.

Appendix VI: Typical Inspection Forms

Typical inspection forms can be obtained from the equipment manuals along with the acceptance criteria. For illustration purposes, Appendix V lists the major components inspection forms used by GE for Frame 52D.

The attached inspection forms are samples for recording the as found condition for the main components.

Attachment # 2 TO SWID/SWIEU - 006/2002

Sh. 1

DATE PRINTED: 21-Apr-02

TURBINE GENERAL INFORMATION

AS OF: 3/31/02

2334

PLANT:	UWIP4 GT4	PLANT TAG:	430 GT4
TURBINE NO:	244529	MODEL:	5002 A
RATING:	19000	COMMISSIONING DATE:	1/1/79
COMBUSTION WRAPPER:	SHORT		

COMPONENT		DATE INSTALLED	ACCUMULATED HOURS
HP BUCKET :	HW	12/11/01	1291
HP NOZZLE :	1G1297 / 2	12/11/01	1291
LP BUCKET:		12/11/01	1291
LP NOZZLE:		9/1/79	92678
No.1 BEARING:	01	12/11/01	1291
No.2 BEARING:	01	12/11/01	1291
No.3 BEARING:	92	4/26/92	49693
No.4 BEARING:	92	4/26/92	49693
TURBINE AIR FILTERS:	DON	6/1/01	2340
TRANSITION PIECE:	FLOATING SEAL	11/1/82	75919

POINTS OF INTEREST:

At the major overhaul carried out in Oct. 15, 2001 at 96,791 fired hours, the turbine was found in satisfactory condition. Both HP & LP rotors were sent to MEELSA Shop for inspection and balancing. The machine was assembled using refurbished HP buckets, new LP buckets, refurbished HP nozzle and new no. 1&2 bearings. Three combustor liners (# 5, 7 & 8), three crossfire tubes and two retainers were replaced. Overspeed test for both HP & LP rotors was carried out in Dec. 12, 2001. The HP & LP rotors were tripped at 5616 & 5218 rpm respectively.

AS OF 3/31/02 THE TOTAL FIRED HOURS AND STARTS ARE:	98082/565
THE NEXT MAJOR OVERHAUL DUE IS A HGP, DUE AT:	126791
AT THE CURRENT RATE OF USE (365 hrs/mo) THIS WILL BE DUE AT:	10/17/08
THE NEXT INSPECTION IS A CI DUE AT:	111791
AT THE CURRENT RATE OF USAGE, THIS WILL BE DUE AT:	5/16/05
THE NEXT PUMP BOROSCOPE IS DUE AT:	87846
AT THE CURRENT RATE OF USAGE, THIS WILL BE DUE AT	11/29/99

GT STANDARD

Attachment #2 TO SWID/SWIEU-006/2002 sh. 2

2334

PREVIOUS T AND I ACTIVITIES

PRINTED: 21-Apr-02

PLANT ID: UWIP4 GT4

OH NO	TYPE INSPECTION	INSPECTION DATE	OH FIRED HOURS	OH FIRED STARTS	REPORT NO	REPORT 2
1	MAJOR	9/1/79	5404	0	X not found	SAOE-WIN-480-73
2	CI	7/1/81	14095	191	WA/ms 6/28/91	
3	CI	11/1/82	22163	235	UP/P&P-623-82	
4	OTHER	6/19/84	24459	258	UP/P&P-230-84	
5	HGP	11/21/84	24891	272	MSD-039-85	
6	CI	8/1/88	35836	352	X not found	
7	OTHER	12/6/88	36700	342	DB/ahj	
8	CI	8/25/91	45386	393	SAOE/UTSU153/91	
9	HGP	11/23/91	45660	390	UOED/UTSU-62/92	
10	MAJOR	4/26/92	48389	410	UOED/UTSU248/94	
11	HGP	5/28/94	62846	461	UOED/UTSU248/94	
12	CI	6/22/96	73974	488	UOED/WIU-194/96	
13	CI	6/30/99	85983	515	SWID/SWEU576/99	
14	MAJOR	12/10/01	96791	551	SWID/SWIEU-6/02 ✓	

GT STANDARD P2

Attachment # 3 TO SWID/SWIEU - 006/2002

sh. 1

2334

**Inspection Report Gas Turbine Maintenance**NOTICE: Any alterations to this form must be approved by the Manager, Technology Programs, PGSD and the Manager, Maintenance Planning Services, Product Service Department, PGCSO.

PGS/GT-FF-6000

(FOR FIELD USE ONLY)

Site InformationFSR NO. _____ TURBINE NO. 244529 DATE Oct. 2001SKETCHES ENCLOSED: ☐ YES ☒ NOPHOTOS ENCLOSED: ☐ YES ☒ NO

Customer _____

Site Location/Unit Number (Customer) UWIPS-4 GT-4

Customer Representative _____

Gas Turbine/Model GE MS 5002 A Rating 26250 HP (ISO)Serial No. 244529 Original C.O.D. _____

Accessory Gear Serial No. _____

Driven Equipment/Model _____ Rating _____

Serial No. _____

Load Gear Serial No. _____

Date Unit Out of Service _____

Date Unit Returned to Service _____

	METER READINGS			COUNTER READINGS				
	Fired Hours	Peak Fired Hours	Manual Initiated Starts	Total Starts	Emergency Stops	Fired Starts	Fast Load Starts	Step Loads
Current Inspection	<u>96,791</u>					<u>551</u>		
Last Inspection	<u>85,983</u>					<u>515</u>		
Interval Total (Current-Last)	<u>10,808</u>					<u>36</u>		

Total Breaker OperationsType of Fuel: ☐ Distillate ☐ Other
☒ Natural Gas ☐ Water InjectionType of Outage ☒ Planned ☐ ForcedType of Inspection ☐ Fuel Nozzle Only ☒ Major
☐ Combustion ☐ Other
☐ Hot Gas Path

GE Representative _____

Reporting District _____

Report Prepared by S. T. Al-ThanyanDate 1/1/2002

ES-GAS-D7.A1.0 (4/90)

NOTE: Assistance in obtaining the data to complete this form can be obtained from PGSD or IPSD.

