Section 1.0

Base Bid Scope of Supply
TITAN 130 POWER GENERATOR SET

BASIC PACKAGE

The Titan 130 Power Generator (PG) is a compact gas turbine designed for power generation applications. The generator set is a completely integrated package ready for installation. The gas turbine engine, gearbox, generator, control system, fuel system, lubrication system, and start system are included in the package.

Package Certification. Solar is supplying a CSA certified NEC package. No modifications are included to comply with GOST or other Russian or European standards.

Base. The turbine and the generator assemblies are each installed on a separate base frame platform that provides rigid support for the driver and driven equipment. In addition, each base provides a permanent mounting structure for the associated operating systems and accessories. The bases are manufactured by Solar using structural steel with welds per AWS D1.1. Four lifting eyes are welded to each base. Drip pans to collect potential liquid spills are welded within each base.

Approximate overall dimensions are:

- 46 ft (14.02 m) long
- 10 ft - 10 in (3.30 m) wide

Approximate height of an unenclosed package is 10 ft - 9 in (3.28 m) and may vary with ancillary equipment and generator selection.

Piping. All tubing and piping with a nominal diameter up to 4 inches, are made of stainless steel. Package piping is designed and fabricated to ANSI B31.3.

Tube Fittings. All tube connections use stainless steel compression fittings.

Electrical System. The PG generator set is designed to comply with the requirements of the National Electrical Code for installation in a non-hazardous location per NFPA 37.

Package motors and heaters are rated for 380 VAC / 50 Hz / 3-Phase, unless otherwise noted.

Single-Phase loads are rated for 220 VAC / 50-60 Hz, unless otherwise noted.

GAS TURBINE ENGINE

The SoLoNOx Titan 130S is a single shaft, axial flow gas turbine engine that includes Solar’s dry, low NOx combustion system. The output gearbox, including accessory drive pads, is a separate, close-coupled unit located at the forward end or turbine air inlet side of the package.

The engine assembly consists of:

- Gear unit with accessory drive pads
- Air inlet collector with a flexible flange connection
• Axially split compressor case in the vertical plane, housing a fourteen-stage axial flow compressor with variable geometry consisting of variable inlet guide vanes control over the first six rows of stators
• Annular SoLoNOx combustor with 14 lean premix fuel injectors
• Three-stage power turbine assembly
• Turbine exhaust collector

The components of the SoLoNOx Titan 130S engine are maintained in accurate alignment by mating flanges and are bolted together to form a rigid assembly. The turbine rotor shaft drives the speed-reducing gearbox. The gearbox mechanically drives the main lube oil pump.

The gas turbine output shaft is mechanically coupled to both the compressor and turbine sections of the engine to form a "solid" or "single" shaft configuration. This feature enhances speed stability and response under constant and varying load conditions - a highly desirable feature in generator applications requiring precise frequency control.

**Inlet Orientation.** The gas turbine air inlet flange terminates in the up position.

**SPEED-REDUCING GEARBOX**

**Gearbox.** The reduction drive gearbox is provided to reduce the output speed of the turbine to the generator’s required input speed of 1500 rpm for 50 Hz applications. The speed-reducing gearbox contains an epicyclic "star-compound" gear designed specifically for the PG turbine-generator set. The gearbox is bolted directly to the gas turbine engine to provide a rigid support; therefore gearbox alignment with the engine is not required.

**Alignment Tool.** Alignment tooling is provided to align the reduction gearbox output shaft with the generator input shaft.

**GENERATOR**

**Generator Rating.** The generator is rated per NEMA standards so that it will not limit turbine performance over the Solar specified range of site ambient temperatures.

