48 MW
Gas Turbine Simple Cycle Power Barge

General Technical Document

HIGHLIGHTS

Rigel I is a barge mounted Siemens-Westinghouse W251B11 simple cycle gas turbine with a nominal rated output of ~48 MW at ISO conditions[1]. She was built in 1996 using proven and reliable technologies. The barge has been run in Kenya for less than 30,000 hours between 1997 and 2004 when the previous owners failed to renew the power contract.

Under current ownership an extensive overhaul and maintenance program has been performed by gas turbine and power barge experts in 2011 according to OEM recommendations and industry standards. Quality control documents have been put in place to make certain that all the necessary checks were done to ensure reliable and efficient operation of the plant.

After completion of the ongoing rehabilitation, Rigel I is expected to have 20+ operating years to come. Siemens Westinghouse W251 frame is of very robust design able to withstand long operations even in difficult locations. Turbine overhauling has been completed. Balance of plant equipment has been checked and a new control system installed. Only commissioning and a few minor works remain outstanding which will be done within ~ one month from re- start once final user's project and site specifics have been determined.

[1] 48 MW is the assumed nominal output rating of a similar unit in brand new, clean and first rate condition running on natural gas fuel at ISO conditions

POWER BARGE OVERVIEW

The power barge is a self contained, electric power generating system ready to provide a quick solution to energy needs.

The Siemens Westinghouse W251B11 gas turbine is a heavy-duty turbine consisting of 19 stage axial flow compressor, a combustor section with 8 combustor assemblies, and a 3 stage reaction type turbine. The single shaft engine is mounted on a bedplate. A lubrication pump, as well as associated pumps, and filters are located adjacent to the engine. The machine rotor is supported by two pressure lubricated pivoted pad journal bearings. A double acting tilting pad thrust bearing maintains axial shaft alignment. The nominal engine speed is 5418 rpm, with the generator driven from the cold (compressor end) through a double helical reduction gear to obtain the 3000-rpm required for 50Hz operation. The turbine is designed with features such as horizontally split sectionalized casing, two bearing support, turbine air cooling system, compensating alignment system, and axial–flow exhaust.

OPERATING HISTORY AND CURRENT STATUS

The power barge went into commercial operation in 1997 and was operated for approximately 30,000 hours in Mombasa running on Fuel Oil (Kerosene). In 2004 the power barge stopped operating as the power contract expired and was not renewed.

Phased overhaul program:

- In 2008 various BOP works and a combustion turbine component inspection was performed by TurboCare (Siemens). Major parts were sent to TurboCare for refurbishment.
- Works were halted while the barge owners initiated a strategic review for their global power barge fleet. A maintenance / preservation program was implemented by a skeleton crew managed by an owners representative with extensive power barge experience.
- In December 2010 the turbine blades were removed and a rotor evaluation was performed by Frank Hick, (FH Project Management & Consulting LLC, ex Siemens)
- In 2011 the barge was dry docked as part of its classification requirement and a complete hot gas path and modified major gas turbine inspection was done on the unit. All the major hot section parts have been replaced including turbine blades, stationary vane segments, transition pieces and combustor baskets. Torque tube and compressor section has been inspected and new compressor

diaphragms were installed on rows 8 to 11. Turbine journal and thrust bearings were also checked and cleaned. All pertinent clearances and readings were taken and checked according to OEM recommendations.

- Turbine controls have been replaced with a modern and versatile PLC based system by a reputable US company.
- Third party technical assistance and QAQC services were provided by FH Project Management & Consulting LLC throughout the overhaul
- Final phase of the project in Kenya will be commissioning and testing up to 2 hours full speed no load. This will be done when the final site has been decided and final project specifications and geography have been determined. Activities will include testing and commissioning of new turbine controls, point to point and loop checks, fuel flushing, as well as I&C and balance of plant checks

TECHNICAL SPECIFICATIONS

Barge information:

Barge name: Classification:
Class number:
Type of construction: General dimensions:

Dynami III Power Barge
American Bureau of Shipping
9734123
Naval steel, flat fund, without propulsion