Attachment # 3 To SWID/SWIEU-006/2002

Sh.2

2334



Inspection Report Gas Turbine Maintenance

NOTICE: Any alterations to this form must be approved by the Manager, Technology Programs, PGSD and the Manager, Maintenance Planning Services, Product Service Department, PGSD.

PGS/GT-FF-6002
 (FOR FIELD USE ONLY)

Simple Cycle Combustion System (Casing)

FSR NO. _____

TURBINE NO. 244529

DATE Oct. 2001

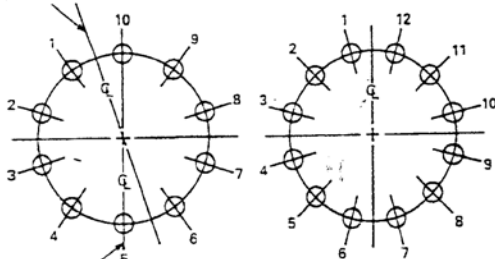
SKETCHES ENCLOSED: ☐ YES ☒ NO

PHOTOS ENCLOSED: ☐ YES ☒ NO

PROCEDURE

1. Make inspection of Combustion Casings (Cans), Inner Shields, and Covers.
2. Report Evidence of:
 - a.) **CORROSION** - Make quantitative judgement of the degree (light, medium, heavy)
 - b.) **CRACKING** - Report directional (axial or circumferential) length in inches, location (weld or parent metal) and disposition (repair or replace)
 - c.) **OVERHEATING** - Look for and report discoloration, bulging (outward), buckling (inward) or holes burned through.

MS7001 VERTICAL CENTERLINE



MS5001 AND MS6001 VERTICAL CENTERLINE MS5002

COMBUSTION LINER ORIENTATION
 LOOKING DOWNSTREAM

CHAMBER NO.	DESCRIBE CONDITION AND DISPOSITION
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	

COMMENTS: All Combustion Casings were in good condition and reinstalled during the assembly.

NOTE: Assistance in obtaining the data to complete this form can be obtained from PGSD or IPSD.

Attachment #3 TO SWID/SWIEU-006/2002

sh.3

2334

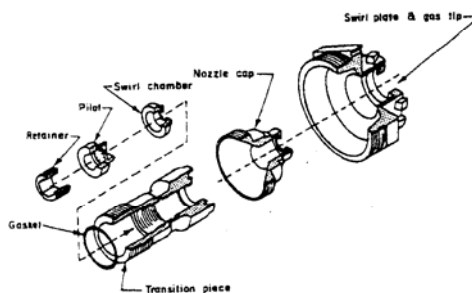
**Inspection Report Gas Turbine Maintenance**NOTICE: Any alterations to this form must be approved by the Manager, Technology Programs, PGSD and the Manager, Maintenance Planning Services, Product Service Department, PGCSO.

PGS/GT-FF-6001

(FOR FIELD USE ONLY)

Fuel Nozzle

FSR NO. _____

TURBINE NO. 244529DATE Oct. 2001SKETCHES ENCLOSED: ☐ YES ☒ NOPHOTOS ENCLOSED: ☐ YES ☒ NO**NOZZLE TYPE:**

- | | |
|---|--|
| ☐ Mechanical Atomizing | ☐ Distillate Only |
| ☐ Air Atomizing | ☐ Gas/Dist |
| ☐ Gas | ☐ Gas/Dist/Residual |

Vendor Out _____

Vendor In _____

Part Number:

*Out _____

*In _____

*Note: If Part Number In is different than Part Number Out, Check with G.T.C.S.D.

EROSION & DEPOSIT CONDITION CODES:

- | | | | | |
|----------------|---|---|---|-----------------|
| No Erosion | - | N | - | No Deposits |
| Slight Erosion | - | S | - | Slight Deposits |
| Heavy Erosion | - | H | - | Heavy Deposits |

DISPOSITION CODES:

- N - No repair or replacement necessary.
R - Repaired/cleaned (On-site, Vendor or GE Service Shop).
RN - Replaced with new component.

Chamber No.	Serial Number		Nozzle Cap		Transition Piece Erosion	Body Leakage		Disposition	Replacement Recommended (Check ✓ if yes)
	Out	In	Deposits	Erosion		Yes	No		
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									

COMMENTS: The set was replaced with a previously cleaned and flow matched set.NOTE: Assistance in obtaining the data to complete this form can be obtained from PGSD or IPSD.

ES-GAS-D7.A1.1 (4/90)

Attachment # 3 TO SWID/SWIEU -0067 2002

Sh.4

2334



Inspection Report Gas Turbine Maintenance

NOTICE: Any alterations to this form must be approved by the Manager, Technology Programs, PGSD and the Manager, Maintenance Planning Services, Product Service Department, PGSD.

