



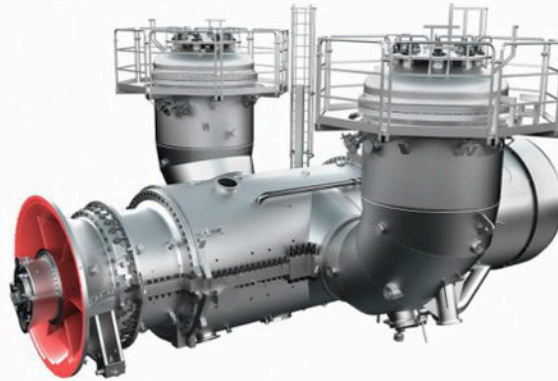
UNEW, INC. | GAS TURBINE FIELD SERVICE AND COMPONENT ENGINEERING

GAS TURBINE INSPECTION REPORT

Hot Gas Path Inspection at 33,000 Equivalent Operating Hours

Capital Parts Renewal Outage

Prepared for
DUBAI ELECTRICITY & WATER AUTHORITY (DEWA)
JEBEL ALI G55 POWER PLANT
Jebel Ali, Dubai, United Arab Emirates



Siemens SGT5-2000E / V94.2 (Si3D) gas turbine, silo combustion arrangement

Gas Turbine Model	Siemens SGT5-2000E / V94.2 (Si3D), 50 Hz
Unit	JEBEL ALI G51, Serial Number 600712
Generator	TLRI 100/42, Serial Number M10892
Job Type	Hot Gas Path Inspection (HGPI) with capital parts renewal
Job Start Date	10 January 2018
Mechanical Completion Date	03 February 2018
Unit Start Up Date	05 February 2018
Outage Duration	27 days
Document Number	UNEW-DEWA-G55-HGPI-2018-G51-001
Contract Reference	UNEW-DEWA-G55-LTSA-2006-001
Purchase Order Reference	PO-DEWA-UNEW-G55-2016-0921 dated 21 September 2016
Report Date	20 February 2018

Prepared by: UNEW, Inc. | Dilip Majumder, Lead Technical Field Advisor
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1. INSPECTION SUMMARY

1.1 Unit and Outage Data

Plant	JEBEL ALI G55 Power Plant, Jebel Ali, Dubai, United Arab Emirates
Owner and Operator	Dubai Electricity & Water Authority (DEWA)
Contractor	UNEW, Inc.
Gas Turbine Model	Siemens SGT5-2000E / V94.2 (Si3D), 50 Hz, single shaft, two external silo combustion chambers
Turbine Serial Number	600712 (Unit JEBEL ALI G51)
Rating	Approximately 165 MW at ISO conditions
Generator Model and Serial	TLRI 100/42, Serial Number M10892
Control System	Siemens SPPA-T3000 with Teleperm XP (T-2000) AS 620 automation interface
Fuel	Natural gas, primary. Gasoil, backup
Service Type	Contract maintenance under Long Term Service Agreement
Job Type	Hot Gas Path Inspection (HGPI)
Work Scope	[Y] Hot Gas Path [Y] Combustion [Y] Compressor Re-blading [N] Major [N] Rotor Destack
Field Technical Advisor	Dilip Majumder
Job Start Date	10 January 2018
Mechanical Completion Date	03 February 2018
Start Up Date	05 February 2018
Outage Duration	27 days, against 26 working days planned in Schedule C4 of the LTSA
Last Inspection	February 2014, Combustion Inspection
Next Inspection	Combustion Inspection at approximately 49,000 EOH, provisionally 2022
Next Major Inspection	Approximately 66,000 EOH, provisionally 2027

1.2 Operating Data and Equivalent Operating Hours

The Unit operates in mid merit and peaking duty on the DEWA network with natural gas as primary fuel and gasoil as backup fuel. Equivalent Operating Hours have been calculated in accordance with Schedule C2 of the Long Term Service Agreement. The EOH log was exported from the SPPA-T3000 control system on 09 January 2018 and jointly verified with the DEWA performance engineering group before shutdown.

Record	Operating Hours	Gas Fuel Hours	Liquid Fuel Hours	Peak Load Hours	Normal Starts	Fast Starts	Trips	EOH
Current, at HGPI	26,782	24,940	1,842	1,120	210	12	9	33,057
Last, at CI Feb 2014	13,120	12,006	1,114	520	114	7	5	16,591
Interval	13,662	12,934	728	600	96	5	4	16,466

The Unit reached the 33,000 EOH Hot Gas Path Inspection trigger defined in Schedule C1 of the Long Term Service Agreement at 33,057 EOH. The inspection was therefore executed within the contractual trigger band. The detailed EOH build up is given in Appendix B.

1.3 Site Personnel

UNEW Site Team

Name	Responsibility
Mr. Dilip Majumder	Lead Technical Field Advisor and report author
Mr. Gary Gannet	Lead Engineer, hot gas path and rotor
Ms. Elena Vance	Inspection Engineer, NDT Level II per ASNT SNT-TC-1A
Mr. Garrett Mitchell	Quality Assurance and parts conformity
Mr. Vaikuntha Rao	Mechanical Supervisor, turbine section
Mr. Nguyen Duc Cuong	Mechanical Supervisor, compressor and combustion section
Mr. Guhan Raman	Controls and Instrumentation Expert
UNEW field crew	Mechanical fitters, riggers and NDT support, 11 personnel at peak

DEWA Site Personnel

Position	Interface Responsibility
Plant Manager, Jebel Ali G55	Overall outage authority and acceptance
Outage Coordinator	Daily coordination, permit issue and schedule control
Mechanical Maintenance Engineer	Joint inspection, check sheet signature and clearance witness
Controls and Instrumentation Engineer	Protection testing, trip testing and start up support
QA and QC Inspector	Witness and hold points, parts conformity verification
HSE Officer	Permit to work, confined space entry and site safety
Operations Shift Charge Engineer	Isolation, LOTO, first fire and synchronization

1.4 Inspection Summary Narrative

This report covers the Hot Gas Path Inspection carried out on the Siemens SGT5-2000E / V94.2 (Si3D) gas turbine Unit JEBEL ALI G51, Serial Number 600712, at the Jebel Ali G55 Power Plant operated by the Dubai Electricity & Water Authority. The plant comprises four SGT5-2000E / V94.2 (Si3D) gas turbine generator trains, Units G51 through G54, each with a TLRI 100/42 generator. The Unit is capable of operation on natural gas and on gasoil.

The Unit has accumulated 26,782 operating hours since commissioning, of which 1,842 hours were on liquid fuel. Applying the factors defined in Schedule C2 of the Long Term Service Agreement, the calculated equivalent operating hours at the start of this outage were 33,057 EOH. The preceding scheduled

event was a Combustion Inspection carried out in February 2014 at 13,120 operating hours and 16,591 EOH.

The purpose of this Hot Gas Path Inspection was the renewal of the hot gas path and compressor capital parts of the Unit. The SGT5-2000E / V94.2 (Si3D) hot gas path comprises four rows of turbine vanes and four rows of turbine blades, with heat shields on blade rows 1, 2 and 4 and inner shroud segments on vane rows 1 and 2. The combustion system comprises two external silo type combustion chambers, each fitted with a ceramic tile lining, eight hybrid burners, a flame tube and K ring assemblies. The compressor comprises sixteen stages of rotor blading with a variable inlet guide vane row. The scope of this outage was defined against this configuration.

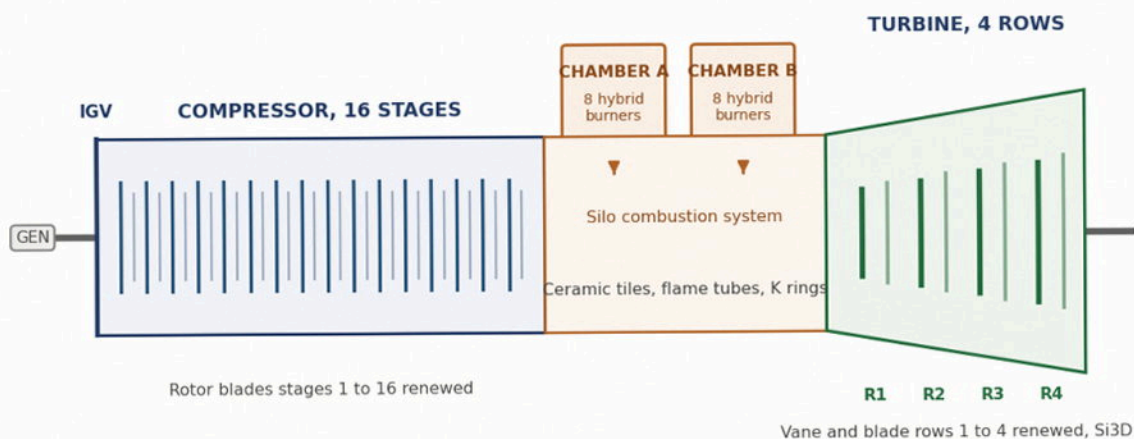


Figure 1. SGT5-2000E / V94.2 (Si3D) flow path arrangement showing the scope of parts renewal at this outage

The following new capital parts, supplied under Purchase Order PO-DEWA-UNEW-G55-2016-0921 dated 21 September 2016 and issued against the Long Term Service Agreement, were installed in the Unit during this outage: turbine vane segments rows 1, 2, 3 and 4 including joint and instrumented segments; turbine blades rows 1, 2, 3 and 4 including locking and weighted blades; and compressor blades stages 1 through 16 including locking blades. A total of 55 part line items and 517 serialized capital parts were installed. The complete serial number register is given in Appendix A and in Section 3 of this report.

The scope also included the complete Combustion Inspection scope defined in Section 3 of Schedule 1 of the Long Term Service Agreement, partial turbine casing opening, compressor upper casing opening, bearing inspection, generator inspection, clearance measurement and full commissioning support. The compressor re-blading element extends beyond the base HGPI scope defined in Schedule C1 of the Long Term Service Agreement and was executed on the basis of the compressor blade sets procured under the above Purchase Order and the compressor condition recorded at the 2016 borescope inspection.

The outage was a planned event. The Unit was shut down on 10 January 2018 at 07:00 hours and released for work after cooldown and isolation. All mechanical work was completed on 03 February 2018. The Unit was placed on turning gear on 04 February 2018 and remained on turning gear for six hours. First fire took place on 05 February 2018 at 09:40 hours. The Unit was synchronized at 13:15 hours on 05 February 2018 and loaded in steps to base load. All operating parameters were observed to be normal and within limits.

Exhaust temperature spread, vibration levels and bearing metal temperatures were recorded after four hours at base load and are given in Section 11.

The controls and protection work carried out during the outage, the electrical overspeed trip test, the start up record and the SPPA-T3000 screen records are reported in Section 12 of this report.

UNEW provided technical advisory service, supervision, skilled manpower, special tools, NDT services and consumables for this outage. UNEW records its appreciation for the continuous support extended by the DEWA plant, operations and maintenance teams, which allowed the outage to be completed within the agreed window.

1.5 Component Condition and Disposition Summary

Component	Hours / EOH Clocked	Inspection Method	Disposition
Inlet Plenum and Filter House	26,782 / 33,057 since commissioning	Visual	Inspected and cleaned, returned to service.
Inlet Guide Vane Assembly	26,782 / 33,057 since commissioning	Visual, FPI, clearance check	Inspected, cleaned, returned to service.
Compressor Rotor Blades Stages 1 to 16	26,782 / 33,057 since commissioning	Visual, FPI, dimensional	Replaced with new, complete set.
Compressor Stationary Blades Stages 1 to 16	26,782 / 33,057 since commissioning	Visual, FPI	Cleaned, inspected, returned to service.
Ceramic Tiles, Chambers A and B	13,662 / 16,466 since last CI	Visual, tile map	38 tiles replaced, balance returned to service.
Hybrid Burner Assemblies, 16 off	13,662 / 16,466 since last CI	Visual, dimensional	Cleaned, sealing rings renewed, returned to service.
Flame Tubes, Chambers A and B	13,662 / 16,466 since last CI	Visual, FPI	Chamber A replaced with refurbished unit, chamber B returned to service.
K Ring Assemblies	13,662 / 16,466 since last CI	Visual	Replaced with new.
Turbine Vane Segments Rows 1 to 4	26,782 / 33,057 since commissioning	Visual, FPI, throat area	Replaced with new, all four rows.
Turbine Blades Rows 1 to 4	26,782 / 33,057 since commissioning	Visual, FPI, dimensional	Replaced with new, all four rows.
Turbine Blade Heat Shields Rows 1, 2 and 4	26,782 / 33,057 since commissioning	Visual	Replaced with new.
Inner Shroud Segments Rows 1 and 2	26,782 / 33,057 since commissioning	Visual, seal groove gauge	Replaced with new.
Turbine Rotor Discs and Root Slots	26,782 / 33,057 since commissioning	Visual, FPI	No indications. Returned to service.
Turbine Casing and Vane Carriers	26,782 / 33,057 since commissioning	Visual, FPI, dimensional	Cleaned, inspected, returned to service.
Abradable and Labyrinth Seal Segments	26,782 / 33,057 since commissioning	Visual, clearance	Replaced with new.
Compressor Rear Journal Bearing	26,782 / 33,057 since commissioning	Visual, clearance, blue check	Returned to service.



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Component	Hours / EOH Clocked	Inspection Method	Disposition
Turbine Thrust Bearing Assembly	26,782 / 33,057 since commissioning	Visual, axial float	Returned to service with new shims.
Exhaust Diffuser and Struts	26,782 / 33,057 since commissioning	Visual, MPI of weld joints	Two hairline indications weld repaired by DEWA. Returned to service.
Generator TLRI 100/42, S/N M10892	26,782 / 33,057 since commissioning	IR, PI, air gap, retaining ring ET	Inspected, returned to service.

2. UNIT INSPECTION HISTORY

The maintenance history of Unit JEBEL ALI G51 since commissioning is summarized below. Records for the period before the effective date of the Long Term Service Agreement were provided by DEWA and have been reproduced as received.