Generator standard features include:

• Sleeve Bearings with pressure fed sumps
• Stator winding RTD’s
• Power terminal box
• Form wound stator windings
• Rotor balance to 125% rated speed
• Permanent magnet pilot exciter
• Anti-condensation space heaters
• 300% short circuit capability for 10 seconds
• Overload capacity per NEMA (continuous duty rating):
  - 150% rated current for 1 minute
  - 110% for 2 hours in any 24-hour period
Voltage Regulator Characteristics. The voltage regulator characteristics are as follows:

- Solid state
- Three-phase sensing (Single phase sensing can be accommodated)
- ±10% voltage adjustment range, voltage resolution is 0.1%
- ±0.50% steady state voltage regulation
- Reactive load sharing to within 5% nameplate rating
- Crosscurrent compensation capability

Voltage Drift. The change in voltage will not exceed ±1.0% when the generator is operating at rated voltage, 0.8 to 1.0 lagging power factor, and with a constant load between no load and full rated load.

Generator Construction. An open drip proof generator per NEMA standards is provided.

Generator Voltage. The generator output is 10,500 Volt / 50 Hz / 3-Phase. Insulation conforms to NEMA class F with class B (80°C) temperature rise.

START SYSTEM

Start Motor. Two direct drive AC electric motors are provided to start the gas turbine engine. A blank plate is located at the package base edge for routing cables or conduits for electrical interconnection to the start motor inside the package.

Variable Frequency Drive. A single variable frequency drive (VFD) is provided to control the speed of the two AC start motors. The VFD is housed in a NEMA cabinet, designed for wall mounting installation off-skid in a non-hazardous location.

NATURAL GAS FUEL SYSTEM

A natural gas fuel system is provided and includes all the hardware and software components necessary to maintain turbine speed and provide a constant generator output frequency and/or load depending on the generator set mode of operation. The fuel system, in conjunction with the electrical control system, includes all necessary components to control the fuel pressure, schedule fuel flow during start-up, and modulate fuel flow during operation. The fuel system also provides the necessary instrumentation for the control system to monitor the operation and automatic shutdown of the unit in the event of a malfunction.

Pilot System. The pilot system is a fail-safe fuel shutoff system in the event of a control system failure. The fuel pilot system requires external compressed air to the customer connection located on the side of the package base. Reference the “Package Utility Requirements List” for air flow and pressure requirements.

Fuel Requirements. The natural gas fuel system requires a constant supply of fuel to the customer connection located at the side of the package base. The fuel quality must conform to Solar Specification ES 9-98. The gas fuel should be free of sulfur, contaminants, entrained water, and liquid hydrocarbons. Please also refer to Solar's Product Information Letter (PIL) 162: "Recommendations for the Sourcing, Handling, Storage, and Treatment of Fuels for Solar Gas Turbines", to ensure the supply of high quality fuel required for optimum performance. Reference the “Package Utility Requirements List” for fuel flow and pressure requirements.
LUBE OIL SYSTEM

A complete lube oil system is provided, and includes instrumentation, flow control devices, and on-skid piping. The lube oil system supplies oil to the bearings in the gas turbine engine, gearbox and generator. The package control system monitors the lube oil operation. For this cold climate the customer will need to heat trace the lube oil lines to/from the package.

Main Lube Oil Pump. An gearbox driven lube oil pump is provided to supply oil to the lube oil system.

Pre/Post Lube Pump. An AC motor driven pump is provided to deliver lube oil prior to start up and after shutdown of the gas turbine. A blank plate is located at the side of the package base for routing cables or conduits for electrical interconnection to the pre/post lube oil motor inside the package.

Backup Post Lube Pump. A DC motor driven pump is provided to supply lubrication during shutdown in the event of power failure or malfunction. Power to the backup pump is provided by a 120 VDC battery system. The DC motor start contactor is included. A blank plate is located at the side of the package base for routing cables or conduits for electrical interconnection to the post lube backup motor inside the package.

Lube Oil Tank. The carbon-steel lube oil tank is integral to the package frame and includes a drain connection located at the side of the package base.

Lube Oil Tank Heater. An AC tank heater is provided to warm the lube oil to the required lubricating viscosity and pour point. A blank plate is located at the side of the package base for routing cables or conduits for electrical interconnection to the lube oil tank heater motor inside the package.

Lube Oil Vent Separator. A lube oil vent separator is provided to remove oil vapor from the lube oil tank vent. Recovered oil drains back to the lube oil tank. The separator is designed for off-skid installation. The oil tank vent piping located externally must be self-supporting.

