APPENDIX C
SPECIFICATION

The following comprehensive details pertain to the Buyer's original specifications request and that the GE be sure of specifying the Gas turbines' operation at the owner's site conditions.

So reference is made to the gas turbine's operation at site conditions other than ISO.

ISO performance is specified the OEM's standard documentation.
Site performance at 447m ASL with natural gas specifications available at site, is detailed in section 3.3 .

Table of Contents

1. GENERAL

This Material Requisition (herein after called "MR") covers the minimum requirements for design, manufacturing, shop testing, insulation, painting, packing, supply and site testing of material and equipment described here below. Contents of this Material Requisition shall not relieve the Vendor from his responsibilities and obligations to provide a safe and workable system in all operating conditions specified in this MR, within the equipment's scope of supply.

The equipment shall be designed in accordance with the requirements of this MR and the attached documentation that shall be considered as integral part of this MR. The equipment shall include all the necessary accessories/auxiliaries to facilitate and ensure safe and satisfactory operation of the equipment, within the equipment's scope of supply.

All documents related to supply must be written in the English language, with the exception of the sections of the equipment's Operational and Maintenance Manual related to the "day-to-day maintenance tasks" that will be written in the Italian language.

This specification states the requirements for the design, manufacture, and factory testing of a baseplate mounted aero-derivative gas turbine generator package (herein after called "GTG") including all accessories described herein.

All operating modes specified in the MR shall be considered. The GTG may be operated either in simple cycle or in combined cycle as a baseloaded unit. When operated in combined cycle, the GTG will be coupled to a heat recovery steam generator equipped with fresh-air system. The GTG shall be capable of operating in an isochronous mode to satisfy the electric loads of the chemical factory (never below 2.3MW per GTG installed) or synchronised to the national grid for power export. GTG operation at 2.3 MW load will be limited to short periods of time. The GTG must also be capable of operating in parallel with an approx. 20 MW steam turbine generator that is also part of the combined cycle plant provided by…… The GTG governor reaction time shall be compatible with these types of operations.

1.1 Vendor Qualification

Equipment's Vendor shall be G.E. Energy.

1.2 Equipment and Services by Vendor

1.2.1 Gas Turbine (DLE).
1.2.2 Couplings and coupling guards.
1.2.3 Speed Reduction Load Gear.
1.2.4 Air Cooled Generator, brushless exciter and voltage regulator.
1.2.5 Acoustic Enclosure and Ventilation System.
1.2.6 Structural steel baseplates for gas turbine, generator and load gear and unit mounted accessories (Baseplates must be drilled and doweled for simplified field re-alignment).

1.2.7 Multi-Stage Inlet Air Filter System with dual purpose coils (Anti-Ice protection and Air Inlet Cooling) and louvers for noise attenuation
1.2.8 Ladders, and Platforms for Filter House Access
1.2.9 Inlet Duct with Silencer for Noise Attenuation
1.2.10 Axial Exhaust Diffuser internal to the package
1.2.11 Gaseous Fuel System with off-skid mounted duplex coalescing gas fuel filter system complete with fuel gas block and vent valves
1.2.12 Lube Oil System for gas turbine
1.2.13 Lube Oil System for generator and load gear
1.2.14 Electrohydraulic Start System
1.2.15 Fire and Gas Detection System
1.2.16 Fire Extinguishing System
1.2.17 Vibration Monitoring System
1.2.18 GTG Control Panel Designed for Indoor Installation, with desk top HMI
1.2.19 Generator Protection System
1.2.20 Auxiliary Skid Gauge Panel (Local)
1.2.21 Motor Control Centre
1.2.22 On-line and Crank Soak Water-wash System for Gas Turbine axial compressor.
1.2.23 Factory Static Testing of Gas Turbine Package
1.2.24 Technical Assistance to Site Performance Verification Test of Gas Turbine Package.
1.2.25 EXW delivery
1.2.26 Marine Packing and marking for shipment
1.2.27 One engineer to visit the site to check the position of the anchor bolts for the equipment immediately after civil works construction is completed by Purchasers and, if the anchor bolts for the equipment are positioned correctly, to certify the correct positioning of the anchor bolts prior the placement on the foundation of the equipment
1.2.28 Installation and commissioning supervision.
1.2.29 Complete Set of Customer Drawings.
1.2.30 Operating and Maintenance Manuals
1.2.31 Training Course for up to 15 Operator Personnel for Familiarization at project site located in Europe.
1.2.32 First Fill of Lubricants
1.2.33 Commissioning Spare Parts
1.2.34 Foundations anchor bolts and embedments
1.2.35 Manual bridge-crane installed within the gas turbine compartment of the package and engine lifting fixture for Installation and Removal of Gas Turbine Engine
1.2.36 Recommended Spare Parts for Operation

1.3 Equipment and Services by Purchaser

The following equipment, materials, and services will be provided by the Purchaser

1.3.1 All interconnection piping and wiring between the GTG control panel, main unit termination boxes and auxiliary system modules
1.3.2 Indoor and outdoor storage (as required) at project site
1.3.3 All fuel gas boostering and treatment systems including piping to flange connections at Vendor's baseplate
1.3.4 Lubricants and fluids required for unit operation
1.3.5 All Conduit for Interconnection wiring
1.3.6 Bolts, nuts, washers, and gaskets required at terminal points
1.3.7 Exhaust heat recovery boiler, by-pass stack, ducting, ducting supports, and necessary transition duct and expansion joints external to the gas turbine package
1.3.8 Civil engineering design of any kind, building and civil works
1.3.9 Site facilities
1.3.10 Support steelworks and hangers for the off-skid pipe work
1.3.11 Drains and/or vent piping from the as turbine package to a remote point
1.3.12 Site grounding and lightning protection
1.3.13 Power systems study
1.3.14 Distributed plant control
1.3.15 Plant utilities, including compressed air supply and off-skid piping
1.3.16 Battery containment
1.3.17 Lube oil measurement other than that those defined in the Vendor's proposal scope of supply
1.3.18 Load sharing control
1.3.19 Ladders, Stairs, and Platforms other than that those defined in the Vendor's proposal scope of supply
1.3.20 Purchaser will protect all fuel and water systems from freezing during both installation and unit operation
1.3.21 Water treatment and forwarding systems

2. REFERENCED DOCUMENTS

Purchaser considers the applicable sections of the following U.S., ISO, and International Codes and Standards to be the most relevant Standards for gas turbine equipment. Manufacturer standard designs and procedures generally compliant with the following Codes and Standard are also accepted.