Length: 64.36 meters Breadth : 18.28 meters Depth : 4,26 meters
Gross Tonnage: 2,876 tons Net Tonnage: 863 tons

Westinghouse 1 X W251B11/12 ECONOPAC

Configuration:
Rated capacity:
Type of fuel (start): Type of fuel (operation): Compressor:

Turbine:
Speed:
Speed Reduction: Water injection: Generator:

GSU rating:
Operating hours: Successful Starts: Hours since last major:

Gas Turbine, simple cycle.
1X~48 MW ISO [2]
No. 1 distillate
Condensate/ Kerosene (HFO / Gas is possible) 19-stages axial flow

3 stages
5,418 rpm
3,000 rpm
included
Brush synchronous 3-phase, air cooled generator 65882 KVA, 11.5 kV, 50 Hz

Output: 11.5 kV - 50 Hz
33 KV
29,937 (operating hours of new turbine rotor: 18,974) 845
0 (zero)

All power generation equipment and other equipment are mounted on the hull. The barge is intended to be moored at an appropriate site and remain in a "floating" condition in a protected location. The hull was designed in accordance with the applicable portions of the current American Bureau of Shipping (ABS) rules for building and classing "Steel Vessel", "Steel Vessels for Service on Rivers and Inter coastal Waterway" and "Steel Barges". The barge was designed to be "dry-towed", expect for coastal voyages of limited duration and exposure where it can be “wet-towed”.

All materials were in accordance with ABS requirements for "ordinary strength steel", Grade A or B, as applicable to thickness and location. All welding procedures and materials were in accordance with ABS requirements. The protection against corrosion and internal coatings were applied to maintain the life span of the barge.

[2] 48 MW is the assumed nominal output rating of a similar unit in brand new, clean and first rate condition running on natural gas fuel at ISO conditions

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SIEMENS WESTINGHOUSE ECONOPAC

The ECONOPAC provided by Siemens Westinghouse were designed and engineered to provide a complete generating system. All components and subsystems were carefully selected and optimized to form a compact plant, house within enclosures, designed to comply with environmental requirements.

The ECONOPAC features modular construction to facilitate shipment and assembly. The system was pre-assembled to the maximum extent permitted by shipping limitations. Were possible, subsystems were grouped and installed in auxiliary

packages to minimize field assembly. These packages were completely assembled and wired at the factory and require only interconnection at the site. Pipe rack assemblies were supplied eliminating the need for extensive piping fabrication during construction.

Recognized as the heart of the ECONOPAC plant, the prime mover consists of three basic elements: the axial flow compressor, a combustion system and power turbine. These three elements are combined into single assemblies that were shipped complete with rotor in place, facilitating erection in the field. Incorporated into the design are such features as a horizontally split casing, tow-bearing support, turbine air cooling system, compensating alignment system, sectionalized casing and axial flow exhaust.

The generator and the brushless exciter are equipped with integral lube oil piping and necessary instrumentation. A solid coupling connects the generator directly to the compressor (the cold end of the combustion turbine).

The electric motor starting package is a self-contained assembly, pre-mounted on a bedplate and shipped as a complete module. The package contains all the equipment necessary to provide breakaway torque for initial rotation of the turbine generator, torque necessary for acceleration to self-sustaining speed and a disconnect means to allow disengagement of the starting device once the unit reaches self-sustaining speed. During the cool-down periods, the turning gear automatically engages to provide for a slow roll of the combined turbine and generator.

A side inlet air duct directs flow into the compressor inlet manifold. The manifold was designed to provide an efficient flow pattern of the air into the axial flow compressor. A parallel baffle-silencing configuration is located in the inlet system for sound attenuation. A two-stage pad filter provides air filtration.

After expanding through the combustion turbine, the gases pass though the exhaust manifold and exhaust transition. The exhaust gases enter the atmosphere through the exhaust stack.

