
HRSO Technical Proposal Attachment 1
HRSO Performance

Ctrl. Termoeletrica Cogeneracion Arroyo Seco

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Design: G

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0	8/7/2017	SR	All	Initial Release
1	11/15/2017	RDT	All	Updated per meeting with Customer
2	11/22/2017	RDT	All	Final Update for Contract
3	12/18/2017	SR	All	Updated to Guarantees to Design G

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1. Thermal Guarantees

1.1. Performance Basis

The HRSG Capacity Guarantees are given in Section 1.2 HRSG Capacity Guarantees, and are based on the exhaust gas conditions, terminal point conditions and fuel analysis as stated in this section. The criteria for validating the HRSG Capacity Guarantees provided by Vogt Power International are given in Section 1.3 Thermal Performance Verification.

Performance Basis			
Job Site		LDC	LDC
Purchaser Reference Number	GT Case	Warm Case	Warm Case
	Operating Case	Maximum Unfired	Fired
Vogt Power International Reference Number		G015b.17C.55C.100%.2U	G016b.17C.55C.100%.2F
Fuel fired in Gas Turbine		Natural Gas	Natural Gas
Fuel fired in Duct Burner		NA	Natural Gas
Ambient Temperature	°C	17.2	17.2
Barometric Pressure	hPa	1012.6	1012.6
Turbine Exhaust Gas Mass Flow	kg/s	133.270	133.270
Turbine Exhaust Gas Temperature	°C	568.9	568.9
Turbine Exhaust Gas Analysis			
N ₂	mol %	74.3322	74.3322
CO ₂	mol %	3.7333	3.7333
H ₂ O	mol %	8.3182	8.3182
Ar	mol %	0.8713	0.8713
O ₂	mol %	12.7450	12.7450
Burner Firing Rate (LHV)	MW	NA	22.43
HP Steam Pressure	bar(a)	69.0	69.0
Min DA Pressure	bar(a)	1.21	1.21
HP Economizer Inlet Temperature	°C	137.0	109.9

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Performance Basis			
Job Site		LDC	LDC
Purchaser Reference Number	GT Case	Warm Case	Warm Case
	Operating Case	Maximum Unfired	Fired
Vogt Power International Reference Number		G015b.17C.55C. 100%.2U	G016b.17C.55C. 100%.2F
Heat Exchanger Cold Side Outlet Temperature	°C	NA	NA
Condensate Temperature	°C	54.6	54.6
Blowdown HP / LP	%	0 / 0	0 / 0

Fuel Analysis		
Natural Gas		
Nitrogen, N ₂	Vol %	2.0
Carbon Dioxide, CO ₂	Vol %	1.0
Methane, CH ₄	Vol %	91.0
Ethane, C ₂ H ₆	Vol %	4.0
Propane, C ₃ H ₈	Vol %	1.0
Butane, C ₄ H ₁₀	Vol %	0.5
Pentane, C ₅ H ₁₂	Vol %	0.5
Sulfur, S	gr / 100 SCF	< 0.2
Heating Value (HHV)	kJ/kg	
Heating Value (LHV)	kJ/kg	46808.7

The thermal and mechanical design will be based on the combustion turbine exhaust and the typical gas turbine exhaust flow, temperature, constituents and velocity distribution profile for the Siemens SGT-800 machine at conditions provided by the Purchaser. This information is required at the time of Notice-To-Proceed (NTP) in order for Vogt Power International to incorporate this into the HRSG design. If the velocity distribution profile is not provided and/or not available at NTP, then a typical profile based on VPI's previous experience will be used. Vogt Power International will not be responsible for the impact on the thermal and mechanical performance of the HRSG on this project if the actual operating velocity distribution profile in the field exceeds the typical used for this design by more than 10% at any spatial point.