73/23/EEC	European Low Voltage Directive
94/9/EC	European Directive for Equipment and Protective Systems Intended for Use in Explosive Atmospheres (ATEX Directive)
98/37/EC	European Machinery Directive
89/336/EEC	European Electro-Magnetic Compatibility (EMC) Directive
AGMA 421	Standard Practice for High Speed Helical and Herringbone Gear Units (Used for the accessory gear except for service factor.)
ANSI/AFBMA	
Std 9	Loading Ratings and Fatigue Life for Ball Bearings.
Std 11	Load Ratings and Fatigue Life for Roller Bearings.
ANSI A58.1	Minimum Design Loads for Buildings and Other Structures (Used for Snow Loads)
ANSI B1.1	Unified Inch Screw Threads (Vendor to comply at the customer's connection only).
ANSI B1.20.1	Pipe Threads
ANSI B16.5	Steel Pipe Flanges and Flanged Fittings
ANSI B16.9	Factory - Made Wrought Steel Butt Welding Fittings
ANSI B16.21	Non-metallic Flat Gaskets for Pipe Flanges. (Spiral-wound gaskets per API 601 may be used, particularly in turbine compartment piping.)
ANSI B31.1	Pressure Piping and gas turbine piping systems comply.
ANSI B133.2	Basic Gas Turbine. Vendor to comply, with the exception of paragraph: 8.5 Loose items such as jackscrews and eyebolts are not furnished. Provisions for use of such items are not included in the design.
ANSI B133.3	Gas Turbine Auxiliary Equipment. Vendor to comply fully with design portions only. Vendor may use its own lube oil flushing procedure. Atomizing air receiver is not applicable.
ANSI B133.4	Gas Turbine Controls and Protection Systems
ANSI B133.5	Gas Turbine Electrical Equipment
ANSI B133.8	Gas Turbine Installation Sound Emissions
ANSI C37.90	Relays Associated with Electric Power Apparatus
ANSI C37.90.1	Guide for Surge Withstand Capability (SWS) Tests
ANSI C50.10	General Requirements for Synchronous Machines
ANSI C50.13	Requirements for Cylindrical Rotor Synchronous Generators

ANSI C50.14	Requirements for Combustion Gas Turbine Driven Cylindrical Rotor Synchronous Generators
ANSI C57.94	American Standard, Guide for Installation and Maintenance of Dry Type Transformers
ANSI C83.16	Relays
ANSI S1.2	Method for the Physical Measurement of Sound
ANSI S1.4	Specification for Sound Level Meters
ANSI S1.13	Method for the Measurement of Sound Pressure Levels
ANSI/ASHRAE 52.1-1992	Gravimetric and Dust Spot Procedures for Testing Air- cleaning Devices Used in General Ventilation for Removing Particulate Matter
ANSI/IEEE C37.2	Electrical Power System Device Function Numbers (Vendor to comply with respect to device designations except that in a few cases device numbers had to be modified or added to fit Vendor's needs.)
ANSI/IEEE 100	IEEE Standard Dictionary of Electrical and Electronics Terms
ANSI/NEMA MG1	Motors and Generators
ANSI/NEMA MG2	Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motor and Generators
ANSI/NFPA 12	Carbon Dioxide Extinguishing Systems
ANSI/NFPA 70	National Electrical Code (Electrical components are designed to meet the intent of this Code for Class 1, Group D, Div. 2, Hazardous area classification where appropriate.).
API 614	Lubrication, Shaft-Sealing, and Control - Oil Systems for Special - Purpose Applications
API 616	Gas Turbine for Refinery Services
API 650	Storage Tanks
API 670	Vibration Monitoring Systems
API 678	Accelerometer - Based Vibration Monitoring System
API RP11PGTG	Packaged Combustion Gas Turbines
ASME PTC22	Gas Turbine Power Plants - Performance Test Codes
ASME Section VIII	ASME Boiler and Pressure Vessel Code
ASME Section IX	ASME Boiler and Pressure Vessel Code
AWS D1.1	American Welding Specification
EIA RS-232	Interface between Data Terminal Equipment and Data Communication Equipment Employing Serial Binary Interchange
IEC 34.1	Rotating Electrical Machines - Rating and Performance
IEC 34.3	Rotating Electrical Machines - Turbine Type Synchronous Machines
IEEE Std. 421	IEEE Standard Criteria and Definitions for Excitation Systems for Synchronous Machines
JIC	Hydraulic Standards for Industrial Equipment
UBC	Uniform Building Code (Used for wind loads and seismic design)

3. TECHNICAL REQUIREMENTS

3.1 Operation

The GE standard design Gas Turbine Generator Package will be located outdoor as shown in the section 7 of this MR. Vendor and Purchase shall co-operate to provide an installation that is safe and functional as specified in this MR.

The GTG shall be capable of satisfactory operation from 75% load to 100% load at the Site Design Conditions specified in section 3.3 of this MR. Subject to timely readiness of the balance of plant equipment, the GTG shall be capable of starting, synchronizing and loading to 100% power without SPRINT® within 10 minutes from a ready to start condition, from cold condition.

With the exception of the ambient emissions control system, the GTG shall be capable of satisfactory operation at any load between 2.3MW load to 100% load at the Site Design Conditions specified in section 3.3 of this MR. It is understood that ambient emissions values, when GTG load is lower than 75% and SPRINT® is off, are higher than those guaranteed. The GTG shall be capable of controlling the NOx and CO emissions when GTG load is from 75% to 100% with or without SPRINT® in operation. It is also understood that GTG operation at 2.3 MW load will be limited to short periods of time.