Year	Event	EOH at Event	Principal Findings and Work Executed
2006	Major Inspection (MI) and Borescope Inspection	0	Contract baseline event at start of LTSA. Complete rotor extraction and destacking performed.
2007	Borescope Inspection (supplemental)	1,840	No indications reported.
2010	Combustion Inspection (CI)	8,120	Ceramic tiles partially renewed, burners serviced.
2011	Borescope Inspection	10,460	Light compressor fouling reported.
2014	Combustion Inspection (CI)	16,591	Flame tubes and K rings inspected, 22 ceramic tiles replaced, burner sealing rings renewed.
2016	Borescope Inspection	24,930	Row 1 blade tip rub and coating depletion reported. Capital parts ordered under PO-DEWA-UNEW-G55-2016-0921.
2018	Hot Gas Path Inspection (HGPI), this report	33,057	Complete hot gas path renewal and compressor re-blading executed.

The Unit has operated without a forced outage attributable to hot gas path component failure. Nine trips from load have been recorded since commissioning, of which four occurred in the interval since the 2014 Combustion Inspection. The trip history has been applied in the EOH calculation at 50 EOH per trip in accordance with Schedule C2 of the Long Term Service Agreement.

3. PARTS INFORMATION

3.1 Basis of Supply

All new capital parts installed during this outage were supplied by UNEW, Inc. under Purchase Order PO-DEWA-UNEW-G55-2016-0921 dated 21 September 2016, issued by DEWA against Long Term Service Agreement UNEW-DEWA-G55-LTSA-2006-001. Parts were manufactured and released against the UNEW quality management system, which holds ISO 9001 certification, ISO/IEC 17025 accredited laboratory scope and Nadcap accreditation through PRI for the applicable special processes.

Each part was supplied with a Certificate of Conformance, material certification, dimensional inspection record and coating record where applicable. Turbine vanes are supplied in FSX-414, turbine blades in IN738LC, and compressor blades in Ti-6Al-4V for the front stages and X20Cr13 or X22CrMoV12-1 for the rear stages, in accordance with the material composition schedule issued with the Purchase Order. Thermal barrier coating on rows 1 and 2 is applied as a MCrAlY bond coat with YSZ top coat, deposited by HVOF and APS respectively.

Each part carries a UNEW serial number in the format AA26Kxxxx, laser etched in a non critical location in accordance with the applicable UNEW marking procedure. Serial numbers were verified against the packing list, the Certificate of Conformance and the receiving inspection record at site before installation, and were recorded by disc slot or carrier position on the jointly signed installation check sheets. The serial number register is reproduced in full in Appendix A.

Part numbers shown in the installed parts list are UNEW part numbers assigned by UNEW as the manufacturer of the supplied parts. Part numbers shown in the removed parts register are the catalogue numbers listed in Appendix 2 of the Long Term Service Agreement and in Annex A of the Purchase Order, as recorded on the parts removed from the Unit.

3.2 Removed Parts Register

The condition of each removed component was assessed by visual inspection, fluorescent penetrant inspection and dimensional measurement after cleaning. Classification was made against the acceptance criteria in Schedule G of the Long Term Service Agreement. Disposition was agreed jointly with DEWA and recorded on the signed check sheets.

No.	Component	Part Number as Removed	Qty	Condition as Found	Disposition
1	Turbine Vane Row 1 (46 segments)	A2A50330301 / A2A50330302	1 Set	Heavy TBC spallation on 14 segments, trailing edge burn back up to 4.5 mm on 6 segments, throat area opened beyond upper tolerance on 9 segments, hot corrosion on all platforms.	Removed from service. Returned to UNEW Stuart, FL for evaluation. Not recommended for further repair.

No.	Component	Part Number as Removed	Qty	Condition as Found	Disposition
2	Turbine Vane Row 2 (48 segments)	A2A50330303 / A2A50330304	1 Set	TBC loss on leading edge of 11 segments, radial cracking at cooling holes on 4 segments, general oxidation, throat area within tolerance.	Removed from service. Returned to UNEW Stuart, FL for repair evaluation.
3	Turbine Vane Row 3 (51 segments)	A2A50290932 / A2A50225277	1 Set	Light to medium oxidation, minor trailing edge erosion, no cracking indicated by FPI.	Removed from service. Returned to UNEW Stuart, FL. Candidate for refurbishment.
4	Turbine Vane Row 4 (55 segments)	A2A50284264 / A2A50007258 / A2A50284265	1 Set	Light oxidation and deposit, no cracking, dimensional condition within tolerance.	Removed from service. Returned to UNEW Stuart, FL. Candidate for refurbishment.
5	Turbine Blade Row 1 (89 blades)	A2A50330305	1 Set	Tip rub on all blades, squealer tip metal loss on 12 blades, coating depletion on 100 percent of the set, cooling hole enlargement on 7 blades, root serration fretting on 3 blades.	Removed from service. Scrap recommended. Retained for metallurgical sampling.
6	Turbine Blade Row 1 Heat Shield	A2A50330309	1 Set	Oxidation and distortion at gas path edge on 18 pieces.	Removed from service. Scrap recommended.
7	Turbine Blade Row 2 (89 blades)	A2A50330307	1 Set	Coating loss on suction side of 41 blades, light tip rub, no FPI indications on airfoils, platform hot corrosion.	Removed from service. Returned to UNEW Stuart, FL for repair evaluation.
8	Turbine Blade Row 2 Heat Shield	A2A50330310	1 Set	Oxidation, no cracking.	Removed from service. Scrap recommended.
9	Turbine Blade Row 3 (63 blades)	A2A50006517 / A2A50006516	1 Set	Discoloration and light deposit, minor trailing edge erosion, no FPI indications.	Removed from service. Candidate for refurbishment.
10	Turbine Blade Row 4 (44 blades)	A2A50107664	1 Set	Light deposit, shroud contact faces worn within limits, no FPI indications.	Removed from service. Candidate for refurbishment.
11	Turbine Blade Row 4 Heat Shield	A2A50330312	40 Pcs	Light oxidation.	Removed from service. Scrap recommended.
12	Turbine Vane Row 1 Inner Shroud Segment	A2A50330313	16 Pcs	Hot corrosion, seal groove wear beyond limit on 5 pieces.	Removed from service. Replaced with new.
13	Turbine Vane Row 2 Inner Shroud Segment	A2A50330314	16 Pcs	Hot corrosion, seal groove wear within limits.	Removed from service. Replaced with new.
14	Compressor Rotor Blades Stages 1 to 16	A2A50320211 through A2A50320205 (per LTSA Appendix 2)	16 Sets	Heavy fouling on stages 1 to 5, leading edge erosion on stages 1 to 3, pitting corrosion on stages 4 to 8, root fretting on 9 blades of stage 1, tip clearance opened beyond design on stages 1, 2 and 3.	Removed from service. Stages 1 to 3 scrap recommended. Stages 4 to 16 returned to UNEW Stuart, FL for evaluation.
15	Compressor Inlet Guide Vane Assembly	A2A50320208 / A2A50320209	1 Set	Light deposit, no cracking after cleaning and FPI, bushings within wear limits.	Cleaned, inspected and returned to service.



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No.	Component	Part Number as Removed	Qty	Condition as Found	Disposition
16	Compressor Stationary Blades Stages 1 to 16	A2A50233554 through A2A50006896 (per LTSA Appendix 2)	16 Sets	Fouling on stages 1 to 6, light erosion, no cracking after cleaning and FPI.	Cleaned, inspected and returned to service.
17	Ceramic Tiles, Combustion Chambers A and B	Per LTSA Appendix 2, Group 3	2 Sets	38 tiles classified REPLACE, 61 tiles classified MONITOR, remainder serviceable.	REPLACE tiles renewed. Balance returned to service.
18	Hybrid Burner Assemblies	Per LTSA Appendix 2, Group 3	16 Pcs	Carbon deposit on diffusion gas spiders, swirler vane erosion on 4 burners, sealing rings compressed.	Cleaned, inspected, sealing rings renewed, returned to service.
19	Flame Tubes, Chambers A and B	Per LTSA Appendix 2, Group 3	2 Pcs	Chamber A flame tube with circumferential cracking at weld seam, 62 mm total length. Chamber B serviceable.	Chamber A flame tube replaced with refurbished exchange unit. Chamber B returned to service.
20	K Ring Assemblies	Per LTSA Appendix 2, Group 3	2 Sets	Distortion and oxidation on both chambers.	Replaced with new.
21	Compressor Rear Journal Bearing	Per LTSA Appendix 2, Group 5	1 Pc	White metal free of wipe and scoring, light polishing marks, clearance within limits.	Returned to service.
22	Turbine Thrust Bearing Assembly	Per LTSA Appendix 2, Group 5	1 Set	Active pads with light polish, inactive pads serviceable, axial float within limits.	Returned to service with new thrust pad shims.
23	Labyrinth and Abradable Seal Segments, Turbine	Per LTSA Appendix 2, Group 7	1 Set	Rub damage on rows 1 and 2 abradable segments, clearance opened.	Replaced with new.

3.3 Installed New Capital Parts List with Serial Numbers

The following table lists the new capital parts installed in Unit JEBEL ALI G51 during this Hot Gas Path Inspection. Quantities were verified against the packing list and the receiving inspection record. Serial numbers are shown as a continuous block where the assigned serial numbers are consecutive. The individual serial numbers of every part are listed in Appendix A.

No.	UNEW Part Number	Description	Unit	Qty.	Assigned Serial Numbers
1	A2A50021940-G001	Standard Turbine Vane Segment, Row 1	each	42	AA26K0001 to AA26K0042
2	A2A50021941-G002	Joint/Lead Vane Segment, Row 1	each	2	AA26K0043, AA26K0044
3	A2A50021942-G003	Instrumented/Transition Vane Segment, Row 1	each	2	AA26K0045, AA26K0046
4	A2A50024312-G001	Standard Turbine Vane Segment, Row 2	each	44	AA26K0047 to AA26K0090
5	A2A50024312-G002	Joint Vane Segment, Row 2	each	2	AA26K0091, AA26K0092
6	A2A50024312-G003	Instrumented Turbine Vane Segment, Row 2	each	2	AA26K0093, AA26K0094
7	A2A5116244-G001	Standard Turbine Vane Segment, Row 3	each	45	AA26K0095 to AA26K0139
8	A2A5116244-G002	Joint Vane Segment, Row 3	each	3	AA26K0140 to AA26K0142
9	A2A5116244-G003	Instrumented Turbine Vane Segment, Row 3	each	3	AA26K0143 to AA26K0145
10	A2A5118611-G001	Standard Turbine Vane Segment, Row 4	each	49	AA26K0146 to AA26K0194
11	A2A5118611-G002	Joint Vane Segment, Row 4	each	3	AA26K0195 to AA26K0197
12	A2A5118611-G003	Instrumented Turbine Vane Segment, Row 4	each	3	AA26K0198 to AA26K0200
13	A2A50012458-G001	Standard Turbine Blade, Row 1	each	85	AA26K0201 to AA26K0285
14	A2A50012458-G002	Locking Turbine Blade, Row 1	each	2	AA26K0286, AA26K0287
15	A2A50012458-G003	Weighted / Balanced Segment Blade, Row 1	each	2	AA26K0288, AA26K0289
16	A2A50014822-G001	Standard Turbine Blade, Row 2	each	85	AA26K0290 to AA26K0374
17	A2A50014822-G002	Locking Turbine Blade, Row 2	each	2	AA26K0375, AA26K0376
18	A2A50014822-G003	Weighted / Balanced Segment Blade, Row 2	each	2	AA26K0377, AA26K0378
19	A2A50113110-G001	Standard Turbine Blade, Row 3	each	59	AA26K0379 to AA26K0437
20	A2A50113110-G002	Locking Turbine Blade, Row 3	each	2	AA26K0438, AA26K0439



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No.	UNEW Part Number	Description	Unit	Qty.	Assigned Serial Numbers
21	A2A50113110-G003	Weighted / Balanced Segment Blade, Row 3	each	2	AA26K0440, AA26K0441
22	A2A50113110-G004	Standard Turbine Blade, Row 4	each	42	AA26K0442 to AA26K0483
23	A2A50113110-G005	Locking Blades (Master Blades / Closing Blades), Row 4	each	2	AA26K0484, AA26K0485
24	A2A2001101-G001	Standard Compressor Blade, Row 1	set	1	AA26K0486
25	A2A2001101-G002	Locking Compressor Blade, Row 1	set	1	AA26K0487
26	A2A2001102-G001	Standard Compressor Blade, Row 2	set	1	AA26K0488
27	A2A2001102-G002	Locking Compressor Blade, Row 2	set	1	AA26K0489
28	A2A2001103-G001	Standard Compressor Blade, Row 3	set	1	AA26K0490
29	A2A2001103-G002	Locking Compressor Blade, Row 3	set	1	AA26K0491
30	A2A2001104-G001	Standard Compressor Blade, Row 4	set	1	AA26K0492
31	A2A2001104-G002	Locking Compressor Blade, Row 4	set	1	AA26K0493
32	A2A2001105-G001	Standard Compressor Blade, Row 5	set	1	AA26K0494
33	A2A2001105-G002	Locking Compressor Blade, Row 5	set	1	AA26K0495
34	A2A2001106-G001	Standard Compressor Blade, Row 6	set	1	AA26K0496
35	A2A2001106-G002	Locking Compressor Blade, Row 6	set	1	AA26K0497
36	A2A2001107-G001	Standard Compressor Blade, Row 7	set	1	AA26K0498
37	A2A2001107-G002	Locking Compressor Blade, Row 7	set	1	AA26K0499
38	A2A2001108-G001	Standard Compressor Blade, Row 8	set	1	AA26K0500
39	A2A2001108-G002	Locking Compressor Blade, Row 8	set	1	AA26K0501
40	A2A2001109-G001	Standard Compressor Blade, Row 9	set	1	AA26K0502
41	A2A2001109-G002	Locking Compressor Blade, Row 9	set	1	AA26K0503
42	A2A2001110-G001	Standard Compressor Blade, Row 10	set	1	AA26K0504
43	A2A2001110-G002	Locking Compressor Blade, Row 10	set	1	AA26K0505



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No.	UNEW Part Number	Description	Unit	Qty.	Assigned Serial Numbers
44	A2A2001111-G001	Standard Compressor Blade, Row 11	set	1	AA26K0506
45	A2A2001111-G002	Locking Compressor Blade, Row 11	set	1	AA26K0507
46	A2A2001112-G001	Standard Compressor Blade, Row 12	set	1	AA26K0508
47	A2A2001112-G002	Locking Compressor Blade, Row 12	set	1	AA26K0509
48	A2A2001113-G001	Standard Compressor Blade, Row 13	set	1	AA26K0510
49	A2A2001113-G002	Locking Compressor Blade, Row 13	set	1	AA26K0511
50	A2A2001114-G001	Standard Compressor Blade, Row 14	set	1	AA26K0512
51	A2A2001114-G002	Locking Compressor Blade, Row 14	set	1	AA26K0513
52	A2A2001115-G001	Standard Compressor Blade, Row 15	set	1	AA26K0514
53	A2A2001115-G002	Locking Compressor Blade, Row 15	set	1	AA26K0515
54	A2A2001116-G001	Standard Compressor Blade, Row 16	set	1	AA26K0516
55	A2A2001116-G002	Locking Compressor Blade, Row 16	set	1	AA26K0517

3.4 Parts Accounting Summary

Group	Component Group	Line Items	Serialized Parts	Serial Number Block
1	Turbine vane segments, rows 1 to 4, including joint and instrumented segments	12	200	AA26K0001 to AA26K0200
2	Turbine blades, rows 1 to 4, including locking and weighted blades	11	285	AA26K0201 to AA26K0485
3	Compressor blades, stages 1 to 16, standard and locking sets	32	32	AA26K0486 to AA26K0517
	Total	55	517	AA26K0001 to AA26K0517

All 517 serialized parts listed above were installed in the Unit. No parts were rejected at receiving inspection, no parts were damaged during handling, and no parts remain unaccounted for. Surplus consumables, seals and fasteners supplied with the parts shipment were handed over to the DEWA warehouse under a signed transfer note.