Lube Oil Cooler. An air / oil lube oil cooler is provided and designed for off-skid installation. The fan is driven by an AC motor, which lowers the oil temperature by providing a flow of air through the cooler fins. Connections for lube oil supply to and from the cooler are located at the side of the package base.

Lube Oil Type. The lube oil quality must conform to the requirements of Solar Specification ES 9-224. This project will be configured for synthesized hydrocarbon oil, viscosity grade C32.

Lube Oil Filter. Duplex oil filters are provided to remove contaminants from the lube oil system. The lube oil filter drain connection is located at the side of the package base.

CONTROL SYSTEM

Solar’s Turbotronic™ control system is provided to operate, control, and protect the gas turbine package. It is a highly integrated programmable controller system that provides an extensive range of options for monitoring and plant control. The control system power is provided by a battery/charger combination, described later in this proposal. The batteries supply the power to the control system when the customer input is interrupted.
The control system includes:

- Programmable controller
- Input / Output (I/O) modules (discrete and analog)
- Relay backup system
- Control and monitoring software
- Package sensing and control elements
- Operator interface control console (TCP and VDU)

**Operator Interface.** The operator interface consists of an on-skid control console installed on the package base in two weatherproof NEMA 4 boxes, and includes a Turbine Control Panel (TCP) with a front-mounted Video Display Unit (VDU). The TCP and VDU include all the necessary switches and indicators for operating the gas turbine and generator. Blank plates are located at the side of the package base for routing cables or conduits for electrical interconnection to the turbine and generator control boxes.

The on-skid Turbine Control Panel has the following switches:

- Start (Starting Indicator Light)
- Normal Stop (Stopping Indicator Light)
- Emergency Stop
- Speed Control (Increase / Decrease)
- Off / Local / Remote (Control Selector with Lockable Positions)
- Acknowledge (Alarms and Shutdown)
- Reset (Alarms and Shutdown)
- Backup System (Active / Reset) (Backup Active Indicator Light)
- Horn Silence (Audible Alarm)

The Video Display Unit provides the following displays:

- Operation Summary
- Temperature Summary
- Vibration Summary
- Alarm Summary
- Discrete Event Log
- Strip Chart
- Trigger Log
- Generator Summary

**Vibration Monitoring.** Vibration monitoring is provided by use of one Y-axis proximity probe per engine bearing, one accelerometer with the gearbox, and two velocity transducers (one per bearing), with the generator. Preset warning indications and malfunction shutdown initiation are standard features of the vibration monitoring system.

**Temperature Monitoring.** Temperature monitoring is provided for the engine thrust bearing, the turbine rotor inlet temperature (based on T5), the lube oil header, the generator bearings, the stator windings, ambient (based on T1), and lube oil tank. For enclosed packages, the enclosure interior space temperature is also monitored. Preset warning indications and malfunction shutdown initiation are standard features.

**Audible Alarm.** An audible alarm horn is provided to sound whenever the unit experiences an alarm or shutdown condition. A horn silence push button is mounted on the face of the on-skid turbine control panel.
**Off-Skid Auxiliary Display and Control.** An off-skid Auxiliary Video Display Unit (Auxiliary VDU) is provided to display the operating information and all the data from the on-skid turbine control panel. It is capable of starting and stopping the unit, initiating automatic synchronization, and opening the generator circuit breaker.

In addition to the features and functionality of the on-skid VDU, the following enhanced features are available with the Auxiliary VDU:

- Additional Historical Data
  - 2 Minute Log- 1 Month of daily files
  - 10 Second Log- Last 14 days
- Larger Trigger Log
  - 25 triggered files
- Higher Resolution Screen
- Larger Memory (RAM and non-volatile storage)
- Program Constants
- DVD Reader / CD Writer

The Auxiliary VDU communicates with the on-skid control system via ControlNet 1.5 and may be located within a cable run of up to 2500 feet (762 m) from the package base. The Auxiliary VDU is intended for installation in the control room or other indoor location. The VDU consists of an industrial-grade computer and monitor combination, with a keyboard and a mouse. The system operates using Solar's TT4000 Human Machine Interface (HMI) software.