A new and modern Allen Bradley PLC based control system from HPI LLC was installed to replace the old Westinghouse WDPF control. New Vibration control protection, Generator protection relays, Synchronizer, and AVR is included in the new control system. The turbine control & AVR panel have been installed in the electrical package and wiring is around 80% complete. Loop checking, point to point checks, and commissioning of the control system will be done (before the full speed no load test) by HPI Controls Engineer. HPI LLC., an established

company based in Houston, Texas, specializing on turbo-machinery application. Sufficient capacity has been installed to cater for future expansion and project specific changes.

All control, protection and monitoring functions for the combustion turbine and ECONOPAC systems will be performed by the new control system. It will process and

perform all of the control and logic functions. The input/output module will provide the interface to the field instrumentation and control devices. A touch screen, panel mounted, HMI and a desktop HMI, will serve as the man-machine interface device for the system. This will be both the systems programming device as well as the operator interface. All control and monitoring functions can be performed from the HMI. A set of standard graphic displays will be provided for all operational and monitoring functions. The control system will also perform the logging function. Standard sets of logs are provided for documenting combustion turbine operational performance.

The local panel also houses other control related equipment such as the vibration monitoring system, electromechanical counters and timers, trip push- button, flame scanner electronics and other ancillary equipment.

PERFORMANCE DATA AND PERFORMANCE CURVES

TABLE 1
251B11/12 Performance for ISO Conditions

Site Conditions

Sea level

Room temperature (oF): 59 Relative humidity (%): 60 Power Generator Factor 0.85 Injection Flow No Loss of Entrance Pressure (pulg. water): 4 Loss of Output Pressure (pulg. water): 4

No. 1 Natural Gas		
net power output	Kw	48000 [3]
Heat rate	BTU/Kwh (LHV)	10600
Efficiency	%	32.2116
Exhaust flow	LB/HR	1373800
Exhaust temperature	oF	974
Fuel Flow	LB/Hr	24280
Exhaust heat	BTU/LB LHV	20960
No2. Diesel		
net power output	Kw	46400 [4]
Heat rate	BTU/Kwh (LHV)	10750
Efficiency	%	31.7621
Exhaust flow	LB/HR	1376500
Exhaust temperature	oF	975
Fuel Flow	LB/Hr	26880
Exhaust heat	BTU/LB LHV	18560

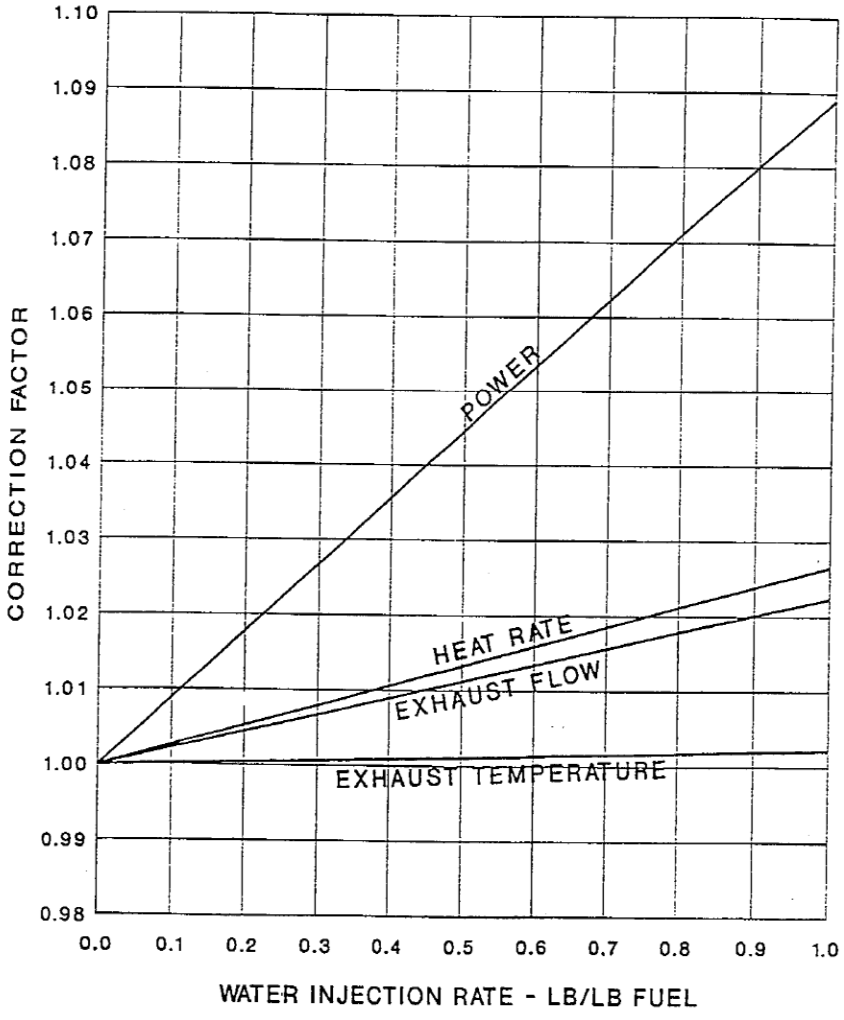
[3] 48 MW is the assumed nominal output rating of a similar unit in brand new, clean and first rate condition running on natural gas fuel at ISO conditions