4. OUTAGE EXECUTION AND EXCERPTS OF INSPECTION

4.1 Outage Schedule as Executed

The outage was planned for 26 working days in accordance with Schedule C4 of the Long Term Service Agreement and was executed over 27 days, including the additional compressor re-blading scope. The daily progress record below was extracted from the Daily Outage Reports issued to DEWA each morning during the outage.

Day	Date	Principal Activities
1	10 Jan 2018	Unit shutdown at 07:00, natural cooldown, LOTO isolation per DEWA matrix, permits issued, HSE induction of UNEW site team.
2	11 Jan 2018	Scaffolding erection, insulation blanket removal on turbine and combustion sections, laydown area set up, tooling receipt and calibration check.
3	12 Jan 2018	Combustion chamber A and B manhole covers removed, gas testing for entry, initial internal inspection and photographic record.
4	13 Jan 2018	Ceramic tile mapping, chamber A. Removal of 8 hybrid burners, chamber A.
5	14 Jan 2018	Ceramic tile mapping, chamber B. Removal of 8 hybrid burners, chamber B. Burner cleaning and inspection commenced.
6	15 Jan 2018	Flame tube removal both chambers, FPI of weld seams, K ring removal, hot gas casing inner hub inspection.
7	16 Jan 2018	Replacement of 38 ceramic tiles, installation of new K ring assemblies, chamber A flame tube exchange.
8	17 Jan 2018	Fuel gas strainer service, ignition system and UV flame detector inspection, instrumentation and cooling air pipe disconnection.
9	18 Jan 2018	Turbine casing horizontal and vertical joint bolt removal, casing jacking of bottom flange, guide pin installation.
10	19 Jan 2018	Upper turbine casing half lift with casing beam, levelling maintained within 2 mm end to end, casing set on stands, bore inspection.
11	20 Jan 2018	Vane carrier upper half removal. Removal of turbine vane segments rows 1 and 2, positions tagged.
12	21 Jan 2018	Removal of turbine vane segments rows 3 and 4. Removal of row 1 and row 2 inner shroud segments.
13	22 Jan 2018	Removal of turbine blades row 1 and row 2, slot by slot tagging, moment weight record verification.
14	23 Jan 2018	Removal of turbine blades row 3 and row 4. Removal of blade row heat shields.
15	24 Jan 2018	Cleaning, FPI and dimensional assessment of removed hot gas path parts. Turbine disc rim and root slot FPI, no indications.
16	25 Jan 2018	Compressor upper casing half bolt removal and lift. Compressor bore and stator inspection.
17	26 Jan 2018	Removal of compressor rotor blades stages 1 to 8 including locking blades, positions recorded.
18	27 Jan 2018	Removal of compressor rotor blades stages 9 to 16. Rotor groove cleaning and FPI.
19	28 Jan 2018	Installation of new compressor rotor blades stages 1 to 8, serial numbers recorded by stage and position.
20	29 Jan 2018	Installation of new compressor rotor blades stages 9 to 16. Locking blade fitment and staking.

Day	Date	Principal Activities
21	30 Jan 2018	Installation of new turbine blades rows 1 and 2 with new heat shields, moment weight distribution per chart.
22	31 Jan 2018	Installation of new turbine blades rows 3 and 4. Installation of new inner shroud segments rows 1 and 2.
23	01 Feb 2018	Installation of new turbine vane segments rows 1 to 4. New abradable seal segments fitted.
24	02 Feb 2018	Compressor rear journal bearing and turbine thrust bearing inspection. Generator inspection in parallel: stator IR test, end winding inspection, air gap measurement, retaining ring ET.
25	03 Feb 2018	Radial and axial clearance measurement and recording. Compressor and turbine casing closure, flange sealant applied, bolts torqued in OEM cross sequence. Mechanical completion.
26	04 Feb 2018	Insulation and lagging restored, instrumentation reconnected, LOTO restoration, lube oil flush check, turning gear run of 6 hours, pre start checks with DEWA.
27	05 Feb 2018	First fire at 09:40, run up to FSNL, protection checks, synchronization at 13:15, step loading to base load, performance data recorded, unit returned to DEWA dispatch.

4.2 Excerpts of Inspection

- Turbine and combustion compartment roof panels and vent assemblies were removed as required to allow crane access for removal of the turbine casing upper half, vane carrier upper half and compressor casing upper half. All panels were reinstalled after cleaning with renewed gaskets and sealant on the joints.
- Fuel gas and gasoil supply piping, atomizing air piping, cooling air and sealing air piping and all instrumentation connected to the turbine and combustion sections were disconnected after position marking. All lines were cleaned and reinstalled to the recorded marking. All flange bolts were tightened to the specified torque and the values were recorded on jointly signed check sheets.
- Both silo combustion chambers were entered under confined space permit after atmosphere testing for oxygen, carbon monoxide and temperature with a calibrated detector. One hundred percent of the ceramic tiles in both chambers were inspected against the tile inspection template and classified as serviceable, monitor or replace. Thirty eight tiles were classified as replace and were renewed. Sixty one tiles were classified as monitor and were recorded by position for the next event.
- All sixteen hybrid burner assemblies, eight per chamber, were removed, cleaned and inspected. Nozzle tips, swirler vanes, diffusion gas spiders and premix manifolds were checked. Swirler vane erosion was noted on four burners and recorded for monitoring. All burner sealing rings were renewed and the burners were reinstalled in their original positions at the specified torque.
- Both flame tubes were removed and subjected to fluorescent penetrant inspection on the weld seams. Circumferential cracking of 62 mm total length was found at the aft weld seam of the chamber A flame tube. The chamber A flame tube was replaced with a refurbished exchange unit. The chamber B flame tube was found serviceable and was returned to service.
- The hot gas casing inner hub surfaces were inspected for erosion, hot corrosion and cracking after cleaning. Light hot corrosion was noted and recorded. No cracking was indicated. All K ring assemblies were replaced with new.

- Casing support jacks were installed beneath the turbine casing horizontal joint before removal of the casing bolts. Jacking values were recorded on the jointly signed check sheet. The jacks were removed after reassembly and bolt tightening.
- The turbine casing upper half was removed after removal of the vertical joint bolts, horizontal joint bolts and body bound bolts. Levelling during the lift was maintained within 2 mm end to end. The casing bore was inspected for erosion, hot corrosion and rub marks. Light rub marking was found in way of rows 1 and 2 and was blended within limits.
- All turbine blades in rows 1 to 4 were removed and tagged by disc slot position. After cleaning, each blade was subjected to fluorescent penetrant inspection and dimensional assessment. All four rows were replaced with new blades supplied under the referenced Purchase Order. The new blades were installed to the moment weight distribution chart supplied with each blade set, with new platform seals, new shank seals, new locking wire and new dowel pins.
- All turbine vane segments in rows 1 to 4 were removed and tagged by carrier position. Throat areas were measured before removal and after installation of the new segments. The measured throat areas of the new row 1 and row 2 segments are within 0.6 percent of nominal, which is within the acceptance band.
- The compressor casing upper half was opened to allow replacement of the compressor rotor blades in stages 1 to 16. All rotor blades were removed with the rotor rotated in stages. Rotor grooves were cleaned and inspected by fluorescent penetrant inspection with no indications found. New blades were installed stage by stage, with locking blades fitted and staked at each stage. Blade root seating was verified with feeler gauge at each stage.
- The variable inlet guide vane assembly was cleaned and subjected to fluorescent penetrant inspection. No cracking, foreign object damage or bushing wear beyond limits was found. Inlet guide vane clearances and lever angles were recorded and the assembly was returned to service.
- The compressor stationary blades in stages 1 to 16 were cleaned in place and inspected. Fouling was present on stages 1 to 6 with light erosion on stages 1 to 3. No cracking was indicated after cleaning and fluorescent penetrant inspection of the sample positions. The stationary blading was returned to service.
- The inlet plenum, bell mouth and filter house were inspected. Light oil traces were found on the plenum floor and were cleaned before manhole closure. Pre filter elements were found with heavy dirt loading and were replaced by the DEWA team.
- Exhaust diffuser struts were cleaned and inspected by magnetic particle inspection. Two hairline indications were found at the turbine side vertical flange pin locations. Both were weld repaired by the DEWA maintenance team and re-inspected with no further indications.
- The compressor rear journal bearing and the turbine end thrust bearing were removed and inspected. White metal surfaces were free of wipe, scoring and fatigue. Bearing clearances and rotor axial float were measured and recorded. Both bearings were returned to service, with new shims fitted to the thrust bearing.



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- Before closure of the exhaust manhole, the row 4 blade and diffuser area was jointly inspected with DEWA and confirmed free of foreign objects. A foreign material exclusion register was maintained throughout the outage and was closed out with DEWA before casing closure.
 - All clearance measurements, torque values, jacking values and blade position records were entered on the applicable check sheets and jointly signed by UNEW and DEWA representatives. Copies were handed over to the DEWA outage coordinator at mechanical completion.

5. RECOMMENDATIONS

- Scheduled inspections should continue to be carried out at the intervals defined in Schedule C1 of the Long Term Service Agreement, with equivalent operating hours calculated on the basis defined in Schedule C2. The next scheduled event is a Combustion Inspection at approximately 49,000 EOH. On the operating profile of the last four years this is expected to fall in 2022.
- The complete hot gas path of the Unit has been renewed at this outage. All rows of turbine vanes and blades now carry zero equivalent operating hours. It is recommended that DEWA establish the parts life record for the new set from this outage, using the serial number register in Appendix A as the baseline, so that residual life can be assessed against the design life at the next event.
- The removed row 1 blades and row 1 vane segments are not recommended for further repair. The removed row 2 blades, row 3 and row 4 blades and row 3 and row 4 vane segments are candidates for refurbishment. UNEW will issue a formal repair evaluation report for each set after receipt at the Stuart, Florida facility. DEWA should confirm whether these sets are to be refurbished for use as a rotatable spare set for the fleet.
- The removed compressor rotor blades from stages 1 to 3 showed leading edge erosion and pitting corrosion consistent with the coastal atmospheric environment at Jebel Ali. It is recommended that the online water wash system be operated on a regular schedule and that offline water wash be carried out at every available opportunity between scheduled outages. This will reduce fouling related performance loss and reduce the risk of blade tip rub.
- The inlet filter house pre filters were found heavily loaded. It is recommended that the filter change interval be reviewed against the recorded differential pressure trend, as filter loading contributes directly to compressor fouling and to salt carry over in this location.
- Sixty one ceramic tiles are classified as monitor and are recorded by position in the check sheets. These positions should be inspected at the next Combustion Inspection and replaced if the classification has moved to replace. It is recommended that a full replacement tile set be held at site before the next Combustion Inspection.
- The chamber A flame tube removed at this outage exhibited weld seam cracking after 13,662 operating hours. It is recommended that flame tube weld seams be included in the borescope inspection scope at every opportunity, and that one exchange flame tube be held in the site store for the fleet.
- The instrument tubing connectors on the compressor discharge and fuel gas headers have been opened and remade on many occasions since commissioning. It is recommended that a stock of stainless steel tube, male, female and straight connectors, unions, ferrules and nuts be held at site, since the probability of leakage through ferrule joints increases with repeated remaking.
- Long lead capital parts for the next Major Inspection, provisionally 2027, should be identified and ordered in accordance with the planning milestones in Schedule C5 of the Long Term Service Agreement, which requires strategic planning to begin 24 months before the event. Bearings, seal sets, tie bolt hardware and the complete combustion parts set are the critical items.
- It is recommended that the same hot gas path renewal scope be planned for Units G52, G53 and G54 as each unit reaches the 33,000 EOH trigger, so that the fleet is maintained in a common configuration and the parts pool can be managed on a fleet basis.



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6. INLET SYSTEM AND COMPRESSOR SECTION

6.1 Inlet Plenum and Variable Inlet Guide Vane Assembly

The inlet plenum was accessed through the designated manhole. Light sooty deposit was visible on the plenum walls, on the bell mouth and on the inlet guide vanes. The plenum and the inlet guide vane assembly were cleaned. No foreign object damage, cracking or distortion was found on any vane. All inlet guide vanes were checked by dye penetrant inspection with no reportable indication. Bushing wear was measured at eight positions around the circumference and was found within limits. Inlet guide vane closed and open angles were checked against the control system feedback and the lever positions were recorded.