**Russian / English Screen And Labels.** All display screens, package labels and console labels will be in Russian and English language.

**Ethernet Network Supervisory Interface.** An Ethernet interface module is installed in the control processor rack and connects to the processor through the rack backplane. The user may connect to the module with a standard 10/100 Base T Ethernet cable. Ethernet is suitable for applications up to 100 m (330 ft). Data are transmitted using the Control and Information Protocol (CIP or DF1 protocol). Analog and discrete data are stored in one-dimensional arrays in the control processor, and may be read by the user. In addition, the user may send supervisory control signals to the processor. Data available include all input analogs, a number of computed values, status indications, and all active alarms and shutdowns.

Typical data include:

- Driven equipment status
- Gas producer turbine speed
- Power turbine speed
- Turbine Rotor Inlet Temperature (thru T5)
- Lube oil header pressure
- Lube oil temperature
- Ambient temperature
- All alarms and shutdowns
- All panel light status

Supervisory control signals include:

- Start
- Stop
- Acknowledge / Reset
- Remote Speed / Load Set Point
**Engineering Units.** Temperature data is displayed in °C. Pressure data is displayed in kilo-Pascals (kPa).

**Language.** Package labels and screen displays are in Russian and English.

**Engine Performance Map.** A display of real time engine performance is provided on the auxiliary or remote VDU. The performance data is corrected to standard operating conditions. The performance map software is provided for reference and to monitor engine performance trends.

**Printer / Logger.** One dot-matrix printer is provided to log events, print standard reports and to print screens from the VDU. The printer operates on 240 VAC / 50-60 Hz power.

The following functions are included:

- Status Print - current status of analog and discrete variables
- Alarm Logging - prints alarms with time and date stamp
- Daily Log - prints last 24 hours of elapsed data
- Print Screen - prints current screen on VDU
- Historical Files - prints data from historical files

**Heat Recovery System Interface.** The Turbine Control Panel interfaces with the heat recovery system and receives the following signals from the heat recovery system:

- Heat recovery system malfunction summary (alarm / status display)
- Heat recovery system malfunction summary (turbine shutdown)
- Heat recovery system purge complete (permissive to ignite)
- Turbine start permissive
- Diverter valve fully open limit switch
- Diverter valve fully closed limit switch

The following signals are sent from the Turbine Control Panel to the heat recovery system:

- Begin heat recovery system purge (Turbine 15% speed signal)
- Turbine running status
- Turbine 90% speed signal
- Diverter valve supervisory open / closed

This interface and control is limited to waste heat applications where each gas or dual fuel gas turbine package is operating with it's own dedicated heat recovery system with a diverter valve.

**GENERATOR CONTROL AND MONITORING**

A Combined Generator Control Module (CGCM) is provided and combines the load sharing, synchronization, voltage control, and reactive power control functions. It also provides basic generator protection functions against catastrophic failures. The module performs synchronization in combination with the programmable controller software program, and voltage regulation via the control of the exciter field current. The module will sense the three-phase voltage and the three-phase current, via potential and current transformers. The system also calculates real and reactive power, power factor and the variables required for synchronization.
**Automatic Synchronizing.** An automatic synchronizer is provided with the control system to automatically synchronize the unit to the bus. It will bring the generator into frequency, voltage and phase compliance, and send a signal to close the unit circuit breaker.

**Voltage Adjustment.** A "raise / lower voltage" push button control is provided on the Turbine Control Panel to adjust the voltage set point.

**Vibration Monitoring.** Depending on the level of unacceptable vibration detected, either a warning is indicated or a turbine shutdown is initiated. The generator is instrumented with one velocity transducer per bearing. These are connected to individual transmitters that provide 4-20 mA signals to be read by the turbine package control system.

**KW Import Control.** A kW import controller is provided to control the real load (kW) on the generator set while operating in parallel with a utility or other large source. The kW import controller monitors the load imported from the utility source and adjusts the turbine generator set fuel flow to maintain a pre-set level amount of minimum load.