3.2 Performance Data and Guarantees

The Vendor shall guarantee the net GTG power output, the heat rate of the GTG referred to the net GTG power output, the exhaust gas energy, the exhaust gas temperature, and ambient emissions (NOx and CO) listed in Paragraph 4.26.4 of this MR.

The Vendor shall provide all the required gas turbine performances correction curves as a part of the project specific site performance verification test procedure. The gas turbine performances correction curves shall be submitted by:

3.3 Site Design Conditions

The GTG and all related equipment furnished by the Vendor shall be designed for proper operation under the following climatic conditions:

3.3.1 Site Climatic Conditions

- Ambient temperature range: -15 to +40°C
- Site rated ambient temperature: +15°C
- Relative humidity range: 50% to 90%
- Site rated relative humidity: 60%
- Site altitude a.s.l.: 447.5 m
- Ambient atmospheric pressure 96.065 kPa
- Maximum wind velocity: 5 m/sec at 10 m elevation
- Maximum snow load: 278 kg/m^2
- Ambient air dust conditions: industrial area, normal dust concentration

3.3.2 Seismic Conditions

The gas turbine skids and structures shall be suitable for installation in earthquake areas (in accordance with UBC 1979, U.S. Seismic Zone 4).

3.3.3 Others Design Conditions

- Inlet system total pressure losses: max 147 mmH_2O (new & clean)
- Exhaust system total pressure losses: max 280 mmH_20 (combined cycle)
- Min Fuel gas pressure at GTG connection: 4520 kPag
- Fuel gas max temperature at GTG: 121°C
- Fuel gas min temperature at GTG: 28°C above dew point or 0°C, whichever is the highest

- Fuel gas composition (% vol):

Methane	90.7738
Ethane	4.1938
Propane	1.1638
Butane	0.4138
Pentane	0.1018
Hexane	0.0658
Carbon Dioxide	0.9138
Nitrogen	2.3738

The fuel gas composition stated above is the composition of the fuel gas estimated to be available at the project site. While confirming that the fuel gas available at project site is going to be pipeline quality natural gas, it is understood that the final fuel gas composition may differ from the one stated above. It is also understood that, in case the final fuel gas composition is different from the one stated above, the GTG performances will be different from the performances calculated using the fuel gas composition stated above.

3.4 Torsional Analysis

Intentionally left blank.

3.5 Surface Temperatures

Surface temperature of components that can be readily accessed during normal operation shall not exceed 50°C without a barrier to protect personnel. The engine compartment interior and roof are excluded from this requirement.

3.6 GTG Operating Conditions

3.6.1 Full Load Rejection

The GTG should be able to accommodate the full load rejection and stay on line. The transient frequency variation for full load rejection should be ± 14% (expected value).

3.6.2 Partial Load Rejection

The GTG should be able to accommodate the partial load rejection, from full load to 2.3MW, and stay on line.

The transient frequency variation for part load rejection should be ±10% (expected value).

3.6.3 Successful transition to island mode

In the event of a failure in the external power supply, the cogeneration plant will be automatically disconnected from the electrical grid through the grid circuit-breaker.

Under these circumstances, the GTG has to be able to continue operating at partial load, subsequent to adapting its power output to the net power demanded by the island loads supposed to be around 8 MW, as communicated by the Customer's DCS. Under this situation the GTG has to control the frequency and the AVR regulator will switch automatically to control the generation voltage instead of power factor. The set-point of such voltage has to be changeable from the HMI or from an external DCS not included in the supply of GE.

3.6.4 Synchronization

The GTG provided will be able to automatically and manually synchronise from either one of the following three breakers:

(a) 11 kV GTG circuit breaker; and
(b) 132 kV GTG circuit breaker; and
(c) 132 kV circuit breaker of interlace with the national grid

The signals from the three breakers, required by the GTG for synchronization purpose, shall be provided by Purchaser. Vendor shall took the synchronization from the three points to be only synchronization with three separate signals from Purchaser saying when to synchronise. Purchaser would provide the signals to synchronise. Vendor shall have no control logic on when to synchronise or reconnect. Vendor is only tripping one generator breaker.

3.7 Generator Design

3.7.1 Withstand for a short-circuit of duration 0.5 s

The generator shall be designed to withstand without failure a short circuit of any kind at its terminals while operating at GTG rated load and up to 1.05 pu rated voltage, provided the maximum phase current is limited by external means to a value which does not exceed the maximum phase current obtained from a three phase short circuit. This is in line with the requirements of IEC 60034-3, clause 4.16, which defines "without failure" to mean that the machine shall not suffer damage that causes it to trip out of service, though some deformation of the stator winding might occur.

3.7.2 Withstand for an out-of-phase reclosing

Subject to normal levels of power system impedance, a 120 degree mal-synchronisation should not cause the generator any problems. This requirement shall not apply for low values of power system impedance.

3.7.3 Voltage Variation

± 10% Voltage Variation should be permitted within ± 2% frequency variation range at 0.85 pf, when the maximum output at 0.85 pf is 47.0 MW @ -10°C air temperature and 43.5 MW @ 15°C air temperature.

± 10% Voltage Variation should be permitted within ± 2% frequency variation range at 0.8 pf, when the maximum output at 0.8 pf is 47.0 MW @ -10°C air temperature (the reduction in output is only at the -10% voltage extreme) and 43.5 MW @ 15°C air temperature.

4. DESIGN REQUIREMENTS

4.1 Gas Turbine

The gas turbine shall be the General Electric model LM6000PD 15PPM Sprint engine. The gas turbine shall be new, unused except for testing, and rated for continuous duty. The turbine shall be shock mounted in its compartment to prevent damage during shipment. The gas turbine shall be provided with a Dry Low Emission annular axial swirler combustor and hydraulic starter.