The water wash nozzle ring was checked for integrity and blockage and was found in good condition. The inlet plenum floor showed light oil traces, which were cleaned before manhole closure. Pre filter elements were found with heavy dirt loading and were replaced by the DEWA team during the outage.

6.2 Compressor Casing Opening

The compressor casing upper half was removed after the turbine section work had progressed to the point where the rotor could be safely supported and rotated. Horizontal joint bolts were removed in the specified sequence and the casing was lifted with the compressor lifting beam. Levelling during the lift was maintained within 2 mm end to end. The casing bore and the stationary blade carriers were inspected for rub marking, erosion and corrosion. Light rub marking was noted in way of stages 2 and 3 and was consistent with the tip clearance measurements recorded before blade removal.

6.3 Compressor Blading Replacement, Stages 1 to 16

All compressor rotor blades in stages 1 to 16 were removed. The rotor was rotated in controlled steps to allow removal of the lower half blades through the horizontal joint. Each blade was tagged by stage and position on removal. The removed blading showed heavy fouling on stages 1 to 5, leading edge erosion on stages 1 to 3, pitting corrosion on stages 4 to 8 and root fretting on nine blades of stage 1. Tip clearance measurement before removal confirmed that stages 1, 2 and 3 had opened beyond the design band.

Rotor blade grooves were cleaned and inspected by fluorescent penetrant inspection at every stage. No indications were found on any groove, retaining feature or locking blade slot. New compressor blades supplied under the referenced Purchase Order were installed stage by stage. Blade root seating was verified by feeler gauge at each position. Locking blades were fitted and staked at each stage in accordance with the applicable procedure. Serial numbers of the installed sets are recorded in Section 3.3 and Appendix A of this report and on the jointly signed installation check sheets.

The compressor stationary blading in stages 1 to 16 was cleaned in place and inspected. Fouling was present on stages 1 to 6 with light erosion on stages 1 to 3. Fluorescent penetrant inspection of the sample positions returned no indications. The stationary blading was returned to service. Anti surge bleed valve internals and the offline water wash system were inspected and returned to service.

6.4 Compressor Radial Tip Clearances



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Radial tip clearances were measured at the horizontal joint at four positions per stage, before removal of the original blading and after installation of the new blading. Representative values are given below. The complete record for all sixteen stages is contained in the jointly signed clearance check sheets.

Stage	Design Band (mm)	Measured Before, Min (mm)	Measured Before, Max (mm)	Measured After, Min (mm)	Measured After, Max (mm)	Assessment
1	1.10 to 1.55	1.62	1.94	1.18	1.36	Within band
2	1.05 to 1.50	1.58	1.86	1.14	1.32	Within band
3	1.00 to 1.45	1.49	1.72	1.09	1.28	Within band
4	0.95 to 1.40	1.33	1.52	1.02	1.24	Within band
8	0.85 to 1.25	1.12	1.31	0.94	1.16	Within band
12	0.80 to 1.20	1.04	1.22	0.88	1.10	Within band
16	0.75 to 1.15	0.98	1.16	0.84	1.04	Within band

7. COMBUSTION SECTION

The SGT5-2000E / V94.2 (Si3D) combustion system consists of two external silo type combustion chambers, designated chamber A and chamber B, each fitted with a ceramic tile lining, eight hybrid burners, a flame tube and K ring assemblies. The design allows complete combustion section inspection without opening the turbine casing. The full Combustion Inspection scope defined in Section 3 of Schedule 1 of the Long Term Service Agreement was executed as the first phase of this Hot Gas Path Inspection.

7.1 Ceramic Tile Lining, Chambers A and B

Both chambers were entered under confined space entry permit after atmosphere testing. One hundred percent of the ceramic tiles in both chambers were inspected against the tile inspection template and classified as serviceable, monitor or replace. The classification result is summarized below. All tiles classified as replace were removed and new tiles were installed in the identified positions. Every replacement was photographed and recorded by position number. Tile retaining hardware was inspected at each position and renewed where distortion was found.

Chamber	Tiles Inspected	Serviceable	Monitor	Replace	Principal Defect Modes
Chamber A	312	198	92	22	Edge chipping, surface spalling, hot face cracking near the burner belt
Chamber B	312	222	74	16	Edge chipping, surface spalling, localized hot spotting
Total	624	420	166	38	

Note: the monitor classification total of 166 includes tiles in secondary and tertiary zones. Of these, 61 tiles in the burner belt and flame zone are recorded by position as priority monitor items for the next Combustion Inspection.



Figure 2. Ceramic tile classification result, chambers A and B

7.2 Hybrid Burner Assemblies

All sixteen hybrid burner assemblies, eight per chamber, were removed and taken to the workshop area for cleaning and inspection. Nozzle tips, swirler vanes, diffusion gas spiders and premix manifolds were

inspected visually and dimensionally. Light to medium carbon deposit was found on the diffusion gas spiders of eleven burners and was removed. Swirler vane erosion was noted on four burners, at chamber A positions 3 and 6 and chamber B positions 2 and 7, and was recorded for monitoring at the next event. No cracking was found on any burner after cleaning and dye penetrant inspection of the tip regions. All burner sealing rings were renewed. All burners were reinstalled in their original positions and tightened to the specified torque, with values recorded on the jointly signed check sheets.

7.3 Flame Tubes

Both flame tubes were removed and inspected after cleaning. Fluorescent penetrant inspection was carried out on all weld seams. The chamber A flame tube was found with circumferential cracking at the aft weld seam, with a total indicated length of 62 mm across three separate indications. The chamber A flame tube was replaced with a refurbished exchange unit supplied by UNEW. The chamber B flame tube showed light oxidation and distortion within limits and no weld seam indications, and was returned to service. The removed chamber A flame tube has been returned to the UNEW Stuart, Florida facility for repair evaluation.

7.4 K Rings and Hot Gas Casing

All K ring assemblies were removed and inspected. Distortion and oxidation were found on the assemblies of both chambers. All K ring assemblies were replaced with new. The hot gas casing inner hub surfaces were cleaned and inspected for erosion, hot corrosion and cracking. Light hot corrosion was found and recorded photographically. No cracking was indicated after visual inspection and penetrant inspection of the accessible weld areas.

7.5 Ignition and Flame Detection

The ignition system was inspected, including igniters, high tension leads, ignition transformers and ultraviolet flame detectors. Two ultraviolet flame detectors were found with degraded output at the bench test and were replaced with new detectors from the site store. The ignition sequence was function tested with the DEWA controls engineer in attendance before chamber closure and again during pre start checks.

7.6 Fuel Gas and Liquid Fuel Systems

Fuel gas strainer elements were removed, cleaned and inspected. Light particulate loading was found and the elements were reinstalled. The fuel gas main shutoff valve, the pilot gas valve and the vent valves were function tested. Liquid fuel check valves were removed, marked, tested and reinstalled with the flow direction jointly verified. Atomizing air lines and purge lines were cleaned and reinstalled with renewed gaskets. All associated check sheets were jointly signed.

8. TURBINE SECTION

The turbine section of the SGT5-2000E / V94.2 (Si3D) comprises four rows of turbine vanes carried in the vane carriers and four rows of turbine blades mounted in the turbine discs of the assembled rotor. Rows 1 and 2 are internally cooled and thermal barrier coated. Rows 1, 2 and 4 blades are fitted with heat shields. Rows 1 and 2 vanes are fitted with inner shroud segments. The complete turbine hot gas path of this Unit was renewed during this outage.

8.1 Turbine Casing Opening

The Unit was confirmed cooled to a metal temperature below 50 degrees Celsius before casing work began. All instrumentation, cooling air piping and sealing air connections were disconnected after marking. Insulation blankets were removed from the turbine section. Casing support jacks were installed beneath the horizontal joint before bolt removal and the jacking values were recorded. Vertical joint bolts, horizontal joint bolts and body bound bolts were removed in the specified sequence. The casing lifting beam was installed and the upper casing half was lifted with levelling maintained within 2 mm end to end. The casing bore was inspected for erosion, hot corrosion and rub marking. Light rub marking was found in way of rows 1 and 2 and was blended within limits. The casing horizontal and vertical parting planes were cleaned and polished before reassembly.

8.2 Turbine Vane Row 1

The row 1 vane segments were removed from the upper and lower vane carriers and tagged by position. The removed segments showed heavy thermal barrier coating spallation on 14 segments, trailing edge burn back of up to 4.5 mm on 6 segments, and hot corrosion on all platform surfaces. Throat area measurement showed 9 segments opened beyond the upper tolerance. The set was removed from service and is not recommended for further repair.

The complete row 1 vane set was replaced with new segments in FSX-414, comprising 42 standard segments, 2 joint and lead segments and 2 instrumented and transition segments, a total of 46 segments. Each segment was verified against its Certificate of Conformance and serial number before installation. Throat areas were measured after installation and were found within 0.6 percent of nominal. New inner shroud segments were fitted. Serial numbers AA26K0001 to AA26K0046 refer.

Removed part number: A2A50330301 / A2A50330302. Installed part numbers: A2A50021940-G001, A2A50021941-G002 and A2A50021942-G003.

8.3 Turbine Vane Row 2

The row 2 vane segments were removed and tagged by position. The removed segments showed thermal barrier coating loss on the leading edge of 11 segments and radial cracking at cooling hole positions on 4 segments, with general oxidation across the set. Throat areas were within tolerance. The set was removed from service and has been returned to the UNEW Stuart, Florida facility for repair evaluation.

The complete row 2 vane set was replaced with new segments in FSX-414, comprising 44 standard segments, 2 joint segments and 2 instrumented segments, a total of 48 segments. New inner shroud segments were fitted. Serial numbers AA26K0047 to AA26K0094 refer.

Removed part number: A2A50330303 / A2A50330304. Installed part numbers: A2A50024312-G001, A2A50024312-G002 and A2A50024312-G003.

8.4 Turbine Vane Row 3

The row 3 vane segments were removed and inspected. Light to medium oxidation and minor trailing edge erosion were found. Fluorescent penetrant inspection returned no indications. The set is a candidate for refurbishment and has been returned to the UNEW Stuart, Florida facility for evaluation.

The complete row 3 vane set was replaced with new segments comprising 45 standard segments, 3 joint segments and 3 instrumented segments, a total of 51 segments. Serial numbers AA26K0095 to AA26K0145 refer.

Removed part number: A2A50290932 / A2A50225277. Installed part numbers: A2A5116244-G001, A2A5116244-G002 and A2A5116244-G003.

8.5 Turbine Vane Row 4

The row 4 vane segments were removed and inspected. Light oxidation and deposit were found, with no cracking indicated and dimensional condition within tolerance. The set is a candidate for refurbishment and has been returned to the UNEW Stuart, Florida facility for evaluation.

The complete row 4 vane set was replaced with new segments comprising 49 standard segments, 3 joint segments and 3 instrumented segments, a total of 55 segments. Serial numbers AA26K0146 to AA26K0200 refer.

Removed part number: A2A50284264 / A2A50007258 / A2A50284265. Installed part numbers: A2A5118611-G001, A2A5118611-G002 and A2A5118611-G003.

8.6 Turbine Blade Row 1

All row 1 blades were removed from the turbine disc and tagged by slot position. The removed blades showed tip rub on the full set, squealer tip metal loss on 12 blades, coating depletion across 100 percent of the set, cooling hole enlargement on 7 blades and root serration fretting on 3 blades. The condition is consistent with the tip rub reported at the 2016 borescope inspection and with the accumulated 33,057 EOH. The set is not recommended for further repair and has been retained for metallurgical sampling.

The complete row 1 blade set was replaced with new blades in IN738LC with MCrAlY bond coat and YSZ thermal barrier coating, comprising 85 standard blades, 2 locking blades and 2 weighted balanced segment blades, a total of 89 blades. Before installation each blade was inspected visually for handling damage and its serial number was matched against the moment weight distribution chart supplied with the set. The set was installed to the moment weight distribution chart, with new platform seals, new shank seals, new locking wire and new dowel pins. New row 1 heat shields were fitted. Serial numbers AA26K0201 to AA26K0289 refer.

Removed part number: A2A50330305. Installed part numbers: A2A50012458-G001, A2A50012458-G002 and A2A50012458-G003.

8.7 Turbine Blade Row 2

All row 2 blades were removed and tagged by slot position. Coating loss was found on the suction side of 41 blades, with light tip rub and platform hot corrosion. Fluorescent penetrant inspection of the airfoils returned no indications. The set has been returned to the UNEW Stuart, Florida facility for repair evaluation.

The complete row 2 blade set was replaced with new blades in IN738LC, comprising 85 standard blades, 2 locking blades and 2 weighted balanced segment blades, a total of 89 blades. The set was installed to the moment weight distribution chart with new seals, locking wire and dowel pins. New row 2 heat shields were fitted. Serial numbers AA26K0290 to AA26K0378 refer.

Removed part number: A2A50330307. Installed part numbers: A2A50014822-G001, A2A50014822-G002 and A2A50014822-G003.

8.8 Turbine Blade Row 3

All row 3 blades were removed and inspected. Discoloration, light deposit and minor trailing edge erosion were found. Fluorescent penetrant inspection returned no indications. The set is a candidate for refurbishment.

The complete row 3 blade set was replaced with new blades comprising 59 standard blades, 2 locking blades and 2 weighted balanced segment blades, a total of 63 blades, installed to the moment weight distribution chart. Serial numbers AA26K0379 to AA26K0441 refer.

Removed part number: A2A50006517 / A2A50006516. Installed part numbers: A2A50113110-G001, A2A50113110-G002 and A2A50113110-G003.

8.9 Turbine Blade Row 4

All row 4 blades were removed and inspected. Light deposit was found, with shroud contact face wear within limits and no penetrant indications. The set is a candidate for refurbishment.