The import control will allow the import of unlimited power while maintaining the minimum generator power output. This control mode is for applications where power cannot be exported to the utility. Protection against excessive kW load, while in parallel with a large source, is provided by the control system "T5" temperature limiter. The kilowatt load level select switch and set-point adjustments are available through the display panel.

**KVAR/Power Factor Controller.** A kVAR/power factor controller is provided to maintain a constant reactive load (kVAR) output or constant power factor (pf) on the generator set while the unit is operating in parallel with a utility or other large source. The controller applies a signal directly to the voltage regulator adjust circuit to maintain a constant reactive load or power factor with changes in the infinite bus voltage level.

From the HMI the operator can enable or disable the controller, choose kVAR or pf control mode and set the desired set points.

**Manual Synchronization Panel.** A manual synchronization panel is included to manually synchronize the generator across one to four circuit breakers selected by the operator. It enables the operator to raise or lower the frequency and voltage of single or multiple units.

A single selector switch is provided to indicate the selected breaker, and dedicated indicator lights for each breaker to signal the status.

Once both the voltage and frequency meters across the selected breaker backed by the synchroscope and synchronizing lights show compliance, the operator can manually send a signal to close the selected circuit breaker. A utility grade sync check relay that is not supplied with this package and must be provided and installed by others, is used as backup to ensure proper synchronization when a breaker close command is given to the selected breaker.

The panel includes the following:

- Two voltmeters to monitor either side of the circuit breaker
- Two frequency meters to monitor either side of the circuit breaker
- One synchroscope
- Two synchronizing lights
- Breaker status lights
- Breaker control and sync enable switches
- Frequency and voltage raise/lower switches
ACCESSORY EQUIPMENT

Compressed Air. External compressed air is required for use in the self-cleaning turbine air inlet filter described later in this proposal. Reference the “Package Utility Requirements List” for airflow and pressure requirements.

Portable Engine Cleaning System. A portable engine-cleaning cart is provided to supply cleaning fluid to the on-skid engine cleaning system. The cart consists of a stainless steel vessel mounted on four heavy-duty wheels. The cart is designed to mix, hold, and pressurize the cleaning solution, and it includes all the required valves, gauges, connections, and a hand-held spraying nozzle. Compressed air is required for the cleaning cart operation. Reference the “Package Utility Requirements List” for airflow and pressure requirements.

On-Crank / On-Line Cleaning. An on-crank and on-line engine cleaning system is provided. The on-crank mode cleans the engine compressor while the engine is cranking, and the on-line mode cleans the engine while the engine is operating in simple cycle. The systems are independent of each other with two separate customer connections at the side of the base frame.

Cleaning fluids such as water, cleaning products, and emulsified kerosene / water mixtures can be used in engine compressor ingestive cleaning, depending on the cleaning mode. Water and cleaning solutions used for engine cleaning must comply with Solar Specification ES 9-62.

MISCELLANEOUS

Preparation for Shipment. The package is prepared for shipment with long-term preservation per Solar’s Specifications ES 9-248 and ES 9-249, and Product Information Letter (PIL) 097 “Package Preservation and Preparation for Shipment,” including export boxing and foil bagging. While the equipment is stored, the Buyer must arrange for periodic inspections to ensure the packing is not compromised. If still in storage after two years from date of shipment, long-term preserved items should be opened, recharged with desiccant and vapor-proof barriers resealed.

Operation and Maintenance Manual. The Operation and Maintenance Instruction Manual is provided and includes descriptive and instructional data for operating and servicing the turbomachinery package. It contains general, functional, and component descriptions and illustrations of the turbine engine and associated package systems.

The Operation and Maintenance Instruction Manual is written in English and contains the following four (4) volumes. Translation to Russian is not provided in this proposal.

The Systems Operator's Guide is intended for the equipment operator to become familiar with the controls and indicators, which are described and illustrated in detail. Package operating procedures are listed for all operating conditions, and safety precautions are provided to aid in the safe operation of the equipment.