4.2 Couplings and Coupling Guards

The GTG package is supplied with dry, flexible-diaphragm couplings between the gas turbine, load gear, and generator. Anti-sparking coupling guards are also provided.

4.3 Speed Reduction Load Gear

The GTG package is supplied with single-stage, vertical offset, parallel shaft speed reducer with a gear rated HP of 70,000 (52,200 kW) from a gas turbine speed of 3627 RPM to a generator speed of 3000 RPM, with a 1.209:1 ratio. This gear is manufactured and tested in accordance with API 613 3rd Edition April 1988 based on a material index number of 303.4. The actual AGMA Service Factor is 1.35. The API service factor is 1.1. The gear design includes a fabricated steel housing, clockwise rotation with pinion on top, double helical precision carburised ground gear elements, split steel backed babbitt-lined journal bearings on all shafts and a low speed quill shaft.

4.4 Air Cooled Generator, brushless exciter and voltage regulator

The generator shall be air cooled and equipped with a brushless permanent magnet generator excitation system. A two-pole synchronous design with NEMA and IEC Class F insulation shall be utilised. The generator shall utilise a beam type design with two radial bearings and a thrust bearing to satisfy seismic requirements. The generator shall be rated to absorb 120% of the baseload output of the gas turbine without exceeding Class B temperature rises when operating at 0.85 power factor, or higher power factor.

The generator shall have the following characteristics:

- Type : Synchronous, Cylindrical Rotor
- Method of cooling : Open Air ventilated (IC 01)
- Rotating speed : 3000 rpm
- Power Factors : 0.8
- Rated Voltage : 11,000 V
- Rated MW : 50.8 MW at 15°C cooling air temperature
- Rated MVA : 63.5 MVA at 15°C cooling air temperature
- Rated Cooling Air Temperature : 15°C
- Insulation Class : Class F
- Temperature Rise : Class B
- Degree of protection : not less than IP32 (Generator) with its enclosure as provided, IP55 for Terminal Boxes and bus bars connections between the generator and terminal boxes
- National Standard : I.E.C. 34-3 / BS5000
- Voltage Variation Range : ± 10% within ± 2% frequency variation, and when the maximum output at 0.85pf is 47.0 MW @ -10°C air temperature and 43.5 MW @ 15°C air temperature
- Voltage Regulation : ± 0.5% (No load to full load)
- Steady State : ± 1% (No load to full load)
- Frequency Variation Range : ± 2%
- Telephone Influence Factor:
  - Balanced : 70
  - Residual : 50
- Total Harmonic Content : 5% Max
- Deviation Factor:
  - at no-load open circuit : 5% Max
  - (Line-Line & Line-Neutral) : 10% Max
- Short Circuit Capability : 235% for 10 sec

The stator shall include six embedded RTDs (two per phase). An RTD shall also be mounted in each radial bearing and in the oil drain line from each radial bearing. A ground fault detection system and monitor shall also be provided.

The generator shall be furnished with an electronic voltage, regulator system. The voltage regulator system shall be rack mounted in the unit control panel and shall be capable of maintaining generator output voltage within ± 0.5% during steady-state operating conditions. The voltage regulator shall utilise single or 3-phase sensing circuitry and be suitable for parallel operation with droop/cross current compensation.

4.5 Acoustic Enclosure and Ventilation System

The GTG shall have an enclosure designed for outdoor installation. This enclosure shall be divided into compartments by bulkheads. The generator set shall have an enclosure designed for outdoor installation. This enclosure shall be divided into compartments by bulkheads. These compartments shall be the gas turbine compartment and the generator compartment (including load gear). The inlet plenum shall be enclosed within the gas turbine compartment. Each compartment shall be provided with suitable access doors and removable panels for entry,

maintenance, and installation or removal of components. All hinges, latches, and mounting hardware shall either be stainless steel or chrome plated. A bridge crane with extension arm shall be furnished inside the gas turbine compartment to facilitate equipment removal. All compartments shall be acoustically insulated. The enclosure shall provide expected average sound attenuation to 85 dB(A) at 1 m distance measured at 1.5 m above grade in a free field condition. The enclosure shall be completely assembled and mounted over the equipment prior to testing and shipment. Explosion-proof lighting shall be provided.

The Vendor shall supply separate ventilation systems for the turbine and generator compartments. All ventilation air shall be fully filtered in accordance with Paragraph 4.7.

The turbine compartment shall be fully ventilated with belt driven fans, while the generator compartment is fully ventilated with direct driven fans.

The generator compartment shall have duplex AC motor driven forced draft fans. The fans shall provide cooling air for the generator compartment, the gear and the generator itself. The generator compartment shall be maintained at a positive pressure in relation to the turbine compartment. Fans shall be sized to induce air flow up to the top of the roof.

4.6 Structural steel baseplates for gas turbine, generator and load gear

The baseplate for the gas turbine, load gear, generator, and air inlet plenum shall be a welded structural steel fabrication and shall be in two sections. The two sections must be doweled for easy field re-assembly. Removable lifting spools shall be incorporated in each section of the baseplate design.

Structural steel shall conform to ASTM A36 or equivalent. The design of the baseplates shall conform to the latest edition of the AISC "Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings". The design shall also satisfy Earthquake Zone 4 of the Uniform Building Code. The baseplates shall be sufficiently rigid for mounting at specified points without continuous grouting under structural members. Holes for foundation anchor bolts shall be drilled in the Vendor's shop. Jacking bolts shall be included. The baseplates shall include seal welded, sloping drip pans with drains at the side of the baseplate for Purchaser connection. All fluids that might leak must be caught in these pans for disposal.