1.2. HRSG Capacity Guarantees

Performance Guarantees			
Job Site		LDC	LDC
Purchaser Reference Number	GT Case	Warm Case	Warm Case
	Operating Case	Maximum Unfired	Fired
Vogt Power International Reference Number		G015b.17C.55C.100%.2U	G016b.17C.55C.100%.2F
Average HP Steam Temperature	°C	485.0	485.0
HP Steam Flow	t/h	70.400	100.000
Gas-side Static $\Delta P^{(1)}$	mm W.C.	221	225

1.3. Thermal Performance Verification

1.3.1. General

The guaranteed performance is expressly stated in Section 1.2 HRSG Capacity Guarantees of this proposal. All other performance of the equipment covered in this proposal is predicted performance intended to show probable operating results. Any predicted performance (performance curves, performance data, or performance predicting software) shall be considered as an indication of performance. Under no circumstances shall any predicted performance be construed as a contractual obligation or performance guarantee.

1.3.2. Testing Requirement

The HRSG performance will be measured per the Performance Test Procedure based on the *ASME Power Test Code PTC 4.4 – 2008 for Heat Recovery Steam Generators*. Measurement uncertainties shall be determined based on the instruments used for collecting the data during the test and will be used as tolerances in any performance evaluation of the HRSG.

The performance test procedure will be written by Vogt Power International and submitted to the Purchaser. This test procedure must be mutually agreed upon at least 90 days prior to running the test.

Performance tests, if required, shall be run within 150 days after first flow of the gas turbine exhaust flow through the HRSG. If a performance test is not completed within the stated period, the equipment shall be deemed accepted.

Due diligence shall be exercised to allow the tests to be conducted at the earliest possible date.

Vogt Power International's representative shall have free access to all test records at all times. The tests shall be conducted in accordance with the agreed upon test procedure. Vogt Power International's representative may request that tests be repeated if he/she observes that the testing is not being conducted in accordance with the agreed upon test procedures, or if the test is not within the specified acceptable Test Conditions. Vogt Power International representatives and/or the representatives from their contractors shall have free access to all Data Acquisition Systems, Testing Instruments, Displays, Recorders, etc. during, before and after the performance test.

1.3.3. Pre-Test information

Vogt Power International will require access to the equipment prior to any testing. The purpose of this is to get familiar with the installed equipment, instruments, and Data Acquisition System (DAS) furnished by others. HRSG operational data may be collected at this for the purpose of:

1. Checking all instruments, methods of measurement, data acquisition system and controls.
2. Confirm proper cycle line-up and isolation.
3. To make adjustment to the equipment
4. Determining whether the HRSG and associated equipment are in suitable condition to conduct the performance test

2. Steam Purity Guarantees

2.1. Average Moisture Content

The average moisture content of the saturated steam leaving each steam drum shall not exceed 0.1 percent from the HP Drum.

2.2. Test Procedure for Moisture Carryover in Saturated Steam

The moisture carryover test shall be conducted and evaluated independent of steam capacity test. The performance guarantee verification methodology is very complex and cannot be directly correlated with the moisture carryover guarantees. Therefore there is a need for separate test and evaluation. In general, the testing shall be conducted according to the guidelines developed by IAPWS in their *Technical Guidance Document: Procedures for the Measurement of Carryover of Boiler Water into Steam*. If the purchaser determines that the moisture carryover in the saturated steam exceeds the guarantee value, after corrections for water conditions, a report prepared by purchaser or his agent, along with the raw data, will be given to Vogt Power International for analysis. Vogt Power International reserves the right to request a re-test if it feels that test guidelines were not followed.

All sampling and testing is to be conducted by Purchaser according to methods prescribed by the American Society for Testing Materials. The moisture carryover in the saturated steam will be determined by comparing the solids in the saturated steam versus the solids in the steam drum water.

It is the responsibility of Vogt Power International to provide sampling nozzles and connections for proper sample taking according to ASTM standards. All methods, rules and practices given in Section 11 of *Annual Book of ASTM Standards*, as applicable, should be used in determining the solids in steam. Some of the specific applicable standards are *D-1192 Equipment and Sampling Techniques*; *D-3370 Sampling of Water*; *D-3864 Continuous Sampling of Water*; *D-1066 Sampling of Steam*; *D-2777 Determination of Precision and Bias*. The solids in the steam will be determined by sodium tracer method using sodium ion electrode, ASTM D-2186, Method C. Vaporous carryover of silica or other gases are not included in the solids.