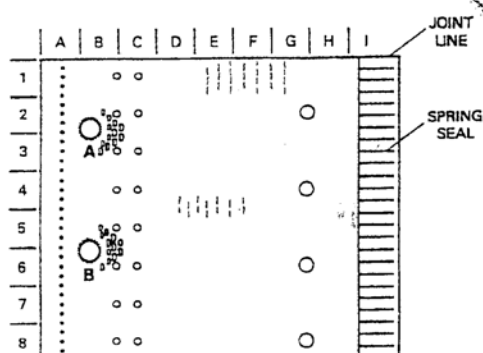
PGS/GT-FF-6003
(FOR FIELD USE ONLY)

Combustion System (Liner)

FSR NO. _____ TURBINE NO. 244529 DATE Oct. 2001

SKETCHES ENCLOSED: ☐ YES ☒ NO

PHOTOS ENCLOSED: ☐ YES ☒ NO



DEVELOPED VIEW OF HOLE,
LOUVER AND SPRING SEAL PATTERN

PART NUMBER OUT*

PART NUMBER IN*

*Note: If Part (Drawing) Number IN (installed) is different than Part (Drawing) Number OUT (removed), check with G.T.C.S.D.

DEFECT CODES:

BU - Burned
CO - Corroded
CR - Cracked
BK - Buckled
H - Hot Spots
TBC - Loss of Thermal Barrier Coating
LO - Louvers open
LC - Louvers closed
BR - Broken
BT - Bent
M - Missing
W - Worn

DISPOSITION CODES:

N - No repairs or replacement necessary
R - Repaired (on site, vendor, or GE Service Shop)
RN - Replaced with new component

Chamber No.	Serial Number		Liner Defects (Code and Location for cracks, also indicate if hole to hole, louver to louver or louver to hole)	X-Fire Tube Collar Defect (Code and Location)
	Out	In		
1	108HT	→	Slight Wear at Fuel Nozzle Collar	Slight wear
2	A502	→	Slight wear at Fuel Nozzle Collar	Medium Wear
3	A204	→	Slight Wear at Fuel Nozzle Collar	Medium Wear
4	A92	→	Slight Wear at Fuel Nozzle Collar	Slight Wear
5	A235	A155	Slight Wear at Fuel Nozzle Collar Cracked Holder (0.25") Long.	Slight ~ Medium Wear (Replaced)
6	A405	→	Slight Wear at Fuel Nozzle Collar	Medium Wear
7	X088	A312	Slight Wear at Fuel Nozzle Collar	Excessive Wear (Replaced)
8	A343	A323	Slight Wear at Fuel Nozzle Collar	Damaged Collar (Replaced)
9	A535	→	Slight Wear at Fuel Nozzle Collar	Medium Wear
10	A183	→	Slight Wear at Fuel Nozzle Collar Bent Spring Seal → Ppe checked → OK	Slight Wear
11	A226	→	Slight Wear at Fuel Nozzle Collar Bent Spring Seal → Ppe checked → OK	Medium Wear
12	A762	→	Medium Wear at Fuel Nozzle Collar	Slight Wear.

(Continued on Back of Form)

NOTE: Assistance in obtaining the data to complete this form can be obtained from PGSD or IPSD.

ES-GAS-D7.A1.3 (4/90)

Attachment# 3 TO SWID/SWIEU-006/2002

sh. 5



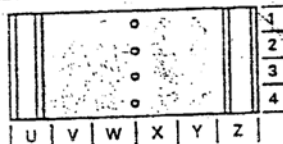
Inspection Report Gas Turbine Maintenance

NOTICE: Any alterations to this form must be approved by the Manager, Technology Programs, PG&E and the Manager, Maintenance Planning Services Product Service Department, PGCSID.

PGS/GT-FF-6004
(FOR FIELD USE ONLY)

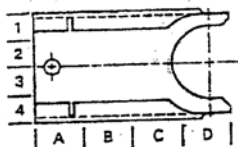
Combustion System (Crossfire Tube)

FSR NO. _____

TURBINE NO. 244529DATE Oct. 2001SKETCHES ENCLOSED: ☐ YES ☒ NOPHOTOS ENCLOSED: ☐ YES ☒ NODEVELOPED VIEW
OF TYPICAL
CROSSFIRE TUBE

DEFECT CODES:

W - Wear
CR - Cracked
BT - Bent
BU - Burned
H - Hot Spots
WA - Wear Coating Lost

RETAINER FOR
CROSSFIRE TUBE

DISPOSITION CODES:

N - No repairs or replacement necessary
R - Repaired (On-site, Vendor or
GE Service Shop)
RN - Replaced with new component

Chbrs.	Cross Fire Tube Defects (Code & Location)	Dispo- sition codes	Replacement Recommended		Retainer Defects Chbr. End	Dispo- sition	Replacement Recommended	
			Yes	No			Yes	No
1-2	SLIGHT-MEDIUM WEAR				1 2	SLIGHT-MEDIUM WEAR		
2-3					2 3			
3-4					3 4			
4-5					4 5			
5-6					5 6			
6-7					6 7			
7-8					7 8			
8-9					8 9			
9-10					9 10			
10-11					10 11			
11-12					11 12			
12-1					12 1			

COMMENTS: Three Crossfire Tubes & two Retainers were replaced. The remaining Crossfire Tubes & Retainers were reinstalled during the assembly.

Attachment # 3 To SWID/SWIEU-006/2002 Sh36



Inspection Report Gas Turbine Maintenance

NOTICE: Any alterations to this form must be approved by the Manager, Technology Programs, PGSD and the Manager, Maintenance Planning Services, Product Service Department, PGCSO.