The complete row 4 blade set was replaced with new blades comprising 42 standard blades and 2 locking or closing blades, a total of 44 blades, installed to the moment weight distribution chart. New row 4 heat shields were fitted. Serial numbers AA26K0442 to AA26K0485 refer.

Removed part number: A2A50107664. Installed part numbers: A2A50113110-G004 and A2A50113110-G005.

8.10 Inner Shroud Segments, Heat Shields and Seals

The row 1 and row 2 vane inner shroud segments were removed and inspected. Hot corrosion was found on all segments, with seal groove wear beyond limit on 5 segments of row 1. All inner shroud segments were replaced with new. The row 1, row 2 and row 4 blade heat shields were replaced with new. Abradable seal segments in way of rows 1 and 2 showed rub damage with opened clearance and were replaced with new. All labyrinth seal segments accessible without rotor extraction were inspected and renewed where clearance was outside the design band.

8.11 Turbine Discs and Rotor

After removal of the blading in rows 1 to 4, the turbine discs were cleaned and inspected visually and by fluorescent penetrant inspection. Root slots, slot corners, locking features and balance weight groove areas were examined at every position. No indications were found on any disc. The central tie bolt was not

disturbed, since rotor destacking is a Major Inspection activity and was not part of this scope. Rotor runout was checked at the accessible positions during turning gear operation before casing closure and was found within limits. The discs were returned to service after cleaning.

8.12 Turbine Radial and Axial Clearances

Radial clearances were measured at four positions per row at the horizontal joint before removal of the original parts and after installation of the new parts. Axial clearances were measured at the same positions. Values below are the recorded ranges after installation. The complete record is contained in the jointly signed clearance check sheets.

Row	Radial Design Band (mm)	Radial Before, Range (mm)	Radial After, Range (mm)	Axial After, Range (mm)	Assessment
Blade Row 1	1.60 to 2.20	2.35 to 2.86	1.72 to 2.04	4.10 to 4.55	Within band
Blade Row 2	1.90 to 2.55	2.62 to 3.08	2.02 to 2.38	4.65 to 5.10	Within band
Blade Row 3	2.30 to 3.00	2.94 to 3.36	2.44 to 2.82	5.30 to 5.85	Within band
Blade Row 4	2.80 to 3.60	3.42 to 3.88	2.96 to 3.38	6.10 to 6.70	Within band
Vane Row 1 inner seal	1.20 to 1.70	1.82 to 2.14	1.30 to 1.56	Not applicable	Within band
Vane Row 2 inner seal	1.35 to 1.85	1.90 to 2.22	1.44 to 1.70	Not applicable	Within band

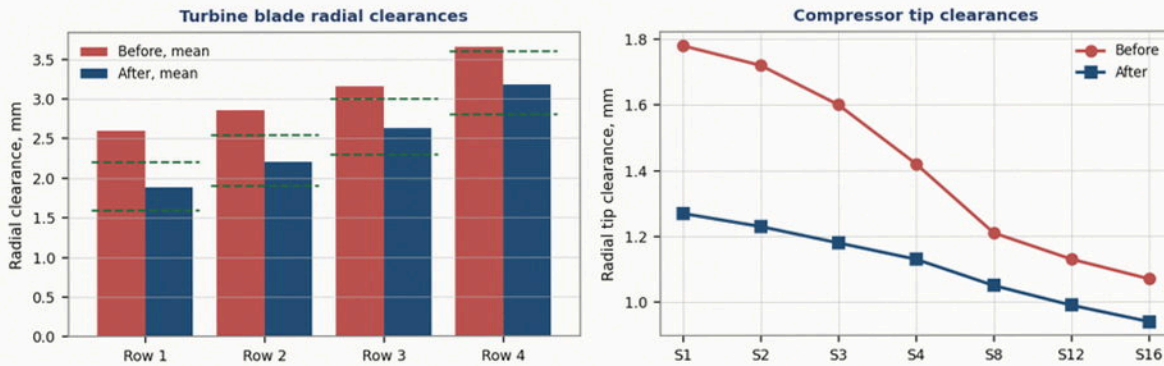


Figure 3. Radial clearance restoration, turbine blade rows 1 to 4 and compressor stages, before and after parts renewal

9. BEARINGS, SEALS AND GENERATOR

9.1 Bearings

The compressor rear journal bearing and the turbine end thrust bearing were removed and inspected. White metal surfaces were free of wipe, scoring and fatigue cracking. Light polishing marks consistent with normal service were noted. Blue contact checks were carried out on both bearings and the contact pattern was found acceptable. Bearing clearances and rotor axial float were measured and recorded. New shims were fitted to the thrust bearing to restore axial float to the middle of the design band. All lube oil piping in way of the bearings was inspected internally and found clean. A lube oil sample was drawn and submitted for laboratory analysis, with results within specification for viscosity, water content, acid number and particle count.

Measurement	Design Band	Measured	Assessment
Compressor rear journal bearing, vertical clearance	0.32 to 0.48 mm	0.41 mm	Acceptable
Compressor rear journal bearing, horizontal clearance	0.30 to 0.46 mm	0.38 mm	Acceptable
Turbine end journal bearing, vertical clearance	0.34 to 0.50 mm	0.44 mm	Acceptable
Rotor axial float, total	0.50 to 0.75 mm	0.62 mm after shimming	Acceptable
Thrust bearing pad thickness, active side	Nominal minus 0.10 mm maximum	Nominal minus 0.03 mm	Acceptable
Bearing metal temperature at base load, maximum	Below 110 degrees C	96 degrees C	Acceptable

9.2 Generator TLRI 100/42, Serial Number M10892

The generator inspection was carried out in parallel with the turbine work in accordance with Section 4.6 of Schedule 1 of the Long Term Service Agreement. The stator insulation resistance and polarization index were measured, the end windings were inspected for looseness, greasing and discharge marking, the air gap was measured at eight positions, the rotor retaining rings were inspected by eddy current, the coolers were pressure tested and the excitation and protection relays were calibrated and function tested. Results are summarized below.

Test	Criterion	Result	Assessment
Stator insulation resistance at 5 kV, 1 minute	Greater than 1,000 megohm at 40 degrees C	3,850 megohm	Acceptable
Polarization index	Greater than 2.0	3.4	Acceptable
Rotor insulation resistance at 500 V	Greater than 10 megohm	210 megohm	Acceptable
Air gap variation	Within 10 percent of mean	4.2 percent	Acceptable
End winding inspection	No looseness, greasing or discharge marking	Minor greasing at two positions, wedges re-tightened	Acceptable after rectification
Retaining ring eddy current inspection	No indication	No indication	Acceptable
Cooler pressure test	No leakage at test pressure	No leakage	Acceptable



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Test	Criterion	Result	Assessment
Protection and AVR function test	All functions operate to setting	All functions verified with DEWA witness	Acceptable



Gas turbine field service and component engineering

10. EXHAUST DIFFUSER SECTION

After removal of the turbine casing upper half and the hot gas path components, the exhaust diffuser was inspected in situ for cracking, distortion and liner damage. Magnetic particle inspection was carried out on the diffuser strut weld joints. No indications were found on the struts. Two hairline indications were found at the turbine side vertical flange pin locations and on the outer heat shield. Both were weld repaired by the DEWA maintenance team using an approved procedure and were re-inspected after repair with no further indication. Diffuser insulation and liner plates were inspected and refitted where fasteners were found loose.

Before closure of the exhaust manhole the row 4 blade area and the diffuser inlet were jointly inspected with the DEWA representative and confirmed free of foreign objects, tooling and consumables. The foreign material exclusion register maintained throughout the outage was closed out and countersigned before closure.

11. REASSEMBLY, START UP AND PERFORMANCE

11.1 Reassembly

New abradable seal segments were installed before casing closure. High temperature flange sealant was applied to the horizontal parting planes of the compressor and turbine casings. The upper casing halves were lowered with levelling maintained within 2 mm end to end. All casing bolts were installed and tightened in the specified cross torque sequence, with bolt size, target torque and achieved torque recorded on the jointly signed check sheets. Casing support jacks were removed after tightening. All instrumentation, cooling air piping, sealing air piping, fuel piping and insulation were restored. Lock out and tag out was released in accordance with the DEWA permit system after joint verification of the work completion.

11.2 Start Up Comments

All mechanical work related to the Hot Gas Path Inspection scope was completed on 03 February 2018. The Unit was placed on turning gear on 04 February 2018 at 14:00 hours and remained on turning gear for six hours while pre start checks were completed by the DEWA operations team with UNEW support. Offline compressor water wash was carried out on the morning of 05 February 2018 and the Unit was drained and dried in accordance with the plant procedure.

First fire took place on 05 February 2018 at 09:40 hours. The Unit was run up to full speed no load, where protection checks and the overspeed test were carried out with the DEWA controls engineer in attendance. The Unit was synchronized at 13:15 hours on 05 February 2018 and loaded in steps to 60 MW, 100 MW, 140 MW and base load, with a hold at each step for temperature stabilization and vibration observation. Exhaust temperature spread, bearing vibration, bearing metal temperature, compressor discharge pressure and blade path temperature distribution were monitored throughout the loading sequence. All parameters were within limits at every step. The Unit was handed back to DEWA dispatch on 05 February 2018 at 20:30 hours.

11.3 Post Inspection Performance Data

Performance data was recorded after four hours at base load on 05 February 2018 and is compared below with the data recorded before shutdown on 09 January 2018. Values are as read from the SPPA-T3000 control system and are not corrected to ISO conditions except where stated.

Parameter	Before Outage, 09 Jan 2018	After Outage, 05 Feb 2018	Change
Ambient temperature	21.4 degrees C	22.1 degrees C	Plus 0.7 degrees C
Gross power output at base load	148.6 MW	158.9 MW	Plus 10.3 MW
Power output corrected to ISO	154.2 MW	164.8 MW	Plus 10.6 MW
Compressor discharge pressure	10.42 bar	11.06 bar	Plus 0.64 bar
Exhaust temperature, mean	551 degrees C	539 degrees C	Minus 12 degrees C
Exhaust temperature spread, maximum	38 degrees C	16 degrees C	Minus 22 degrees C
Heat rate, LHV basis	10,610 kJ/kWh	10,180 kJ/kWh	Minus 430 kJ/kWh

Parameter	Before Outage, 09 Jan 2018	After Outage, 05 Feb 2018	Change
Bearing vibration, maximum	3.4 mm/s	1.9 mm/s	Minus 1.5 mm/s
NOx at 15 percent oxygen	41 ppm	36 ppm	Minus 5 ppm

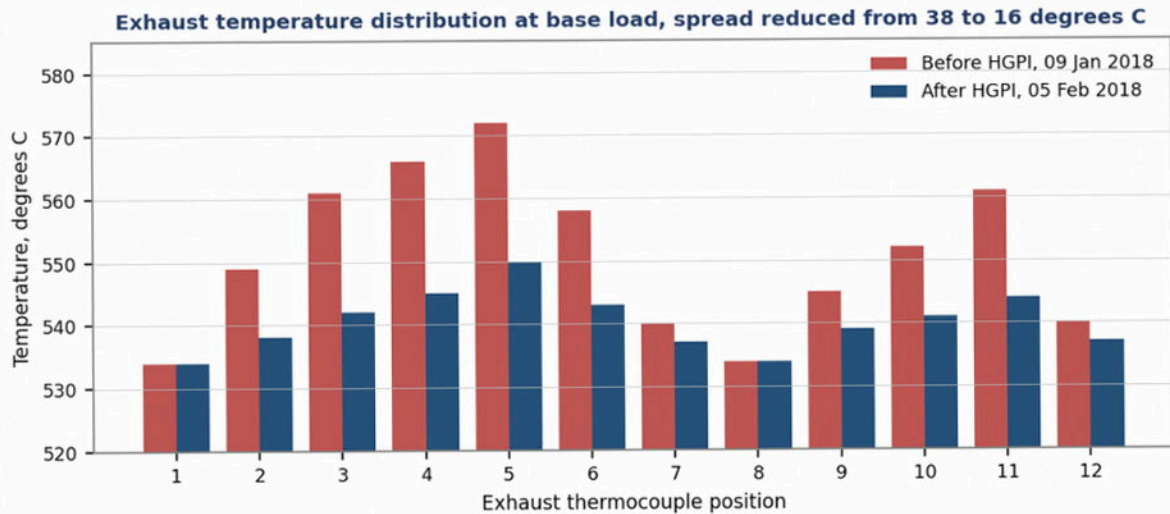


Figure 4. Exhaust temperature distribution at base load recorded on the SPPA-T3000 operator station, before and after the outage

The recovery in output, heat rate and exhaust temperature spread is consistent with the renewal of the complete hot gas path and the compressor blading and with the restoration of design clearances.

12. CONTROL SYSTEM REPORT, SIEMENS SPPA-T3000 AND TELEPERM XP (T-2000)

This section covers the work performed on the turbine control and protection system of Unit JEBEL ALI G51 during the Hot Gas Path Inspection. The work was carried out by the UNEW Controls and Instrumentation Technical Advisor with the support of the DEWA instrumentation and electrical teams. It is issued as an integral part of this inspection report.

Unit type	Gas turbine generator train
Model designation	Siemens SGT5-2000E / V94.2 (Si3D)
Unit and serial number	JEBEL ALI G51, Serial Number 600712
Inspection type	Hot Gas Path Inspection with capital parts renewal
Control system	Siemens SPPA-T3000, Release 6.2 SP2, with retained Teleperm XP (T-2000) AS 620 B automation system
Operator station	SPPA-T3000 thin client operator stations, unit control room and central control room
Automation processors	AS 620 B, redundant, unit control, turbine protection and generator protection subsystems
Remote input and output	SIMATIC ET 200M with PROFIBUS DP field bus to the turbine local marshalling cabinets
Turbine protection	Hardwired two out of three trip logic, independent of the automation processors
Fuel configuration	Natural gas, primary. Gasoil, backup
Rated speed	3000 rpm, 50 Hz
Overspeed trip setpoint	3300 rpm, 110 percent of rated speed
Total operating hours at HGPI	26,782
Total equivalent operating hours at HGPI	33,057
Normal starts, fast starts, trips	210, 12, 9
Controls Technical Advisor	Mr. Guhan Raman, UNEW, Inc.
Period of controls work	02 February 2018 to 05 February 2018

12.1 Job Scope and Summary

Introduction

During the Hot Gas Path Inspection, field devices, control valves, actuators and instrumentation connected to the turbine and combustion sections were disconnected for the mechanical work. The scope of the Controls Technical Advisor was to verify, recommission and restart the Unit after the mechanical work, to support the DEWA instrument and electrical teams in the function testing of all pneumatic and hydraulic valves, sensors and transmitters, and to record the start up and loading behaviour of the Unit on the SPPA-T3000 system.