Maintenance Instructions provide the maintenance and field service personnel detailed functional descriptions of package systems and procedures for preventive and corrective maintenance. Preventive procedures include periodic inspection requirements, and alignment procedures and tolerances. For major functional components, corrective procedures are furnished for cleaning, removal, installation, adjustment, and testing.

Supplementary Data consists of supplier information of components and assemblies not covered or fully discussed in the Maintenance Instructions volumes. The data is arranged alphabetically by manufacturer, and is intended for Solar field service technicians.
The Illustrated Parts List contains part numbers, part names, quantities, reference designators, photos, and line drawings to aid the user in locating and ordering of parts.

The Operation and Maintenance Instruction Manual set is provided on CD-ROM. Nine (9) CD’s are supplied for the project. Extra copies may be ordered at any time at an additional cost.

The CD-ROM manual set includes the following features:

- Electronic viewing of data in a windows environment
- All sections of the manual set on one CD
- Search feature including full text search for supplier data
- Ability to open graphics in a separate window for simultaneous viewing of text with the associated illustration
- PDF version for printing
- Package and Control Console photos
- Hotspot links include:
  - Ability to jump from a referenced table or figure to the table or figure icon
  - Ability to view supplier data from links in the Parts List
  - Table of content links

The Operation and Maintenance Instruction Manual set is provided in multiple volume notebooks. Nine (9) copies are supplied for the project. Extra copies may be ordered at any time at an additional cost.

Standard Drawings.

Electronic Document Control. Solar utilizes an Electronic Document Control process based on a collaborative workspace technology. This collaborative workspace allows a single location for project documentation. Document transfers between Solar, Customers, Major Suppliers, and Contractors occurs instantly through this workspace area on the web. Documents are routed, and tracked on a "real time" basis using email tasking and notifications. This process provides immediate access and complete visibility of all project documentation from the Customer “kick-off” meeting, all the way through to commissioning of the project. Upon agreement, users are provided with a user name, password, and instructions. The Electronic Document Control operates on standard Internet protocols, and meets the highest Internet security standards.

Drawings will be available through this system per the schedule detailed below:

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<tr>
<th>Drawings</th>
<th>INITIAL RELEASE</th>
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<tr>
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<td>Weeks (i)</td>
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<td>Weeks (iii)</td>
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<tr>
<td>Electrical Schematic</td>
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<td>Electrical Wiring Diagram</td>
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<tr>
<td>In-Crate</td>
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<tr>
<td>Out-Crate</td>
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<tr>
<td>Start System Schematic</td>
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<tr>
<td>Fuel System Schematic</td>
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<td>Lube Oil System Schematic</td>
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<tr>
<td>Air Drain System Schematic</td>
<td>10 (i)</td>
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<tr>
<td>Software Documentation (iv)</td>
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(i) From completion of initial Customer “kick-off” meeting.
(ii) Upon notification of “Readiness to Ship” unit.
(iii) Upon receipt in San Diego of marked-up field changes to the drawings.
(iv) A CD-ROM of the complete Software Documentation is provided for both the “As-Shipped”, and “As-Installed” releases.
(v) The Mechanical Installation drawing is made up of two sections - an “in-crate” section (genset package), and an “out-crate” section (ancillary equipment including inlet and exhaust systems, lube oil cooler, battery system, etc.).

Three (3) sets of prints may be furnished upon request.

TESTING AND QUALITY ASSURANCE

Package acceptance testing is performed at Solar's factory in accordance with Solar Specifications as generally outlined below. The purchaser or purchaser's designated representative may observe factory production tests scheduled in accordance with production and testing schedules. Unavailability of the purchaser or purchaser’s representative shall not be cause for delay in the performance of the production tests.

**Inspection and Test Plan.** An Inspection and Test Plan (ITP) is provided to describe the Quality Assurance and Quality Control Program requirements for each project. The ITP defines quality requirements for purchased and manufactured material from receiving inspection to the final package inspection. The ITP lists the primary controlling and verifying documents, codes and standards used to define the quality requirements and identifies inspection points. The ITP always includes relevant Solar documentation requirements and can include acceptable Purchaser specified requirements.