4.7 Multi-Stage inlet Air Filter System

The GTG package shall be supplied with a modular, multi-stage filtration system consisting of inlet screens, a pre-filter and a final barrier filter. The inlet air module shall be mounted above the GTG. To facilitate maintenance access to the GTG, the inlet air module shall be supported by the turbine and generator enclosures without legs or other structural work requiring separate foundation mounts. The Vendor shall furnish ducting from the inlet air module to the inlet air plenum and the necessary expansion joint. The inlet air module shall be designed to provide filtered air for the combustion gas turbine, the generator, and ventilation of each rotating equipment compartment. The filtration system shall consist of a pre-filter and a barrier filter capable of removing 99% by weight of all particles sized 5.0 micron and larger during all ambient conditions.

Acoustical louvers for noise control shall be installed to the intake of the inlet filter. The acoustic louvers shall be approximately 600 mm deep. The acoustical louvers for noise control shall provide a guaranteed average noise emission of 82 dB(A) at locations around the air filter front face intake region, at a horizontal distance of lm from the exterior plane of the filter inlet face, during full load operation, as tested in free-filed condition over a hard reflecting ground plane.

4.8 Inlet Air Multi-Purpose Coils

The GTG package shall be supplied with high performance multi-purpose coils for combustion air heating and chilling as an integral part of the air inlet system. Purchaser will provide adequate quantities of hot water and chilled water and interconnecting piping to coils at filter house to provide positive protection against ice formation within the air inlet module, plenum or gas turbine bellmouth during cold days and an efficient cooling system to cool the inlet air to improve the GTG performances at summer.

4.9 Ladders, and Platforms for Filter House Access

Platforms and ladders to service the inlet filter shall be supplied also. These items are packaged separately for shipment.

4.10 Inlet Duct with Silencer for Noise Attenuation and Bellmouth Screen

Filtered air shall be silenced before entering the turbine plenum. The Vendor shall furnish ducting from the inlet air module to the inlet air plenum and the necessary expansion joint. The Vendor shall supply an inlet air silencer that will reduce the inlet noise, measured in a free field condition at 1 m from the GTG package at 1.5 m above grade to a level at average 85 dB(A) or below. The silencer shall be fabricated from stainless steel or a suitable noncorrosive material. Carbon steel, painted or galvanised, is acceptable for the ducting.

A bellmouth screen and plenum seal shall be furnished by the Vendor to protect the turbine from foreign object damage.

4.11 Axial Exhaust Diffuser

The gas turbine exhaust outlet shall be designed for convenient connection to a purchaser supplied heat recovery steam generation system (HRSG). The exhaust outlet shall have low pressure drop and shall be located on the turbine axis, in the end of the turbine enclosure.

An expansion joint to be mounted at gas turbine exhaust outlet shall be furnished by the Purchaser to absorb the thermal expansion between the gas turbine and the exhaust duct.

4.12 Gaseous Fuel System

The gaseous fuel system for the gas turbine shall be complete and self-contained on the package. This system shall have all piping, valving, and instruments necessary for operation at any power load from minimum power setting through baseload at the specified ambient conditions. The Vendor shall include a Y screen, fuel metering valve, vent valve, high and low pressure alarm/shutdown controls. The gaseous fuel system shall be constructed of stainless

steel piping and fittings. Valves shall have stainless steel trim. Unless differently required by the applicable laws or EU directives, all fuel system piping welds shall be examined by 10 % X-ray. Purchaser will connect to the system flange located at the edge of the baseplate. Analyser/Calorimeter will also be included and shipped loose to be installed by Purchaser.

The Vendor shall supply one (1) two-stage, off-skid mounted fuel gas filter. The filter shall be constructed of stainless steel piping and fittings. Valves shall have stainless steel trim. The filter shall be supplied as a loose item. Purchaser will connect the filter to the GTG fuel gas system.

4.13 Water Injection System for power augmentation

A Water Injection System for power augmentation shall be included in the supply. The system shall be designed to reduce the temperature of combustion air from the summer ambient basis to boost gas turbine power output. The system shall include water spray manifold and nozzles located at the gas turbine axial compressor inlet and at intermediate stage. Vendor shall furnish a complete system, metering valve, manifolds, water spray nozzles, piping, instruments and a microprocessor based controller. All vendor supplied water piping shall be stainless steel and valves shall have stainless steel trim. Purchaser will supply pure water at the pressure and temperature specified by Vendor. Vendor will specify water purity and quality requirements.

4.14 Lube Oil System for Gas Turbine

The lube oil system for the gas turbine shall be complete and self-contained. The lube oil tank and duplex Shell and Tube heat exchangers shall be mounted on separate skids. Each heat exchanger shall be sized to reject the maximum system heat load. The pump shall be a positive displacement type, mechanically driven from the gas turbine accessory drive gear.

Duplex filters, 6 microns absolute, shall be furnished for supply and scavenge circuits. The filters will include valving to allow transfer from filter to filter without interruption of lube oil flow to the equipment. Lube oil filters shall be accessible from outside the turbine enclosure. The reservoir and all piping shall be stainless steel, An electric immersion heater with automatic temperature control shall be provided in the reservoir. All lube oil system valves shall have stainless steel trim.

4.15 Lube Oil System for Generator and Load Gear

The electric generator and load gear lube oil system shall be totally separate from the gas turbine lube oil system. The system shall be complete with duplex Shell and Tube heat exchangers which shall be mounted on a separate baseplate. Each heat exchanger shall be constructed from carbon steel 304 stainless steel tubes. Each heat exchanger shall be sized to reject the maximum system heat load. The primary pump shall be a positive displacement type, driven by an AC motor. A 100% auxiliary pump shall be AC motor driven. A DC motor driven emergency pump shall be also provided. Rundown tanks shall be provided to protect the generator during a "black coastdown". Duplex filters, 6 microns absolute, shall be furnished with valving to allow transfer from filter to filter without interruption of lube oil flow to the equipment. The reservoir and all piping shall be stainless steel. An electric immersion heater with automatic temperature control shall be provided in the reservoir. All lube oil system valves shall have stainless steel trim.