Cold Commissioning

Cold commissioning was carried out on 02 and 03 February 2018, before the first start. All transmitters and associated control loops were checked from the field device to the SPPA-T3000 process display. The inlet guide vane actuator was stroked and calibrated over the full range with the feedback verified at the closed, part open and full open positions. The fuel gas control valve and the fuel gas stop valve were stroked and the closing times verified against the protection requirement. The gasoil control valve, the water injection control valve and the anti surge bleed valves were stroked and verified. Igniters, ultraviolet flame detectors and the flame monitoring channels were function tested. The SPPA-T3000 input and output modules and the AS 620 B automation processors were checked for diagnostic alarms, and the redundancy changeover of both processor pairs was tested with no loss of process image.

Hot Commissioning

Hot commissioning covered the monitoring of the Unit from first fire through full speed no load, the electrical overspeed trip test, synchronization, step loading and base load operation. The Controls Technical Advisor monitored each step of the start up sequence, logged the events from the SPPA-T3000 alarm and event sequence, and verified that measured values remained within the specified limits at every step. Combustion tuning was carried out on natural gas with the exhaust temperature spread and the combustion dynamics monitored continuously.

12.2 Instrumentation and Loop Checks

Loop or Device	Check Performed	Result
Inlet guide vane actuator and position feedback	Full stroke, calibration at 0, 50 and 100 percent, hysteresis check	Calibrated, hysteresis 0.4 percent, acceptable
Fuel gas control valve	Full stroke, response time, closing time on trip signal	Closing time 0.32 seconds, within limit
Fuel gas stop valve	Function test, closing time on trip signal	Closing time 0.21 seconds, within limit
Gasoil control valve and check valves	Stroke and flow direction verification	Verified with DEWA witness
Anti surge bleed valves	Stroke and limit switch verification	Both valves verified
Exhaust thermocouples, 12 positions	Continuity, cold junction and reading comparison	All 12 within 3 degrees C at ambient, acceptable
Blade path and hot gas casing thermocouples	Continuity and reading comparison	Acceptable
Shaft vibration probes and seismic transducers	Gap voltage, signal and loop check	One channel replaced, see Section 12.4
Speed pickups, three channels	Signal check at turning gear and during run up	All three channels healthy
Ultraviolet flame detectors	Bench test and in situ response	Two detectors replaced, see Section 12.4
Lube oil and hydraulic pressure transmitters	Calibration against test gauge	Within tolerance
Generator protection relays and AVR	Function test and setting verification	All functions verified with DEWA witness
SPPA-T3000 to AS 620 B communication	Redundancy changeover, diagnostic check	No loss of process image, no diagnostic alarm

12.3 Start Up Sequence

The Unit was started on 05 February 2018. The static frequency converter start command was accepted at 09:12 hours. The purge sequence completed at 09:26 hours. Ignition of both combustion chambers occurred at 09:40 hours with flame established in chamber A and chamber B within the permitted window. The warm up period completed at 09:52 hours and acceleration was released. Full speed no load at 3000 rpm was reached at 10:46 hours. The speed and exhaust temperature record taken from the SPPA-T3000 fast trend is shown below.

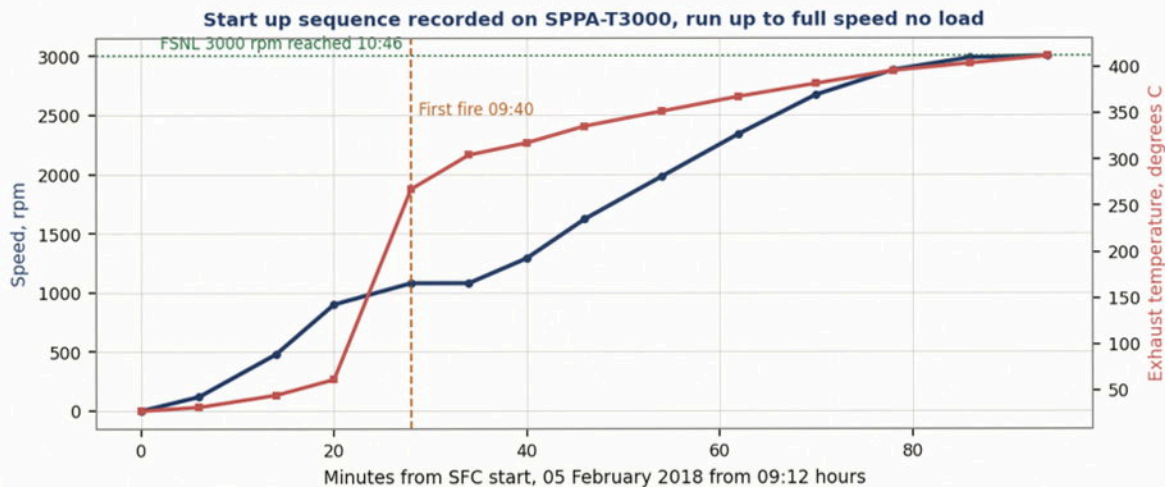


Figure 5. Start up sequence recorded on the SPPA-T3000 fast trend, run up to full speed no load

12.4 Findings and Corrective Actions

12.4.1 Shaft vibration channel, bearing 2 vertical

Erratic readings were observed on the bearing 2 vertical vibration channel during the first turning gear run. Diagnostic checks confirmed an open circuit in the sensor cable at the junction box. The cable section was replaced by the DEWA instrument team and the channel was recalibrated. The channel read correctly through the run up and all subsequent load steps.

12.4.2 Ultraviolet flame detectors, chamber A positions 1 and 3

Two ultraviolet flame detectors showed degraded output on the bench test carried out during cold commissioning. Both detectors were replaced with new units from the site store and were verified in situ during the first fire. Flame signal strength on all channels was within the required band at ignition and throughout the run up.

12.4.3 Fuel gas filter differential pressure alarm

A fuel gas filter differential pressure high alarm annunciated at 16:04 hours during base load operation. The differential pressure returned below the alarm setting after the standby filter was placed in service by the DEWA operations team. The duty filter elements were replaced and the alarm cleared. No operational restriction resulted.

12.4.4 Inlet guide vane feedback deviation

A deviation of 1.8 percent was observed between the two inlet guide vane position feedback channels during cold commissioning. The secondary feedback potentiometer was recalibrated and the deviation reduced to 0.3 percent, which is within the deviation monitoring setting of 2 percent. No control action was affected.

12.5 Electrical Overspeed Trip Test

An electrical overspeed trip test was carried out at full speed no load on 05 February 2018 at 11:35 hours in the presence of the DEWA controls engineer and the shift charge engineer, in order to verify the integrity of the overspeed protection function after the outage. The Unit was accelerated under controlled conditions from 3000 rpm. The overspeed trip operated at 3297 rpm against a setpoint of 3300 rpm, which is 110 percent of rated speed and within the acceptance band of plus or minus 0.5 percent. All protective devices responded within the required time, all fuel stop valves closed and the shutdown sequence completed without anomaly. The Unit was then restarted and synchronized.

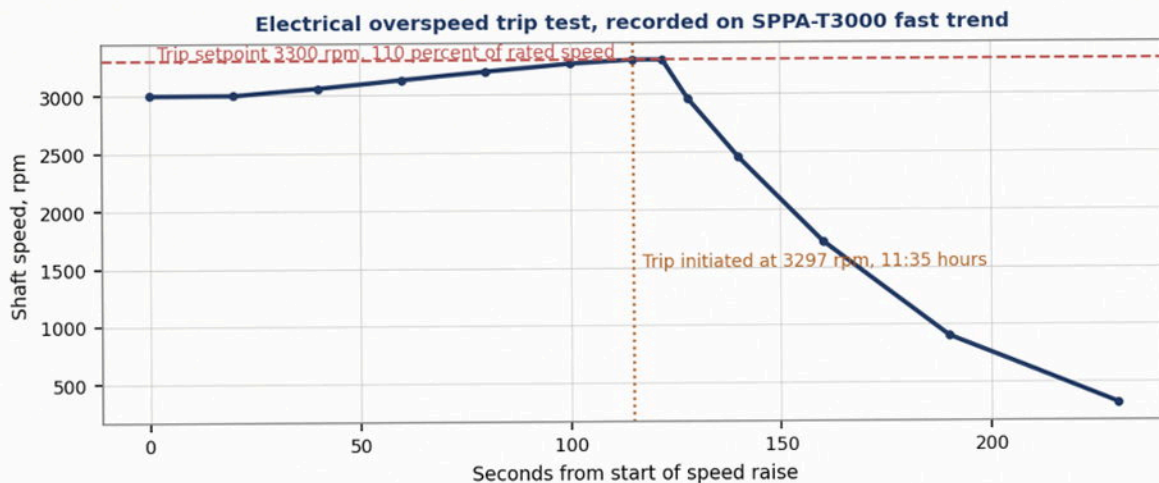


Figure 6. Electrical overspeed trip test, speed trace recorded on the SPPA-T3000 fast trend

12.6 Loading Test Results

The Unit was synchronized at 13:15 hours on 05 February 2018 and loaded in steps on natural gas, with a hold at each step for temperature stabilization and observation. Values below were read from the SPPA-T3000 operator station at each load step.

Load, MW	Speed, rpm	IGV, percent	Exhaust Temp Mean, deg C	Exhaust Spread, deg C	CDP, bar	Fuel Gas Flow, kg/s	Vib Max, mm/s	NOx, ppm	Remarks
30	3000	38	448	11	4.2	2.1	1.2	21	Stable after synchronization
60	3000	52	486	13	6.5	3.6	1.4	26	Smooth loading transition
90	3000	66	512	15	8.4	5.3	1.6	30	Stable combustion
120	3000	76	528	15	9.8	7.1	1.7	33	Good combustion stability
145	3000	82	536	16	10.7	8.6	1.8	35	Emissions within limit

Load, MW	Speed, rpm	IGV, percent	Exhaust Temp Mean, deg C	Exhaust Spread, deg C	CDP, bar	Fuel Gas Flow, kg/s	Vib Max, mm/s	NOx, ppm	Remarks
158.9	3000	86	539	16	11.06	9.4	1.9	36	Base load, stable operation

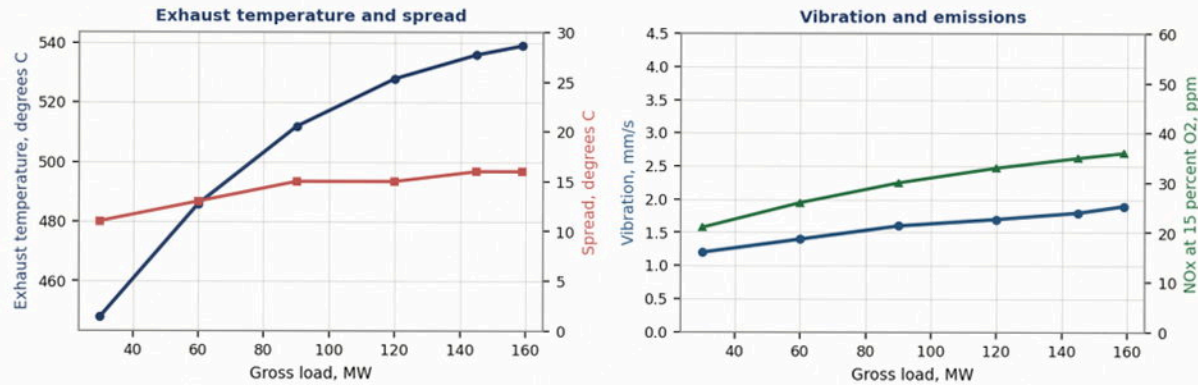


Figure 7. Loading test results recorded on the SPPA-T3000 operator station, exhaust temperature, spread, vibration and emissions

Item	Result
Speed control	Stable at 3000 rpm at all load points, no governor hunting
Combustion stability	Exhaust temperature spread maintained between 11 and 16 degrees C across the load range
Vibration	Turbine and generator bearing vibration remained below 2.0 mm/s at all load points
Emissions	NOx increased progressively with load and remained below the 50 ppm limit at 15 percent oxygen
Combustion dynamics	Pressure fluctuation remained low and stable through base load
Base load condition	158.9 MW achieved with all parameters within limits, held for four hours without abnormality

12.7 Timers and Counters

The operating hour counters, start counters and trip counters in the SPPA-T3000 system were read and recorded before shutdown and after return to service. The equivalent operating hour counter continues without reset. The hot gas path component life counters were reset to zero for the newly installed parts, so that the accumulated life of the new blading is tracked from this outage. The reset was carried out with the DEWA performance engineer present and was recorded in the event sequence.