[4] Assumed nominal output rating of a similar unit in brand new, clean and first rate condition at ISO conditions

251B11/12 ECONOPAC PERFORMANCE

CORRECTION CURVE FOR POWER, HEAT RATE, EXHAUST TEMP & FLOW vs WATER INJECTION NATURAL GAS

FIGURE 6a



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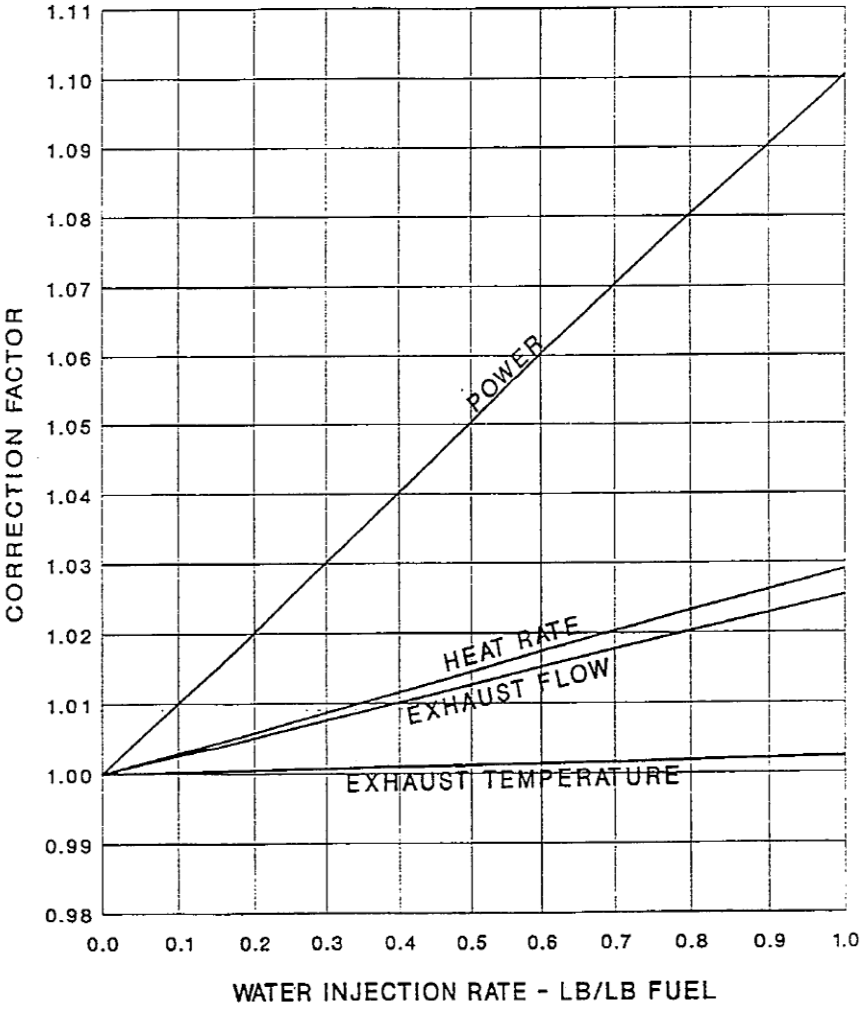
251B11/12 ECONOPAC PERFORMANCE