**Gas Turbine Engine Testing.** The gas turbine engine is tested in accordance with Solar Specifications to confirm that power, heat rate, and vibration levels meet Solar standards.

**Generator Testing.** The generator is tested in accordance with IEEE Standard Specifications and Solar Specifications at the generator manufacturer's plant. These tests satisfy requirements for NEMA and Solar. Supplier testing is under periodic Solar quality control review to ensure compliance with required specifications.

**Radiography Inspection.** Radiographic inspection is performed in accordance with ASME Section V. Five percent (5%) of each welder's work (circumferential butt welds only) is inspected by radiographic examination in accordance with ANSI/ASME B31.3. The specific manifolds on a given unit may or may not be part of the 5% of each welder's work that is examined.

**Quality Assurance.** All testing operations are conducted under the direct control of Solar's Quality Assurance Activity. This Activity ensures compliance with the specified test limits and procedures.

Quality Control engineers maintain surveillance over the manufacture of all purchased parts and subassemblies, and are responsible for functional testing of incoming components. The same rigid standards applied to parts manufactured by Solar are applied to all parts from suppliers.

**Emissions Testing.** The unit will be tested for exhaust emissions of NOx, CO, and UHC in accordance with Solar Specification ES 9-97.

**Observe on Noninterference Basis.** The purchaser is invited to tour Solar’s Production Test Facilities to observe units undergoing factory production testing at the time, not necessarily the unit(s) purchased.
Quality Control Documentation.  A Quality Control Data Book is provided and contains the following typical data and documents:

- Engine and Package Acceptance Test Report
- Generator Test Report
- Major Ancillary Equipment Certificates of Compliance and ASME Data Reports (as applicable)
- Engine related documentation including casing leak test charts, balance records, and mechanical / electrical run-out records (as applicable).
- Solar Certificate of Compliance
- Documentation from sub-suppliers of major package components such as inlet and exhaust system components, oil coolers, oil filters, gearboxes, and driven equipment. Typical documentation includes shop inspection sheets, material process and inspection certificates, pressure test, and flushing data sheets.
- Solar base skid documentation including welding procedures, welder qualification records, oil tank pneumatic leak test, oil tank coating, dimensional checks, and surface preparation and painting.
- Manifolds and piping documentation including welding procedures and procedure qualification records, x-ray reports (if applicable), and hydrostatic test reports.
- Package assembly and test documentation including package acceptance test report.
- Final Inspection documentation including certificate of compliance.

Canadian Standards Association Certification.  Canadian Standards Association (CSA) Certification is provided and includes:

- Modification to standard package and electrical wiring tests to meet CSA requirements
- Electrical Device Certification List
- CSA Package Type Certification includes control panel and package electrical system

AIR INLET SYSTEM

The air inlet system is designed to supply a clean, smooth airflow to the turbine. The air inlet system pressure loss is low and consistent with the requirements for air filtration and acoustic attenuation. Pressure loss is normally expected to be less than 4 inches (102 mm) of water with a clean air filter. All inlet system components are designed to withstand a 120 mph (193 km/hr) wind load when properly installed.

Self-Cleaning Barrier Air Inlet Filter.  A self-cleaning turbine air inlet filter suitable for any climatic condition is provided for installation in the field. The filter is designed for off-skid installation, supported independently from the gas turbine package. An outlet is located in the back of the filter for ducting connection to the turbine inlet. A leg kit is provided to support the air inlet filter.

Air Inlet Silencer.  An air inlet silencer is provided to reduce air inlet noise to required levels and is intended for installation in the field.

Air Inlet Ducting.  The following air inlet ducting sections are provided.

- Duct section:  7.5 x 7.5 ft, 10 ft long (2.3 x 2.3 m, 3 m long).
- Elbow:  90 degrees, 7.5 x 7.5 ft (2.3 x 2.3 m).