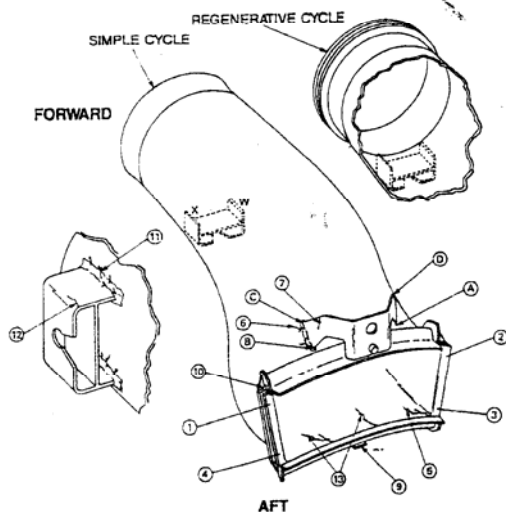
PGS/GT-FF-6314 (AT)
(FOR FIELD USE ONLY)

MS5002 Transition Piece

FSR NO. _____ TURBINE NO. 244529 DATE Oct. 2001

SKETCHES ENCLOSED: ☐ YES ☒ NO

PHOTOS ENCLOSED: ☐ YES ☒ NO



CRACK LOCATION CODES:

- A, B, C, D-Positions on aft bracket.
- W, X-Positions on forward bracket.
- 1, 2, 3, 4-Positions on aft corners.
- 5-Casting corner cracks.
- 6-Aft bracket weld cracks.
- 7-Aft bracket body cracks.
- 9-Floating seal retainer weld cracks.
- 10-End cover (ear) weld cracks or wear (floating seals).
- 11-Forward bracket weld cracks.
- 12-Forward bracket breaking.
- 13-Transition piece rupture.

PART NUMBER OUT* _____

PART NUMBER IN* _____

*Note: If Part Number IN is different than Part Number OUT, Check with G.T.P. & C.S.D.

DISPOSITION CODES:

- N - No Repair or replacement necessary
- R - Repaired (On-site, Vendor or GE Service Shop)
- RN - Replaced w/new component

DEFECT CODES:

- W - Wear
- H - Hot Spots

Chmbr. No.	Serial		Cracks (State Location & Length)
	Out	In	
1	5281096	→	ALL TRANSITION PIECES WERE IN GOOD CONDITION EXCEPT FOR SLIGHT TO MEDIUM FRETTING BETWEEN THE SEALS AND SIDE FRAMES. ALL WERE RETURNED TO SERVICE.
2	5281053	→	
3	5281097	→	
4	5281086	→	
5	5281112	→	
6	5281116	→	
7	5281094	→	
8	5281104	→	
9	5281084	→	
10	5281076	→	
11	5281073	→	
12	5281085	→	

(Continued On Back Of Form)

NOTE: Assistance in obtaining the data to complete this form can be obtained from PGSD or IPSD.

Attachment # 3 TO SWID/SWIEU-006/2002 sh. 7 10-LS--1

8496

2334

GE Inspection Report Gas Turbine Maintenance

PGS/GT-FF-6046
(FOR FIELD USE ONLY)

MS5002 Series Bearing & Seal Clearances

FSR NO. WIP-4 TURBINE NO. GT-4 DATE 11-15-2001

SKETCHES ENCLOSED: ☐ YES ☐ NO MAJOR O/H PHOTOS ENCLOSED: ☐ YES ☐ NO

CONDITION CODE:

M - Missing Metal
W - Worn
CR - Cracked

DISPOSITION CODE:

N - No repair or replacement necessary
R - Repaired (On-site or GE Service Shop)
RN - Replaced with new component

NOTE:

1. All axial clearances are to be measured with H.P. rotor blocked toward the inlet, and the L.P. rotor blocked toward the exhaust (against loaded thrust faces "XA" and "XB").

2. Bearing angularity is determined from the bottom B1 and B2 lead wire readings.

3. Bearing angularity: $\frac{(B1-B2)}{L}$ or $\frac{(B2-B1)}{L}$

CLEARANCES

	Left	Right	Top	Bottom	Condition	Disposition	COMMENTS
1S1	0.004	0.010					
1S2	0.004	0.010					
1S3	0.006	0.008					
1S4	0.007	0.008					
1S5	0.007	0.008					
1S6	0.008	0.008					
1S7	0.0015	0.0015					
1XS	Top half		Btm half				
T1							
TIS	Top half		Btm half				
1B1	0.010	0.010					
1B2	0.010	0.010					
2S1	0.005	0.010					
2S2	0.005	0.010					
2S3	0.011	0.014					
2S4	0.015	0.014					
2S5	0.006	0.006					
2S6	0.006	0.006					
2B1	0.010	0.010					
2B2	0.010	0.010					

No. 1 Bearing Angularity = in./in. No. 2 Bearing Angularity = in./in.

ADDITIONAL COMMENTS: AXIAL CLEARANCE 0.019 OF HP

(Continued on back of form)

NOTE: Assistance in obtaining the data for Form 1000 this form can be obtained from PGSD or PDS.