CORRECTION CURVE FOR POWER, HEAT RATE, EXHAUST TEMP & FLOW vs WATER INJECTION No. 2 FUEL OIL

FIGURE 7a



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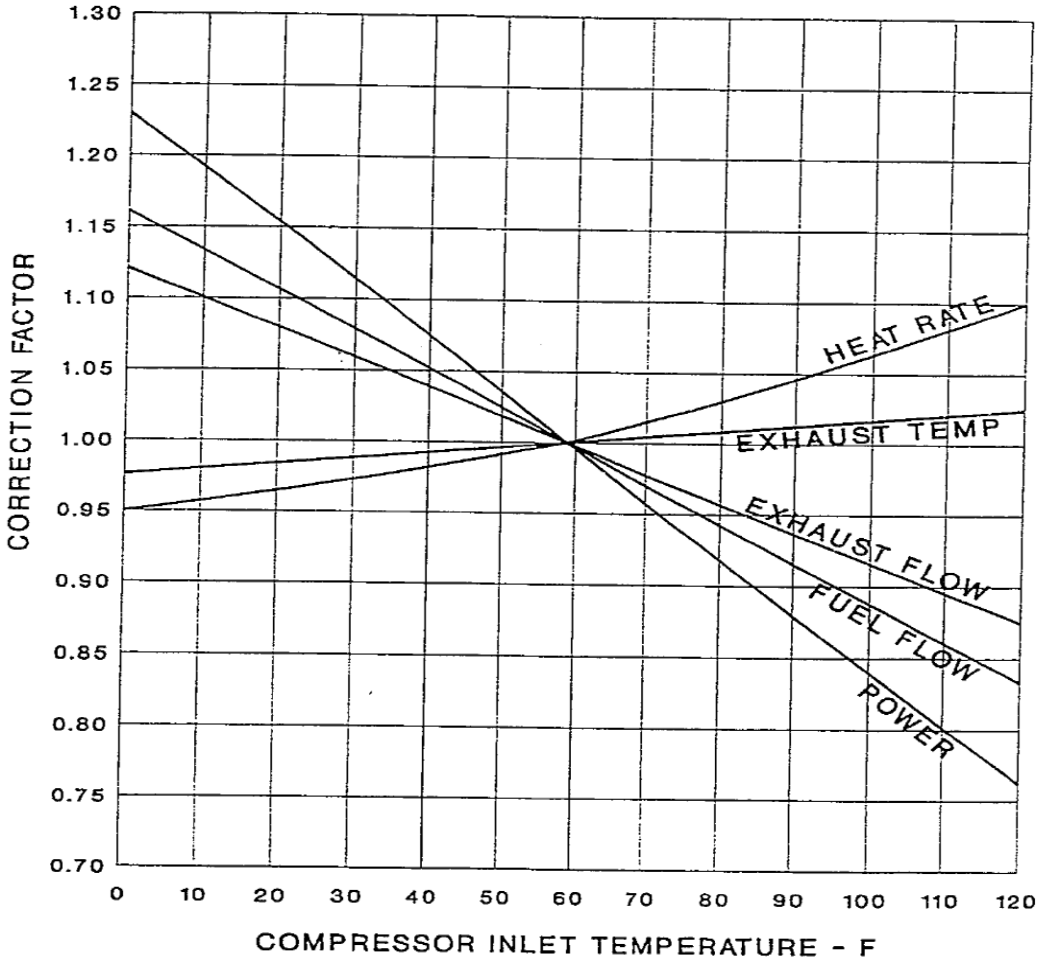
251B11/12 ECONOPAC PERFORMANCE

CORRECTION CURVE FOR POWER, HEAT RATE, FUEL FLOW, EXHAUST TEMP & FLOW vs COMPRESSOR INLET TEMPERATURE

FIGURE 2a



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