4.16 Electrohydraulic Start System

An electrohydraulic start module shall be provided on a separate skid. This module shall include a reservoir, electric immersion heater, all piping, valving, and instruments necessary for operation. The reservoir and all piping shall be stainless steel. The hydraulic start module shall include adequate heat rejection capability to handle "motoring" cycles required for extended purging and water-washing.

4.17 Fire and Gas Protection System

The GTG package shall be supplied with an installed fire and gas protection system complete with optical flame detection, hydrocarbon sensing and thermal detectors, piping and nozzles in both generator and gas turbine compartment. The fire and gas detection system shall be in accordance with NFPA requirements. The fire protection system includes cylinders containing CO_2 mounted on a separate module. A 24V DC battery and charger to power the fire protection system is also included in the supply. All alarms and shutdowns are annunciated at the GTG control panel. An alarm sounds at the turbine if the gas detectors detect high gas levels, or if the system is preparing to release the CO_2. When activated, the package shuts down, and the primary CO_2 cylinders are discharged into the turbine and generator compartments via multiple nozzles, and the ventilation dampers automatically close. After a time delay and if required, the slow extended discharge of CO_2 is discharged.

4.18 Vibration Monitoring System

The Vendor shall supply a complete vibration monitoring system. The gas turbine vibration shall be measured by accelerometers mounted on the turbine casing. The load gear and generator vibration shall be measured by X and Y coordinate displacement probes at each radial bearing. The vibration of the gas turbine shall not exceed the limits as set forth by the turbine manufacturer. The generator vibration shall not exceed the limits as set forth by the generator manufacturer.

All displacement probes shall be Bently-Nevada. Each vibration channel shall be continuously displayed and monitored, utilizing a Bently-Nevada 3500 series monitor rack mounted in Vendor's GTG control panel.

All vibration information will be transmitted to the GTG control panel.

4.19 GTG Control Panel

The GTG package shall be supplied with a free-standing control panel suitable for mounting in an indoor, non-hazardous area provided by Purchaser. The control system shall feature a microprocessor based control panel for gas turbine fuel/airflow management, and auxiliary system sequencing/protective functions, vibration monitor, digital meter and a HMI display of key discrete and analogue data. Interface between GTG control panel and Purchaser's DCS will be provided by means of a serial link connection port RS-485 with MODBUS RTU communication protocol.

For allow the operation and control of the GTG as an integrated heat production plant from the Purchaser's DCS the main I/O hardwired provisions, up to 20 I/Os, (such as: start, stop, start

automatic synchronization, power factor increase, power factor decrease, power output up, power output down) shall be included.

The GTG control system will include a card in the HMI to receive IRIG B time synchronisation signal from the Purchaser's DCS.

The operator may select HMI displays with a mouse or trackball. Alarm and shutdown events shall be displayed on the HMI automatically. The 24V DC power for the control panel shall be provided by a dedicated battery system with dual 100% chargers.

The GTG control system will consists of:

- Full MicroNetTM (Woodward MicroNet Simplex Digital Control) microprocessor based control panel for gas turbine fuel/airflow management, and auxiliary system sequencing/protective functions
- Manual and Automatic Synchroniser
- Fire and Gas Detection Controls
- Bently Vibration Monitoring
- Electronic Voltage Regulator with Automatic/Manual Control
- Generator Metering
- Digital Generator Protection
- Desk top HMI computer (human machine interface) providing graphical displays and logging of key gas turbine, generator, and auxiliary system data.

4.19.1 Woodward MicroNet Simplex Digital Control

The Woodward governor shall be rack mounted on the unit control panel. As a minimum, the Vendor shall include the following electronic controls:

- Engine Temperature Monitoring
- Speed Monitoring (dual sensors plus indication for each turbine shaft)
- Digital Fuel Control
- Auxiliaries Control
- Fully automatic start of the gas turbine generator set by a single "push button" command from the operator. Likewise, a single stop command shall trigger a fully automatic shutdown sequence.
- Monitor the unit mounted sensors through I/O interface connections
- For the time synchronization Vendors should provide a 637PCI card in the HMI which utilises IRIG-B

4.19.2 Synchronisation

The Vendor's unit control panel shall contain a synchroscope, controls and circuitry to permit Local Manual synchronisation by the Operator. The panel shall also contain an auto synchroniser and other circuitry to allow auto synchronisation to be initiated locally or remotely, via the Purchaser's DCS, The auto synchroniser shall control the generator frequency, phase, and voltage and match them to the bus. The auto synchroniser shall then issue a "breaker close" command signal.

The control panel shall also include a synchronisation check relay (Device 25). This relay shall be wired in series with the circuit breaker close signal (either manual or automatic) so that synchronisation is proved before circuit breaker closure is permitted.

4.19.3 Fire and Gas Detection System

A rack mounted fire and gas detector system dedicated to the monitoring of optical flame detectors, thermal detectors, and gas detectors shall be provided as a part of the unit control panel.

4.19.4 Vibration Monitoring System

The vibration monitoring system shall be mounted in 19" racks within the unit control panel. Vibration levels for each point shall be displayed on individual meters. Vibration "alarm", "shutdown", and "vibration system failure" signals shall be provided for use by the control system.

4.19.5 Electronic Voltage Regulation

An electronic voltage regulation system shall be supplied. The voltage regulator shall provide means for manual or automatic voltage control, power factor control, excitation control, ground fault monitoring, and diode failure monitoring with indication.

4.19.6 Generator Metering

The unit control panel, on the HMI, shall provide digital readout of the following parameters as a minimum:

- Exciter Amps
- Exciter Volts
- Generator MW Output
- Generator Amps
- Power Factor
- Generator/Bus Frequency
- Generator Voltage
- Bus Voltage

4.19.7 CRT Annunciator

All alarm and shutdown events shall be audibly annunciated and shall be visually displayed on the CRT. A "first out" feature shall be provided. All analogue signals to the unit control panel shall be capable of being displayed on the CRT. The CRT must provide menu selections to allow the operators to display the system analogue and status information.