ES-GAS-D7.A1.46 (4/90)

8496

Attachment # 3 TO SWID/SWIEU-006/2002

sh. 8

2334



Inspection Report Gas Turbine Maintenance

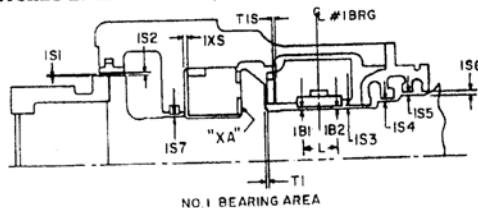
PGS/GT-FF-6046
(FOR FIELD USE ONLY)

WIP-4 GT-4

MAJOR O/H

MS5002 Series Bearing & Seal Clearances

FSR NO. WIP-4 TURBINE NO. GT-4 DATE _____
SKETCHES ENCLOSED: ☐ YES ☐ NO PHOTOS ENCLOSED: ☐ YES ☐ NO



NO. 1 BEARING AREA

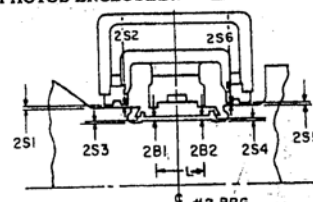
CONDITION CODE:

M - Missing Metal
W - Worn
CR - Cracked

DISPOSITION CODE:

N - No repair or replacement necessary
R - Repaired (On-site or GE Service Shop)
RN - Replaced with new component

closing



NO. 2 BEARING AREA

NOTE:

1. All axial clearances are to be measured with H.P. rotor blocked toward the inlet, and the L.P. rotor blocked toward the exhaust (against loaded thrust faces "XA" and "XB").
2. Bearing angularity is determined from the bottom B1 and B2 lead wire readings.
3. Bearing angularity: $\frac{(B1-B2)}{L}$ or $\frac{(B2-B1)}{L}$

	CLEARANCES				VISUAL INSPECTION		COMMENTS
	Left	Right	Top	Bottom	Condition	Disposition	
1S1	0.005"	0.010"					
1S2	0.004"	0.009"					
1S3	0.008"	0.007"					
1S4	0.008"	0.007"					
1S5	0.006"	0.002"					
1S6	0.008"	0.007"					
1S7	0.002	0.002					
1XS	Top half		Btm half				
T1							
TIS	Top half		Btm half				
1B1	0.011"	0.010"					
1B2	0.011"	0.010"					
2S1	0.017	0.016					
2S2	0.017	0.016					
2S3	0.018	0.017					
2S4	0.020	0.019					
2S5	0.014	0.011					
2S6	0.014	0.012					
2B1	0.010	0.013					
2B2	0.010	0.013					

No. 1 Bearing Angularity = in./in.

No. 2 Bearing Angularity = in./in.

ADDITIONAL COMMENTS:

(Continued on back of form)

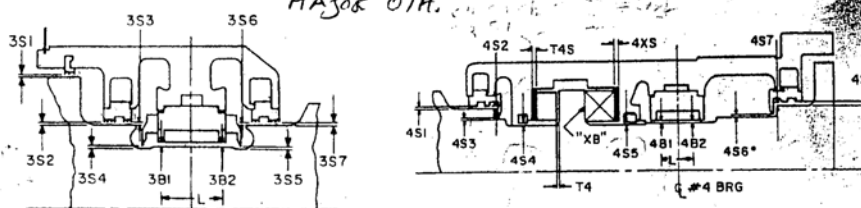
NOTE: Assistance in obtaining the data to complete this form can be obtained from PGSD or IPSD.

8496 Attachment #3 TO SWID/SWIEU-006/2002 56.9

Inspection Report Gas Turbine Maintenance

PGS/GT-FF-6046
 (FOR FIELD USE ONLY) WIP-4 GT-4 10-15-2011 MS5002 Series Bearing & Seal Clearances

NOTICE: Any alterations to this form must be approved by the Manager, Technology Programs, PCMD and the Manager, Maintenance Planning Services, Product Service Department, PGCS.



NO. 3 BEARING AREA *opening* NO. 4 BEARING AREA
 *Not applicable for all units

CONDITION CODE: M - Missing Metal RN - Replaced with New Component
 W - Worn R - Repaired (On-site or GE Service Shop)
 CR - Cracked N - No Repair or Replacement Necessary

	CLEARANCES				VISUAL INSPECTION		COMMENTS
	Left	Right	Top	Bottom	Condition	Disposition	
3S1	0.018	0.027					
3S2	0.09	0.04					
3S3	0.09	0.04					
3S4	0.07	0.09					
3S5	0.09	0.09					
3S6	0.04	0.04					
3S7	0.04	0.04					
3B1	0.11	0.12					
3B2	0.13	0.13					
4S1	0.011	0.011					
4S2	0.010	0.012					
4S3	X	X					
4S4	0.002	0.002					
4S5	0.002	0.002					
4S6	X	X					
4S7	X	X					
4S8	X	X					
4XS	Top half 0.360	Btm half 0.360					
T4	X	X					
T4S	Top half 0.485	Btm half 0.485					
4B1	0.012	0.012					
4B2	0.011	0.012					

No. 3 Bearing Angularity = in/in. No. 4 Bearing Angularity = in/in.

ADDITIONAL COMMENTS: AXIL K100-1000
 WIP-4 GT-4 10-15-2011
 OIL CLEARANCE 0.002

8496

Attachment # 3 TO SWID/SWIEU-006/2002

sh. 10

2334



Inspection Report Gas Turbine Maintenance

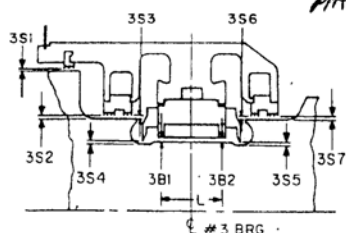
NOTICE: Any alterations to this form must be approved by the Manager, Technology Programs, PGSD and the Manager, Maintenance Planning Services, Product Service Department, PGSD.