Counter	Reading at Shutdown	Reading after Return to Service	Action
Total operating hours	26,782	26,782	Continues, no reset
Equivalent operating hours	33,057	33,057	Continues, no reset
Total starts	222	223	Continues, no reset
Trip counter	9	9	Test trip excluded, recorded as test event

Counter	Reading at Shutdown	Reading after Return to Service	Action
Hot gas path parts life counter, vane rows 1 to 4	33,057	0	Reset for new parts
Hot gas path parts life counter, blade rows 1 to 4	33,057	0	Reset for new parts
Compressor blading life counter, stages 1 to 16	33,057	0	Reset for new parts
Combustion parts life counter	16,466	16,466	Continues, parts retained in service
Turning gear hours	4,318	4,324	Continues, no reset

12.8 Controls Recommendations

- The unit control room air conditioning should be verified to maintain the cabinet room ambient temperature within 18 to 27 degrees C. Cabinet inlet temperature was measured at 29.4 degrees C during the outage, which is above the recommended band and reduces the service life of the electronic modules.
- The AS 620 B automation processors and the associated input and output modules of the Teleperm XP (T-2000) subsystem should be reviewed against the Siemens lifecycle status before the next Major Inspection, since spares availability for this generation of hardware is reducing. A hardware lifecycle audit is included in the Major Inspection scope in Section 5.8 of Schedule 1 of the Long Term Service Agreement.
- A full backup of the SPPA-T3000 project, including the application software, the graphics and the parameter set, was taken before and after the outage and handed to DEWA on removable media. It is recommended that this backup be repeated after any parameter change and stored off site.
- The spare parts holding for ultraviolet flame detectors, speed pickups and vibration transducers should be reviewed. Two flame detectors and one vibration cable were consumed at this outage.
- The exhaust thermocouple set has now completed 33,057 equivalent operating hours. Although all 12 channels are within tolerance, replacement of the complete set should be planned at the next Combustion Inspection to maintain the accuracy of the spread monitoring function.

12.9 SPPA-T3000 Screen Records

The following records were taken from the SPPA-T3000 operator station after the Unit reached stable base load operation on 05 February 2018 and were handed to DEWA with the outage documentation.

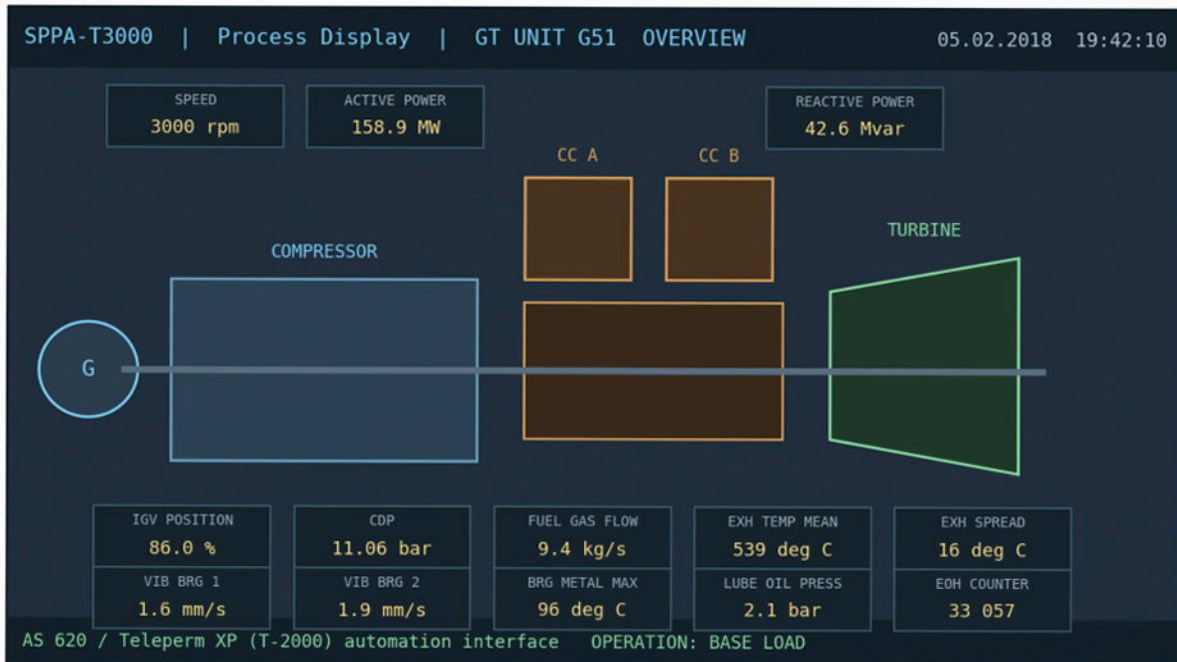


Figure 8. SPPA-T3000 turbine overview process display, Unit G51 at base load, 05 February 2018

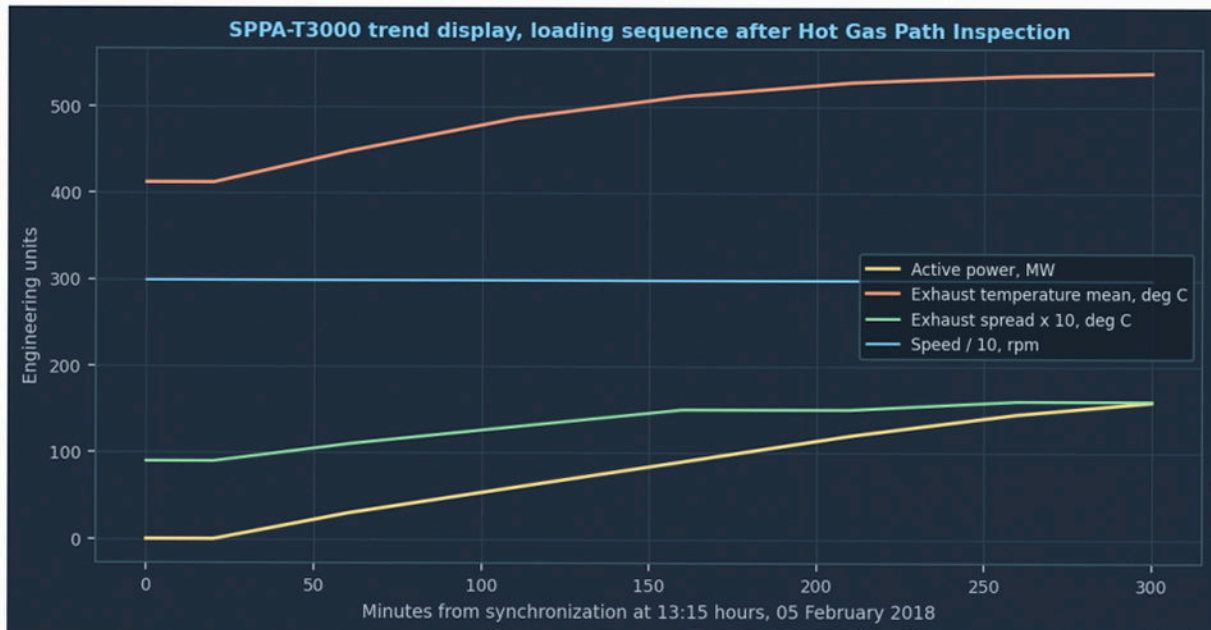


Figure 9. SPPA-T3000 trend display, loading sequence from synchronization to base load

SPPA-T3000 Alarm and Event Sequence GT UNIT G51 05.02.2018			
TIME	TAG	MESSAGE	STATUS
09:12:04	MBA10 GT	SFC START COMMAND ACCEPTED	EVENT
09:26:38	MBM20 CO	PURGE SEQUENCE COMPLETE	EVENT
09:40:12	MBM10 IG	IGNITION CHAMBER A AND B, FLAME ESTABLISHED	EVENT
09:52:47	MBA10 GT	WARM UP PERIOD COMPLETE, ACCELERATION RELEASED	EVENT
10:46:03	MBA10 GT	FULL SPEED NO LOAD 3000 RPM REACHED	EVENT
11:35:19	MBA20 OS	ELECTRICAL OVERSPEED TRIP TEST, TRIP AT 3297 RPM	TEST OK
11:36:02	MBA10 GT	TURBINE TRIP, TEST INITIATED, ALL STOP VALVES CLOSED	ACK
12:58:41	MBA10 GT	RESTART, FLAME ESTABLISHED CHAMBER A AND B	EVENT
13:15:26	MKA10 GN	GENERATOR CIRCUIT BREAKER CLOSED, SYNCHRONIZED	EVENT
13:52:10	MBA30 TC	EXHAUST TEMPERATURE SPREAD 16 DEG C, WITHIN LIMIT	INFO
14:31:55	MBV10 VB	BEARING VIBRATION 1.9 MM/S, WITHIN LIMIT	INFO
15:40:08	MBA10 GT	BASE LOAD REACHED 158.9 MW	EVENT
16:04:22	MBL20 FG	FUEL GAS FILTER DIFFERENTIAL PRESSURE HIGH	CLEARED
19:42:10	MBA90 CT	EOH COUNTER 33 057, HGP PARTS LIFE COUNTER RESET TO ZERO	EVENT
20:30:00	MBA10 GT	UNIT HANDED OVER TO DEWA DISPATCH	EVENT

Figure 10. SPPA-T3000 alarm and event sequence, start up, overspeed trip test and loading

13. NON DESTRUCTIVE TESTING AND CHECK SHEET INDEX

Non destructive testing was carried out by UNEW personnel qualified to Level II in accordance with ASNT SNT-TC-1A and ISO 9712 for the applicable methods. Consumables were within date and batch certificates are attached to the applicable check sheets. The following check sheets were completed during the outage and jointly signed by UNEW and DEWA representatives. The signed originals were handed over to the DEWA outage coordinator at mechanical completion and copies are held in the UNEW project file.

Ref.	Check Sheet	Sheets	Status
CS-01	Disassembly and assembly record, turbine and compressor sections	14	Signed
CS-02	Combustion chamber A and B tile map and classification record	12	Signed
CS-03	Hybrid burner removal, inspection and installation record	8	Signed
CS-04	Flame tube and K ring inspection and FPI record	6	Signed
CS-05	Turbine vane rows 1 to 4 removal and installation position record	16	Signed
CS-06	Turbine blade rows 1 to 4 removal and installation position record with moment weight distribution	22	Signed
CS-07	Compressor blade stages 1 to 16 removal and installation position record	24	Signed
CS-08	Serial number verification record, 517 parts	18	Signed
CS-09	Turbine radial and axial clearance record	9	Signed
CS-10	Compressor radial tip clearance record	11	Signed
CS-11	Casing bolt torque record, turbine and compressor	7	Signed
CS-12	Casing jacking and lifting record	4	Signed
CS-13	FPI and MPI report, discs, grooves, casings, diffuser struts	13	Signed
CS-14	Bearing inspection and clearance record	6	Signed
CS-15	Generator inspection and electrical test record	10	Signed
CS-16	Foreign material exclusion register and close out	3	Signed
CS-17	Lock out and tag out record and permit register	5	Signed
CS-18	Pre start check list, first fire and loading record	8	Signed
CS-19	Protection and trip function test record	9	Signed
CS-20	Certificates of conformance and material certification file, installed parts	55	Filed
CS-21	SPPA-T3000 loop check, valve stroke and calibration record	12	Signed
CS-22	Electrical overspeed trip test record	2	Signed
CS-23	SPPA-T3000 project backup and counter reset record	3	Signed

14. CONCLUSION AND SIGN OFF

The Hot Gas Path Inspection of Unit JEBEL ALI G51, Serial Number 600712, was completed at 33,057 equivalent operating hours in accordance with Section 4 of Schedule 1 of Long Term Service Agreement UNEW-DEWA-G55-LTSA-2006-001. The complete turbine hot gas path, comprising vane rows 1 to 4 and blade rows 1 to 4, and the complete compressor rotor blading, stages 1 to 16, were replaced with new capital parts supplied under Purchase Order PO-DEWA-UNEW-G55-2016-0921. A total of 55 part line items and 517 serialized capital parts were installed and recorded. All clearances were restored to the design bands and all check sheets were jointly signed.

No unresolved defect remains open on the Unit at the date of this report. The Unit was returned to DEWA dispatch on 05 February 2018 and has operated at base load without abnormality during the observation period following return to service. The next scheduled event is a Combustion Inspection at approximately 49,000 equivalent operating hours.

Function	Name	Position	Signature and Date
Prepared by	Dilip Majumder	Lead Technical Field Advisor, UNEW, Inc.	
Reviewed by	Gary Gannet	Lead Engineer, UNEW, Inc.	
Inspection verified by	Elena Vance	Inspection Engineer, NDT Level II, UNEW, Inc.	
Quality assurance	Garrett Mitchell	Quality Assurance Manager, UNEW, Inc.	
Approved by	Ronald Miller	Operations Director, UNEW, Inc.	
Received and accepted by		For Dubai Electricity & Water Authority (DEWA)	

This report is issued under Long Term Service Agreement UNEW-DEWA-G55-LTSA-2006-001 and is confidential to the Parties. Distribution: DEWA Plant Manager Jebel Ali G55, DEWA Generation Directorate, UNEW Contract Service Manager, UNEW project file.



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APPENDIX B. EQUIVALENT OPERATING HOURS CALCULATION BASIS

Equivalent operating hours have been calculated in accordance with Schedule C2 of Long Term Service Agreement UNEW-DEWA-G55-LTSA-2006-001. The source data was exported from the SPPA-T3000 control system on 09 January 2018 and was jointly verified with DEWA before shutdown.

Condition	Factor or Adder	Recorded Quantity	EOH Contribution
Normal full load operation on natural gas	1.0 EOH per operating hour	24,940 hours	24,940
Liquid fuel operation	1.5 EOH per operating hour	1,842 hours	2,763
Peak load above 105 percent rated, additional factor	0.2 EOH per operating hour	1,120 hours	224
Normal start on natural gas	20 EOH per start	210 starts	4,200
Emergency or fast start	40 EOH per start	12 starts	480
Trip from full load	50 EOH per trip	9 trips	450
Total equivalent operating hours at HGPI			33,057

The 33,000 EOH Hot Gas Path Inspection trigger defined in Schedule C1 was reached at 33,057 EOH. Total operating hours since commissioning are 26,782, of which 24,940 hours were on natural gas and 1,842 hours were on gasoil. The peak load hours are included within the natural gas operating hours and attract the additional 0.2 factor only.

APPENDIX A. NEW PARTS SERIAL NUMBER REGISTER

The following register lists every serialized capital part installed in Unit JEBEL ALI G51, Serial Number 600712, during the Hot Gas Path Inspection carried out between 10 January 2018 and 05 February 2018. Parts were supplied by UNEW, Inc. under Purchase Order PO-DEWA-UNEW-G55-2016-0921. Serial numbers were verified against the Certificate of Conformance and the receiving inspection record before installation and were recorded by disc slot or carrier position on check sheet CS-08. The register comprises 55 line items and 517 serialized parts.