4.19.8 Remote Control

The unit control panel shall be designed to permit remote control by Purchaser's Distributed Control System (DCS). The unit control panel shall accept, as minimum, the following commands from voltage-free relay contacts in the DCS:

- Turbine Start/Stop
- Raise/Lower Voltage
- Raise/Lower VAR's (or Power Factor)
- Raise/Lower Speed (or Power Output)
- Initiate Auto Synchronisation Trip Generator Circuit Breaker
- Emergency Shutdown
- Power/load set point

The unit control panel / modules shall be provided serial link connection port RS485 with Modbus RTU communication protocol to transmit all signals to the DCS. See ANNEX E for reference.

As minimum the following functions shall be included:

- Unit Status (shutdown, starting, on-line, etc.)
- Analogue values (speeds, temperatures, pressures, etc.)
- Electrical Values (amps, volts, watts, VARs, Power Factor)
- Generator Circuit Breaker Status (closed/tripped)
- Alarms
- Shutdowns
- Sensor Failures

4.19.9 Generator Protection

Vendor's unit control panel shall contain a Digital Generator Protection system and associated circuitry to trip the generator circuit breaker in the event of fault. The DGP shall also be programmed to shut down the turbine in case of critical faults, moreover protection system shall be in compliance with national grid code requirements, as specified above.

All information will be transmitted to the DCS via a serial link port RS485 Port with Modbus RTU communication protocol.

Main / safety signals will be hardwired to the DCS.

4.19.10 Control Batteries and Charger Assembly

A 24 volt DC nickel-cadmium battery and dual 100% battery chargers shall be furnished. The battery system shall be capable of supplying the control loads for at least three hours without recharging. The battery rack shall be made of steel, properly insulated, and painted with two coats of acid resisting paint.

The battery chargers shall operate from a 220 volt, 50 Hz, 1-phase power supply supplied by the Purchaser. The chargers shall be static rectifier type and sized to maintain the battery fully charged during "worst case" conditions, with a maximum recharge time of eight hours.

4.20 Gas Turbine Set Gauge Panel (Local)

Gauges indicating the pressure of the turbine auxiliary systems shall be mounted on a panel on the auxiliary skid of the rotating equipment module. Temperature gauges shall be locally mounted in the system piping as necessary.

4.21 Motor Control Centre

The Vendor shall provide a free-standing line-up of motor controls for all motors furnished by Vendor. The Motor Control Centre shall be suitable for indoor installation and shall include modular contactors for each 400 V motor, lighting transformer and lighting distribution panel. The Motor Control Centre shall be I.E.C. approved or listed or otherwise suitable for the intended application. The MCC shall have dual incoming feeder. Vendor shall supply detailed technical specification during engineering phase.

4.22 Induction Motors

All motors within the package supplied by Vendor, shall be high-efficiency type.

Following technical requirements shall be applied to all motors of 3 kW rated power or greater:

- Duty : S1
- Preferred Construction Form : B3
- Mechanical Protection : IP55
- Insulation Class : F/B
- Cast iron casing : for 30 kW higher

4.23 On-line and Crank Soak Water-wash System

The GTG package shall be supplied with an "on-line" cleaning system, which allows the operator to clean the compressor section of the engine during full power operation. The same system reservoir and piping are utilised for off-line soak washing. Baseplate connections shall be provided for Purchaser supplied purified water at 1 - 5.9 bar(g) filtered to 20 microns and air at 5.9 - 8.3 bar(g) filtered to 5 microns. Detergent also will be supplied to unit connection by Purchaser.

4.24 Interconnection wiring

The Vendor shall offer as an OPTION the supply of all electrical cables required to interconnect the GTG package with the Vendor supplied auxiliary skids (100 meters total length). This includes low voltage, as well as control and instrumentation wiring. All electrical wiring shall be suitable for the intended application. In any case, Vendor shall provide detailed cable list, sizing criteria, wiring diagrams.

4.25 Interconnection piping

The Vendor shall offer as an OPTION the supply of all piping required to interconnect the GTG package with the Vendor supplied auxiliary skids.

4.26 Testing

4.26.1 Major Component Testing

The gas turbine engine shall be performance tested under load by the manufacturer. This test shall verify the engine horsepower capability, efficiency, and mechanical integrity. A copy of the factory test report shall be included in the Vendor's documentation package.

The speed reduction gear shall be mechanically tested at its factory of manufacture. A copy of the factory report shall be included in the Vendor's documentation package.

The generator shall be tested to IEC 34-3 or ANSI C50.14 standards at its factory of manufacture. A copy of the factory test report shall be included in the Vendor's documentation package.

4.26.2 Gas Turbine Package Factory Test

The Vendor shall conduct a factory test of the complete gas turbine package at the Vendor's manufacturing facility. During this factory static test, the gas turbine package should receive a rigorous 400-point test according to the standard Vendor testing procedure, including:

a) Switch State (NO or NC, actuation, wiring, and set-point)
b) Temperature element output, and wiring
c) Transmitter range, output, and wiring
d) Solenoid operation
e) Control valve torque motor, excitation, and return signal
f) Fire system continuity, and device actuation
g) System flushing verification
h) Tubing integrity

Purchaser shall have the right to witness the gas turbine package factory static test, that will be carried-out at the Vendor’s European packaging facility. A copy of this test report shall be transmitted to Purchaser.

4.26.3 Site Performance Verification Test

The assembled GTG package will be tested by Purchaser at the site within 200 running hours after initial start-up. This performance test shall be accepted as the "new and clean" test. This test will be conducted using project instruments where applicable. Vendor and Purchase shall supply all necessary instrumentation to carry out the test.

The Site Performance Verification Test shall be carried out to verify the performance guarantees stated in the Contract.