PGS/GT-FF-6046

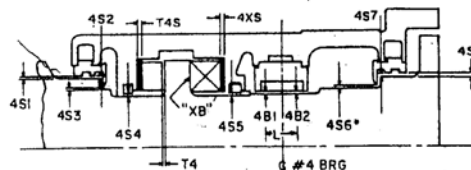
(FOR FIELD USE ONLY)

WIP-4 CR-4

MS5002 Series Bearing & Seal Clearances



NO. 3 BEARING AREA



NO. 4 BEARING AREA

*Not applicable for all units

CONDITION CODE:

- M - Missing Metal
- W - Worn
- CR - Cracked

CONDITION CODE:

- RN - Replaced with New Component
- R - Repaired (On-site or GE Service Shop)
- N - No Repair or Replacement Necessary

	CLEARANCES				VISUAL INSPECTION		COMMENTS
	Left	Right	Top	Bottom	Condition	Disposition	
3S1	.021	.021					
3S2	.014	.0115					
3S3	.014	.014					
3S4	.006	.007					
3S5	.012	.009					
3S6	.014	.012					
3S7	.014	.013					
3B1	.011	.014					
3B2	.012	.012					
4S1	.011	.012					
4S2	.010	.012					
4S3							
4S4	.003	.003					
4S5	.003	.003					
4S6							
4S7							
4S8							
4XS	Top half		Btm half				
T4							
T4S	Top half		Btm half				
4B1	.012	.012					
4B2	.012	.011					

No. 3 Bearing Angularity = in./in.

No. 4 Bearing Angularity = in./in.

ADDITIONAL COMMENTS:

Attachment # 3 TO SWID/SWIEU - 006/2002 Sh-11

Inspection Report Gas Turbine Maintenance

PGS/GT-FF-6312 (AT)
(FOR FIELD USE ONLY) WIP-4

MS5001 Compressor Rotor Clearances

FSR NO. 87 TURBINE NO. GT-4 DATE 10-24-2001

SKETCHES ENCLOSED: ☐ YES ☐ NO PHOTOS ENCLOSED: ☐ YES ☐ NO

Major O/H.

1. All axial clearances are to be measured with rotor in forward position against the loaded thrust face.
2. Refer to clearance diagram for specified dimensions.
3. Take readings with rotor positioned as follows:
a. Position 1L with #1 bolt hole of comp. rotor at left horizontal joint.
b. Position 1R with #1 bolt hole of comp. rotor at right horizontal joint.

POSITION 1 WITH #1 BOLT HOLE OF COMP ROTOR AT LEFT

COMPRESSOR STUB SHAFT S/N _____
16TH STAGE WHEEL S/N _____

STAGE	OPENING		CLOSING		STAGE	OPENING		CLOSING	
	1L	1R	1L	1R		1L	1R	1L	1R
RO					R11	0.067	0.052		
SO					S11	0.060	0.051		
R1	0.046	0.045			R12	0.077	0.055		
S1	0.046	0.052			S12	0.056	0.056		
R2	0.050	0.046			R13	0.062	0.056		
S2	0.050	0.042			S13	0.058	0.055		
R3	0.070	0.055			R14	0.076	0.067		
S3	0.060	0.049			S14	0.065	0.060		
R4	0.058	0.046			R15	0.073	0.062		
S4	0.045	0.036			S15	0.030	0.030		
R5	0.070	0.051			R16				
S5	0.041	0.041			S16				
R6	0.061	0.050			EXGV1				
S6	0.055	0.036			EXGV2				
R7	0.070	0.050			XA	0.068	0.051		
S7	0.047	0.036			XB	0.070	0.050		
R8	0.057	0.041			RA				
S8	0.080	0.041			4R				
R9	0.062	0.047			4E				
S9	0.053	0.036			10E				
R10	0.078	0.072			XX	0.197	0.207		
S10	0.062	0.051							

NOTE: Assistance in obtaining the data to complete this form can be obtained from PGSD or PSD.



Attachment #3 TO SWID/SWIEU-006/2002 Inspection Report Gas Turbine Maintenance

NOTICE: Any alterations to this form must be approved by the Manager, Technology Programs, PGSD and the Manager, Maintenance Planning Services, Product Service Department, POCSD.

PGS/GT-FF-6312 (AT)
(FOR FIELD USE ONLY)

MS5001 Compressor Rotor Clearances

FSR NO. _____

TURBINE NO. W-4 GT-4

DATE 06-28-2001 1126

SKETCHES ENCLOSED: ☐ YES ☐ NO

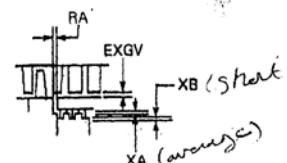
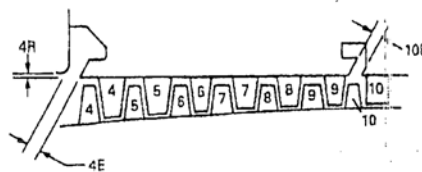
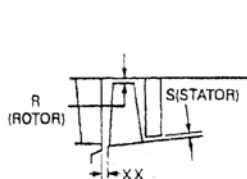
PHOTOS ENCLOSED: ☐ YES ☐ NO

MAJOR O/H



POSITION 1 WITH #1
BOLT HOLE OF COMP
ROTOR AT LEFT

- All axial clearances are to be measured with rotor in forward position against the loaded thrust face.
- Refer to clearance diagram for specified dimensions.
- Take readings with rotor positioned as follows:
 - Position 1L with #1 bolt hole of comp. rotor at left horizontal joint.
 - Position 1R with #1 bolt hole of comp. rotor at right horizontal joint.