No.	UNEW Part Number	Description	Unit	Qty.	Assigned Serial Numbers
1	A2A50021940-G001	Standard Turbine Vane Segment, Row 1	each	42	AA26K0001, AA26K0002, AA26K0003, AA26K0004, AA26K0005, AA26K0006, AA26K0007, AA26K0008, AA26K0009, AA26K0010, AA26K0011, AA26K0012, AA26K0013, AA26K0014, AA26K0015, AA26K0016, AA26K0017, AA26K0018, AA26K0019, AA26K0020, AA26K0021, AA26K0022, AA26K0023, AA26K0024, AA26K0025, AA26K0026, AA26K0027, AA26K0028, AA26K0029, AA26K0030, AA26K0031, AA26K0032, AA26K0033, AA26K0034, AA26K0035, AA26K0036, AA26K0037, AA26K0038, AA26K0039, AA26K0040, AA26K0041, AA26K0042
2	A2A50021941-G002	Joint/Lead Vane Segment, Row 1	each	2	AA26K0043, AA26K0044
3	A2A50021942-G003	Instrumented/Transition Vane Segment, Row 1	each	2	AA26K0045, AA26K0046
4	A2A50024312-G001	Standard Turbine Vane Segment, Row 2	each	44	AA26K0047, AA26K0048, AA26K0049, AA26K0050, AA26K0051, AA26K0052, AA26K0053, AA26K0054, AA26K0055, AA26K0056, AA26K0057, AA26K0058, AA26K0059, AA26K0060, AA26K0061, AA26K0062, AA26K0063, AA26K0064, AA26K0065, AA26K0066, AA26K0067, AA26K0068, AA26K0069, AA26K0070, AA26K0071, AA26K0072, AA26K0073, AA26K0074, AA26K0075, AA26K0076, AA26K0077, AA26K0078, AA26K0079, AA26K0080, AA26K0081, AA26K0082, AA26K0083, AA26K0084, AA26K0085, AA26K0086, AA26K0087, AA26K0088, AA26K0089, AA26K0090
5	A2A50024312-G002	Joint Vane Segment, Row 2	each	2	AA26K0091, AA26K0092
6	A2A50024312-G003	Instrumented Turbine Vane Segment, Row 2	each	2	AA26K0093, AA26K0094
7	A2A5116244-G001	Standard Turbine Vane Segment, Row 3	each	45	AA26K0095, AA26K0096, AA26K0097, AA26K0098, AA26K0099, AA26K0100, AA26K0101, AA26K0102, AA26K0103, AA26K0104, AA26K0105, AA26K0106, AA26K0107, AA26K0108, AA26K0109, AA26K0110, AA26K0111, AA26K0112, AA26K0113, AA26K0114, AA26K0115, AA26K0116, AA26K0117, AA26K0118, AA26K0119, AA26K0120, AA26K0121, AA26K0122, AA26K0123, AA26K0124, AA26K0125, AA26K0126, AA26K0127, AA26K0128, AA26K0129,



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No.	UNEW Part Number	Description	Unit	Qty.	Assigned Serial Numbers
					AA26K0130, AA26K0131, AA26K0132, AA26K0133, AA26K0134, AA26K0135, AA26K0136, AA26K0137, AA26K0138, AA26K0139
8	A2A5116244-G002	Joint Vane Segment, Row 3	each	3	AA26K0140, AA26K0141, AA26K0142
9	A2A5116244-G003	Instrumented Turbine Vane Segment, Row 3	each	3	AA26K0143, AA26K0144, AA26K0145
10	A2A5118611-G001	Standard Turbine Vane Segment, Row 4	each	49	AA26K0146, AA26K0147, AA26K0148, AA26K0149, AA26K0150, AA26K0151, AA26K0152, AA26K0153, AA26K0154, AA26K0155, AA26K0156, AA26K0157, AA26K0158, AA26K0159, AA26K0160, AA26K0161, AA26K0162, AA26K0163, AA26K0164, AA26K0165, AA26K0166, AA26K0167, AA26K0168, AA26K0169, AA26K0170, AA26K0171, AA26K0172, AA26K0173, AA26K0174, AA26K0175, AA26K0176, AA26K0177, AA26K0178, AA26K0179, AA26K0180, AA26K0181, AA26K0182, AA26K0183, AA26K0184, AA26K0185, AA26K0186, AA26K0187, AA26K0188, AA26K0189, AA26K0190, AA26K0191, AA26K0192, AA26K0193, AA26K0194
11	A2A5118611-G002	Joint Vane Segment, Row 4	each	3	AA26K0195, AA26K0196, AA26K0197
12	A2A5118611-G003	Instrumented Turbine Vane Segment, Row 4	each	3	AA26K0198, AA26K0199, AA26K0200
13	A2A50012458-G001	Standard Turbine Blade, Row 1	each	85	AA26K0201, AA26K0202, AA26K0203, AA26K0204, AA26K0205, AA26K0206, AA26K0207, AA26K0208, AA26K0209, AA26K0210, AA26K0211, AA26K0212, AA26K0213, AA26K0214, AA26K0215, AA26K0216, AA26K0217, AA26K0218, AA26K0219, AA26K0220, AA26K0221, AA26K0222, AA26K0223, AA26K0224, AA26K0225, AA26K0226, AA26K0227, AA26K0228, AA26K0229, AA26K0230, AA26K0231, AA26K0232, AA26K0233, AA26K0234, AA26K0235, AA26K0236, AA26K0237, AA26K0238, AA26K0239, AA26K0240, AA26K0241, AA26K0242, AA26K0243, AA26K0244, AA26K0245, AA26K0246, AA26K0247, AA26K0248, AA26K0249, AA26K0250, AA26K0251, AA26K0252, AA26K0253, AA26K0254, AA26K0255, AA26K0256, AA26K0257, AA26K0258, AA26K0259, AA26K0260, AA26K0261, AA26K0262, AA26K0263, AA26K0264, AA26K0265, AA26K0266, AA26K0267, AA26K0268, AA26K0269, AA26K0270, AA26K0271, AA26K0272, AA26K0273, AA26K0274, AA26K0275, AA26K0276, AA26K0277, AA26K0278, AA26K0279, AA26K0280, AA26K0281, AA26K0282, AA26K0283, AA26K0284, AA26K0285
14	A2A50012458-G002	Locking Turbine Blade, Row 1	each	2	AA26K0286, AA26K0287
15	A2A50012458-G003	Weighted / Balanced Segment Blade, Row 1	each	2	AA26K0288, AA26K0289
16	A2A50014822-G001	Standard Turbine Blade, Row 2	each	85	AA26K0290, AA26K0291, AA26K0292, AA26K0293, AA26K0294, AA26K0295, AA26K0296, AA26K0297, AA26K0298, AA26K0299, AA26K0300, AA26K0301, AA26K0302, AA26K0303, AA26K0304, AA26K0305, AA26K0306, AA26K0307, AA26K0308, AA26K0309,



Gas turbine field service and component engineering

No.	UNEW Part Number	Description	Unit	Qty.	Assigned Serial Numbers
					AA26K0310, AA26K0311, AA26K0312, AA26K0313, AA26K0314, AA26K0315, AA26K0316, AA26K0317, AA26K0318, AA26K0319, AA26K0320, AA26K0321, AA26K0322, AA26K0323, AA26K0324, AA26K0325, AA26K0326, AA26K0327, AA26K0328, AA26K0329, AA26K0330, AA26K0331, AA26K0332, AA26K0333, AA26K0334, AA26K0335, AA26K0336, AA26K0337, AA26K0338, AA26K0339, AA26K0340, AA26K0341, AA26K0342, AA26K0343, AA26K0344, AA26K0345, AA26K0346, AA26K0347, AA26K0348, AA26K0349, AA26K0350, AA26K0351, AA26K0352, AA26K0353, AA26K0354, AA26K0355, AA26K0356, AA26K0357, AA26K0358, AA26K0359, AA26K0360, AA26K0361, AA26K0362, AA26K0363, AA26K0364, AA26K0365, AA26K0366, AA26K0367, AA26K0368, AA26K0369, AA26K0370, AA26K0371, AA26K0372, AA26K0373, AA26K0374
17	A2A50014822-G002	Locking Turbine Blade, Row 2	each	2	AA26K0375, AA26K0376
18	A2A50014822-G003	Weighted / Balanced Segment Blade, Row 2	each	2	AA26K0377, AA26K0378
19	A2A50113110-G001	Standard Turbine Blade, Row 3	each	59	AA26K0379, AA26K0380, AA26K0381, AA26K0382, AA26K0383, AA26K0384, AA26K0385, AA26K0386, AA26K0387, AA26K0388, AA26K0389, AA26K0390, AA26K0391, AA26K0392, AA26K0393, AA26K0394, AA26K0395, AA26K0396, AA26K0397, AA26K0398, AA26K0399, AA26K0400, AA26K0401, AA26K0402, AA26K0403, AA26K0404, AA26K0405, AA26K0406, AA26K0407, AA26K0408, AA26K0409, AA26K0410, AA26K0411, AA26K0412, AA26K0413, AA26K0414, AA26K0415, AA26K0416, AA26K0417, AA26K0418, AA26K0419, AA26K0420, AA26K0421, AA26K0422, AA26K0423, AA26K0424, AA26K0425, AA26K0426, AA26K0427, AA26K0428, AA26K0429, AA26K0430, AA26K0431, AA26K0432, AA26K0433, AA26K0434, AA26K0435, AA26K0436, AA26K0437
20	A2A50113110-G002	Locking Turbine Blade, Row 3	each	2	AA26K0438, AA26K0439
21	A2A50113110-G003	Weighted / Balanced Segment Blade, Row 3	each	2	AA26K0440, AA26K0441
22	A2A50113110-G004	Standard Turbine Blade, Row 4	each	42	AA26K0442, AA26K0443, AA26K0444, AA26K0445, AA26K0446, AA26K0447, AA26K0448, AA26K0449, AA26K0450, AA26K0451, AA26K0452, AA26K0453, AA26K0454, AA26K0455, AA26K0456, AA26K0457, AA26K0458, AA26K0459, AA26K0460, AA26K0461, AA26K0462, AA26K0463, AA26K0464, AA26K0465, AA26K0466, AA26K0467, AA26K0468, AA26K0469, AA26K0470, AA26K0471, AA26K0472, AA26K0473, AA26K0474, AA26K0475, AA26K0476, AA26K0477, AA26K0478, AA26K0479, AA26K0480, AA26K0481, AA26K0482, AA26K0483
23	A2A50113110-G005	Locking Blades (Master Blades / Closing Blades), Row 4	each	2	AA26K0484, AA26K0485



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No.	UNEW Part Number	Description	Unit	Qty.	Assigned Serial Numbers
24	A2A2001101-G001	Standard Compressor Blade, Row 1	set	1	AA26K0486
25	A2A2001101-G002	Locking Compressor Blade, Row 1	set	1	AA26K0487
26	A2A2001102-G001	Standard Compressor Blade, Row 2	set	1	AA26K0488
27	A2A2001102-G002	Locking Compressor Blade, Row 2	set	1	AA26K0489
28	A2A2001103-G001	Standard Compressor Blade, Row 3	set	1	AA26K0490
29	A2A2001103-G002	Locking Compressor Blade, Row 3	set	1	AA26K0491
30	A2A2001104-G001	Standard Compressor Blade, Row 4	set	1	AA26K0492
31	A2A2001104-G002	Locking Compressor Blade, Row 4	set	1	AA26K0493
32	A2A2001105-G001	Standard Compressor Blade, Row 5	set	1	AA26K0494
33	A2A2001105-G002	Locking Compressor Blade, Row 5	set	1	AA26K0495
34	A2A2001106-G001	Standard Compressor Blade, Row 6	set	1	AA26K0496
35	A2A2001106-G002	Locking Compressor Blade, Row 6	set	1	AA26K0497
36	A2A2001107-G001	Standard Compressor Blade, Row 7	set	1	AA26K0498
37	A2A2001107-G002	Locking Compressor Blade, Row 7	set	1	AA26K0499
38	A2A2001108-G001	Standard Compressor Blade, Row 8	set	1	AA26K0500
39	A2A2001108-G002	Locking Compressor Blade, Row 8	set	1	AA26K0501
40	A2A2001109-G001	Standard Compressor Blade, Row 9	set	1	AA26K0502
41	A2A2001109-G002	Locking Compressor Blade, Row 9	set	1	AA26K0503
42	A2A2001110-G001	Standard Compressor Blade, Row 10	set	1	AA26K0504
43	A2A2001110-G002	Locking Compressor Blade, Row 10	set	1	AA26K0505
44	A2A2001111-G001	Standard Compressor Blade, Row 11	set	1	AA26K0506
45	A2A2001111-G002	Locking Compressor Blade, Row 11	set	1	AA26K0507
46	A2A2001112-G001	Standard Compressor Blade, Row 12	set	1	AA26K0508
47	A2A2001112-G002	Locking Compressor Blade, Row 12	set	1	AA26K0509
48	A2A2001113-G001	Standard Compressor Blade, Row 13	set	1	AA26K0510



Gas turbine field service and component engineering

No.	UNEW Part Number	Description	Unit	Qty.	Assigned Serial Numbers
49	A2A2001113-G002	Locking Compressor Blade, Row 13	set	1	AA26K0511
50	A2A2001114-G001	Standard Compressor Blade, Row 14	set	1	AA26K0512
51	A2A2001114-G002	Locking Compressor Blade, Row 14	set	1	AA26K0513
52	A2A2001115-G001	Standard Compressor Blade, Row 15	set	1	AA26K0514
53	A2A2001115-G002	Locking Compressor Blade, Row 15	set	1	AA26K0515
54	A2A2001116-G001	Standard Compressor Blade, Row 16	set	1	AA26K0516
55	A2A2001116-G002	Locking Compressor Blade, Row 16	set	1	AA26K0517

End of Appendix A. Total serialized parts installed: 517. Serial number block: AA26K0001 to AA26K0517.

Approved by

Ronald Miller, Operations director

Prepared by

Dilip Majumder, Lead Engineer