4.26.4 Performance Guarantee

The Vendor shall guarantee the performance of the GTG in the new and clean condition as follows:

GUARANTEES CONDITIONS

Altitude	:	447.5 m a.s.l.
Ambient Pressure	:	96.065 kPa
Air Inlet Conditioning	:	None
Inlet Losses	:	147 mmH_2O
Exhaust Losses	:	280 mmH_2O
Inlet Air Temperature	:	+15°C
Inlet Air Relative Humidity	:	60%
Fuel	:	46.694 kJ/kg LHV, pipeline quality natural gas fuel
Fuel Temperature	:	25/121°C (min/max)
Generator Voltage	:	11 kV, 50 Hz
Generator Power Factor	:	0.9
GTG Condition	:	New and clean with max 200 fired hours

PERFORMANCE GUARANTEES

Net GTG Power Output	:	43,286 kW
GTG Heat Rate ref. to -		
Net GTG Power Output	:	9,048 kJ/kWh, LHV
Exhaust Energy	:	96,061 kJ/sec (ref. 0°K)
Exhaust Gas Temperature	:	452.5°C
GTG Near Field Noise - Emission Pressure Level	:	average 85 dB(A) around the GTG package, measured at a horizontal distance of 1.0 m and at a horizontal distance of 1.5 m above grade, in a free field condition over a hard reflecting ground plane and with the GTG operating at full load
Air Filter Near Field Noise - Emission Pressure Level	:	average 82 dB(A) at locations around the air filter front face intake region, measured at a horizontal distance of 1.0 m from the exterior plane of the filter inlet face, in a free field condition over a hard reflecting ground plane and with the GTG operating at full load
Max NOx Emission Level	:	(*) 30 mg/Nm^3, ref. 15% O_2
Max CO Emission Level	:	(*) 50 mg/Nm^3, ref. 15% O_2

(*) NOx and CO emissions guarantee is valid for gas turbine engine inlet temperature between -6.7°C and 37.78°C, and GTG load from 75% to 100% load.

4.27 Transportation

The Purchaser shall provide transportation from the equipment manufacturing facilities to the job site and unloading of the GTG package on the foundations (supplied by Purchaser). Vendor shall provide packing and marking suitable for marine transportation.

4.28 Installation Supervision Services

The Vendor shall provide supervision services at the job site for the installation and commissioning of the gas turbine generator package, as described in the Vendor's proposal. The Vendor technician shall attend the operation of the GTG on a 10-hour continuous basis during

day time, 7 days a week during the 28-day GTG trial run. During the remaining 14-hour operation, the Vendor technician shall be available on the phone. Extension of the 28-day GTG trial run due to reasons other than that of Vendor will result in applying the applicable Vendor field service rates for the additional time spent on site.

4.29 Complete Set of Drawings

The Vendor shall supply one (1) customer drawing package that includes all information necessary to integrate the GTG into the combined cycle plant. The customer drawing package shall include, at least, the general arrangement drawings, flow and instrument diagrams, and interconnection plan. Additional electrical schematic diagrams and logic drawings are provided for record. Vendor shall made available all engineering drawings online at a secure server (www.project-net.com). Purchaser can enter this database and view, print or annotate his own project drawings.

Vendor shall supply the GTG data required for Purchase developing the civil works design. Vendor shall supply the GTG foundation bolts and embedments positions referred to an agreed "0" level and main GTG axis (gas turbine centre line and gas turbine exhaust). The GTG static loads will be supplied in accordance with the specification in ANNEX E.

4.30 Operating and Maintenance Manuals

The Vendor shall furnish six (6) complete sets of Operating and Maintenance Manuals. Operating and Maintenance Manuals are provided, printed in the English language. The Section of the Operating and Maintenance Manuals related to day-by-day maintenance is printed in the operator’s language. The manuals cover operating concepts for gas turbine equipment, guides to troubleshooting, and basic information on components and equipment within the GTG package.

4.31 Training Course for Operator Personnel

The Vendor shall provide hands-on training for up to 15 Purchaser's operators and supervisors at the project site in the English language. Training duration shall be 5 days. The Vendor training shall include the "Gas Turbine Familiarisation Training" at the project site located in EUROPE.

The Vendor shall be responsible for travel and subsistence expenses for its instructors. The Purchaser shall be responsible for travel and subsistence expenses of the trainees. The Purchaser provides classroom, projector, etc.

4.32 First Fill of Lubricants

The Vendor shall supply the first fill of lubricants for the GTG package. These are: synthetic lube oil for gas turbine, mineral lube oil for gear and generator, and mineral lube oil for gas turbine hydraulic start system.

4.33 Commissioning Spare Parts

The Vendor shall supply the spare parts for commissioning the GTG package.

4.34 Special Tools

The Vendor shall supply the following special tools necessary for installation and removal of the gas turbine engine from its enclosure.

- Manual bridge crane installed within the gas turbine compartment of the package
- Engine lifting fixture

4.35 Painting and Coating

The GTG package shall be painted in accordance with the Vendor painting specification that is accepted by Purchaser.

5. UTILITIES

The Purchaser will supply, at the Vendor's terminal points, the plant air, instrument air, gas fuel, and water required for commissioning, start-up and operation of the gas turbine generator package. Vendor shall indicate, during engineering phase, the required flow rates, pressures, temperatures, and quality requirements.

Purchaser will also supply necessary 3-phase AC power for commissioning, start-up and operation of the gas turbine generator package.

6. POSITIVE APPROACH

During the execution of the Contract, Vendor and Purchaser shall take a positive approach and reasonably support each other by exchanging all the information required by the other Party to timely fulfil its obligations set forth in the Contract.

Upon the reasonable request by the Purchaser, the Vendor shall promptly and actively assist the Purchaser in its endeavours relating to the permitting required and cooperate by providing information and support during any hearings and meetings in the process of obtaining the permits.

In particular, upon the reasonable request by Purchaser, Vendor shall ensure to Purchaser the technical assistance to Purchaser in its endeavours relating to the permitting of dispatching the power generated by the power plant to the national grid and active cooperation by providing GTG related information and reasonable support during any hearings and meetings with the European Grid Operator in the process of obtaining such permits for dispatching.

7. General Plant Layout