COMPRESSOR STUB SHAFT S/N _____

16TH STAGE WHEEL S/N _____

CLOSING

STAGE	OPENING		CLOSING		STAGE	OPENING		CLOSING	
	1L	1R	1L	1R		1L	1R	1L	1R
RO					R11	.068	.055		
R1	.049	.046			S11	.056	.051		
S1	.050	.052			R12	.072	.052		
R2	.060	.050			S12	.057	.060		
S2	.056	.044			R13	.063	.060		
R3	.055	.044			S13	.058	.057		
S3	.061	.050			R14	.069	.069		
R4	.062	.042			S14	.070	.057		
S4	.050	.047			R15	.075	.062		
R5	.058	.050			S15	.018	.030		
S5	.046	.037			R16				
R6	.082	.042			S16				
S6	.060	.041			EXGV1	.010	.029		
R7	.061	.050			EXGV2	.014	.028		
S7	.050	.033			XA	.070	.050		
R8	.063	.047			XB	.070	.051		
S8	.057	.040			RA				
R9	.058	.050			4R				
S9	.050	.037			4E				
R10	.074	.059			10E				
S10	.064	.052			XX				

1P AXIAL FLOAT = .018

ES-GAS-D7.A1.312 (AT) (4/90)

NOTE: Assistance in this form can be obtained from the PGSD.

6330

Attachment #3 TO SWID/SWIEU-006/2002

Sh 13



Inspection Report Gas Turbine Maintenance

NOTICE: Any alterations to this form must be approved by the Manager, Technology Programs, PCHS and the Manager, Maintenance Planning Services, Power Service Department, PCHS.

PGS/GT-FF-6045
(FOR FIELD USE ONLY)

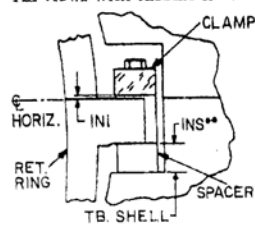
MS5002 Series Turbine Rotor Clearances

FSR NO. WIP-4TURBINE NO. GT-4DATE 10-15-2001SKETCHES ENCLOSED: ☐ YES ☐ NOMAJOR O/HPHOTOS ENCLOSED: ☐ YES ☐ NO

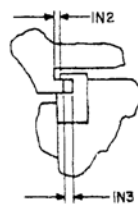
CLEARANCES CHECKED BY _____

APPROVED BY _____

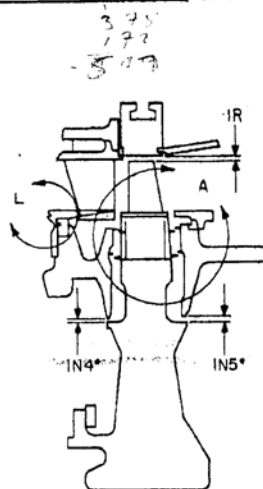
All views with turbine flow



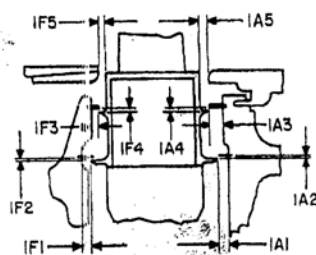
1st STAGE NOZZLE CLAMP



VIEW L



1st STAGE WHEEL



VIEW A

*Not applicable for all units

**Measurement required when a new nozzle is installed

1ST STAGE							
	OPENING		CLOSING			OPENING	
	Left	Right	Left	Right		Left	Right
1N1	0.015	0.015	0.011	0.012	1F5		0.428
1N2					1A1	0.510	0.513
1N3					1A2	0.243	0.205
1N4					1A3	0.679	0.687
1N5					1A4	0.260	0.228
1NS					1A5	0.558	0.530
1F1	0.385	0.370	0.380	0.385			
1F2	0.099	0.126	0.105	0.120	1R	0.190	0.182
1F3	0.393	0.375	0.400	0.380			
1F4	0.106	0.150	0.110	0.127			

COMMENTS: _____

(Continued on back of form)

ES-GAS-D7.A1.45 (4/90)

NOTE: Assistance in obtaining the data to complete this form can be obtained from PGSD or PCHS.