3. HRSG Noise Levels

3.1. Steam Silencer Noise Levels Guarantees

Silencer	dB(A)	Location
HP System Safety Valves	85	@ 3 ft (1m) from silencer exhaust
LP/DA System Safety Valves	85	@ 3 ft (1m) from silencer exhaust
HP Start-up	85	@ 3 ft (1m) from silencer exhaust
LP/DA Start-up	85	@ 3 ft (1m) from silencer exhaust

3.2. GT Sound Power Level Requirement

Center Frequency (Hz)	31.5	63	125	250	500	1K	2K	4K	8K
Sound Power Level	81	92	112	119	125	132	132	132	131

Performance based upon a typical single Siemens SGT-800 unit in operation under steady state operating conditions. Sound pressure levels to be measured per ANSI B133.8, and all reflective noise shall be removed. Corrections for uncertainty and measurement tolerance shall be applied according to standard industry practice.

3.3. HRSG Noise Level Guarantees

Near Field: 85 dBA @ 1 m horizontal and 1.5 m above grade.
These guarantees are based on an individual HRSG operating under normal conditions with no emergency blowoff.

Notes:

1. Sound pressure levels are in dB re 2×10^{-5} Pa.
2. Sound power levels are in dB re 10^{-12} W.

3.4. Responsibilities

The following is designed to outline the method of measuring noise radiating from the Vogt Power International HRSG and associated equipment.

The noise level testing for the HRSG shall be completed with the Gas Turbine and HRSG operating at a steady state condition with all safety valves, vent valves, and sky valves closed and all reflective noises from equipment not supplied by Vogt Power International removed.

3.5. Test Equipment

The sound level meter used shall be in accordance with ANSI S1.4 Specification for Sound Level Meters, Type 1 Precision Sound Level Meter.

The windscreen used shall meet ANSI Specifications and shall have background data on its effect on the sound level meter response at the different octave band center frequencies.

A calibrator with a known sound pressure level at 1000 Hz shall be used. The calibrator must be calibrated to a primary standard as recommended by the manufacturer.

3.6. Method

The sound level meter shall be used in accordance with the recommendations of the manufacturer. The meter shall be mounted on a tripod with the measurer standing at least 1 m behind the microphone. The angle incidence of the sound on the microphone shall be in accordance with the ANSI recommendations.

All readings shall be taken with the sound level meter on the slow time response setting. All sound levels shall be recorded by strip chart and reported to the nearest decibel.

In case there is a variance of greater than 5 decibels in the sound level between a maximum and minimum, then the LEQ shall be taken as the sound level, otherwise the mean shall be taken as the sound level.

The date and time of the measurements shall be recorded.

The manufacturer name and model number of all equipment used shall be recorded.

The meteorological conditions such as temperature, barometric pressure, relative humidity, wind speed and direction, and cloud cover shall be recorded.

A drawing and photographs indicating all measurement locations around the equipment shall be completed.

At each measurement location the overall A-weighted sound level and the unweighted level in the octave band center frequencies between 31.5 Hz and 8000 Hz shall be recorded. For each data point, monitoring shall be performed for one minute or until a steady state sound reading is achieved.

Before and after all measurements the sound meter shall be calibrated. If the calibration indicates an error of more than 1 dB, then all measurements taken under this condition shall be repeated.

Before and after all measurements the plant operating personnel shall be consulted to confirm normal operating conditions. Any conditions encountered that might affect the noise levels measured would require the measurements to be repeated.

All measurements shall be taken at 10 ft (3m) intervals around the perimeter of the major surfaces of Vogt Power International's scope of supply and on all accessible platforms and walkways, with the exception of the CEMS port platform. At each location the noise

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level will be recorded at a 3 ft (1m) horizontal distance from the equipment and at a 5 ft (1.5m) elevation.

If at any location it is subjectively determined by the measurer, the Purchaser and Vogt Power International that a noise source not in Vogt Power International's scope of supply is affecting the readings, then unless this equipment can be operated alone, the affected measurement locations should be ignored. If the equipment can be run alone, then measurements shall be taken at the required locations with this equipment running alone to determine its effect on the noise generated by Vogt Power International's scope of supply.

All measurements shall be repeated after taking into account the effect of the windscreen and noise sources outside of Vogt Power International's scope of supply and the average of the two readings will be used for the purpose of evaluation.