ISE GT-FF 6045
FOR FIELD USE ONLY

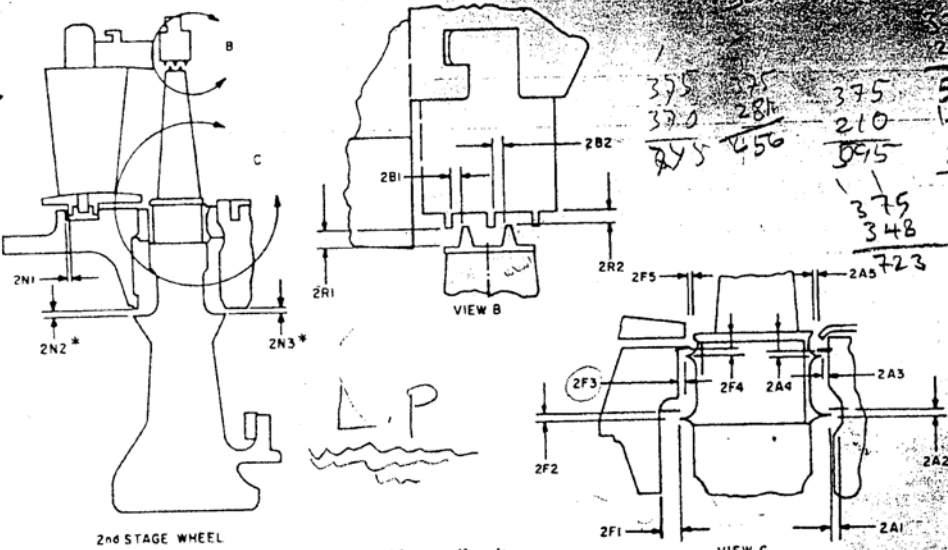
INSPECTION REPORT

NOTICE: Any alterations to this form must be approved by the Manager, Turbine Engineering, IASE and the Manager, Technical Information and Procedures, G.T.M.D.

GAS TURBINE MAINTENANCE WIP-4 GT-4 1025-2001

375
370
375
281
456
375
210
295
375
348
723
587
375
283
658
379
291
666
379
392
76

2334



2N1
2N2*
2N3*

2B1
2B2
2R1
2R2

VIEW B

2F1
2F2
2F3
2F4
2F5

2A1
2A2
2A3
2A4
2A5

VIEW C

2nd STAGE WHEEL

*Not applicable for all units

2ND STAGE				
DIM.	OPENING		CLOSING	
	Left	Right	Left	Right
2F1	0.415	0.418	0.425	0.438
2F2	0.240	0.237	0.245	0.230
2F3*	0.204	0.212	0.215	0.223
2F4	0.260	0.233	0.273	0.245
2F5	0.315	0.310	0.327	0.295
2N1				
2N2				
2N3				

DIM.	OPENING		CLOSING	
	Left	Right	Left	Right
2A1	0.565	0.590	0.587	0.582
2A2	0.195	0.180	0.195	0.173
2A3	0.643	0.656	0.652	0.636
2A4	0.258	0.215	0.257	0.230
2A5	0.708	0.745	0.723	0.767
2R1	0.260	0.233	0.250	0.214
2R2	0.260	0.235	0.145	0.150
2B1	0.175	0.158	0.159	0.153
2B2	0.178	0.158	0.158	0.150

CLEARANCE METER HOLE CHECK

COMMENTS:

65

ES-CAS-D7.A1.45 (7/79)

GENERAL ELECTRIC

NOTE: Assistance in completion of this report is available from:

2946

Attachment # 3 10 SW1000000

ISE/GT-FF 6009
FOR FIELD USE ONLY
GAS TURBINE MAINTENANCE

INSPECTION REPORT

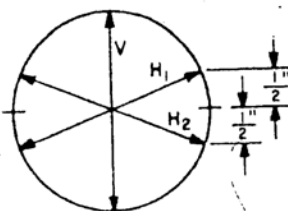
Sleeve Journal Bearings

FSR NO. W13-4 TURBINE NO. GT-4 DATE 10-15-2001

SKETCHES ENCLOSED: ☐ YES ☐ NO PHOTOS ENCLOSED: ☐ YES ☐ NO

(NOTE: SEE ADDITIONAL INSTRUCTIONS ON BACK OF FORM)

DIMENSIONAL CHECKS



1. Measure horizontal (H_1 & H_2) and vertical (V) dimensions of bearing shell inner diameter at both the forward and the aft ends. Bearing halves must be clamped together for measurement.
2. Measure thrust bearing clearance dimension by jacking rotor axially and monitoring axial movement with dial indicator. Dial indicator to be mounted on the bearing housing containing the thrust bearing.

CONDITION CODES:

Using the figures on the back of this form for reference, indicate by number the babbitt conditions observed. If more than one number is used, keep damage and zones in respective order.

DISPOSITION CODES:

- N - No repair or replacement necessary
R - Repaired (On-site, Vendor or GE Service Shop)
RN - Replaced with new component

JOURNAL BEARINGS NOTE: Use Form ISE/GT-FF 6044 for Tilting-Pad Journal Bearings

LINER NO.	1		2		3		4		5	
PART NO.										
MEASUREMENTS	FWD	AFT	FWD	AFT	FWD	AFT	FWD	AFT	FWD	AFT
H1	8.022	8.024	10.030	10.0305						
H2	8.0235	8.022	10.031	10.0305						
V	8.011	8.011	10.014	10.0145						
CONDITION	CODE	ZONE	CODE	ZONE	CODE	ZONE	CODE	ZONE	CODE	ZONE
A. BURNISH										
B. CRACKS										
C. BABBITT LOSS										
D. BABBITT SMEAR										
DISPOSITION										

JOURNAL NO.	1		2		3		4		5	
MEASUREMENTS	FWD	AFT	FWD	AFT	FWD	AFT	FWD	AFT	FWD	AFT
H										
V										
CONDITION	(CHECK / IF CONDITION IS OBSERVED)									
SCORED										
PITTED										
DISPOSITION										

THRUST BEARINGS See Form ISE/GT FF6029

COMMENTS:

ES-GAS-D7.A1.9 Rev. 1(9/78)

GENERAL ELECTRIC

NOTE: Assistance in obtaining the data to complete this form can be obtained from I&SE/ISE/D.