The customer needs to advise Solar of the installed air inlet system configuration so that required ducting can be added.
**EXHAUST SYSTEM**

An exhaust system is provided and designed to ensure a smooth transition from the turbine exhaust to the heat recovery system or the exhaust silencer. Ideally, pressure losses should be as low as possible to provide for best possible turbine performance. Typically, pressure losses will be on the order of 4 inches water column (w.c.) (102 mm w.c.) for a system with a silencer, and on the order of 6 to 10 inches w.c. (152 to 254 mm w.c.) for a system with heat recovery. Exhaust system components supplied by Solar are designed to withstand a 120-mile per hour (193 km/hr) wind load when properly installed.

**Exhaust Silencer.** An in-line exhaust silencer is included, 8 x 8 ft, 10 ft long (2.5 x 2.5 m, 3 m long).

**Exhaust Ducting.** The following exhaust ducting sections are provided for connection to the exhaust silencer. Attaching hardware and gasket are provided for the inlet flange of each component.

- Bellows: 6 ft (1.8 m) inside diameter, 2 ft (0.6 m) long.

**ENCLOSURE**

**Basic Construction.** An all-steel enclosure is provided for the complete package. The enclosure is self-contained, weatherproof, insulated, sound-attenuated, and assembled on the turbine package base.

The enclosure is constructed with a solid roof, and doors that open to provide access and clearance for engine and gearbox removal. Enclosure doors are placed in key locations for access of major components requiring inspection and maintenance, and removal by forklift or overhead crane. Internal maintenance trolley rails are located above the turbine and the gearbox. The enclosure walls and roof are treated with fiberglass material for noise attenuation and thermal insulation. The enclosure is constructed to support a roof load of 50 pounds per square foot and to withstand a wind load of 120 miles per hour.

The package control panel is installed in the exterior wall of the enclosure.

The customer must ensure that the enclosure ventilation air is above 0 deg F.

**Sound Attenuation.** The sound-attenuated enclosure is intended for use with suitable turbine air inlet and exhaust silencing systems in environments where lower noise levels are required. Ventilation openings are equipped with suitable silencers for additional sound attenuation. For additional sound data, reference "Noise Prediction, Guidelines for Industrial Gas Turbines" (Solar publication SPNP/898/4M).

**Exterior Connections.** Connections for the oil tank vent line, ventilation fan wiring, CO₂ fire suppression systems, and the turbine air inlet and exhaust are terminated outside of the enclosure.

**Ventilation System.** The enclosure ventilation is AC motor driven. The fan supplies the airflow required for generator cooling, and ensures that the air temperature inside the enclosure remains within acceptable limits. Openings to provide adequate flow of ventilation air are strategically positioned on the enclosure roof.

**Dust Protection System.** The enclosure inlet vent is equipped with filter units consisting of disposable, barrier type panel filters to remove dust and sand. The exhaust vent also contains back draft dampers to prevent dust ingress when unit is not running.
Fire Detection and Suppression. The complete system required for fire detection and suppression consists of a number of elements, not all of which are in Solar's scope of supply. The design, installation and regulatory approvals for the complete fire system are the responsibility of the owner and must comply with all the requirements and regulations for the geographic area in which it will be installed and operated. When properly installed and tested, the completed system will meet the requirements of the U.S. National Fire Protection Association (NFPA) Code 12. Solar's scope includes:

An automatic, electronically controlled fire detection and monitoring system installed in the enclosure. The primary fire detection system uses multi-spectrum infrared (MIR) detectors due to their superior performance for enclosed gas turbine applications. The secondary fire detection system consists of rate-compensated thermal detectors. The two detection methods operate independently. If fire is detected, the system activates the suppression system and communicates with the Turbotronic 4 package control system to initiate a shutdown.

Indicator lights, strobe lights and an alarm horn mounted on the package exterior. Included are a keyswitch to inhibit the system and a push button switch for manual activation.

Rack-mounted carbon dioxide cylinders that provide primary total flooding distribution and secondary metered distribution to maintain the design concentration of 37% carbon dioxide for 20 minutes.

The following required items are not in Solar's scope of supply:

Approved interconnecting piping, pressure switches and manual lockout valves.

NFPA-12 total flooding test of the system at site.

Combustible Gas Monitor. A single-channel combustible gas monitoring system is provided to continuously monitor for combustible gases within the enclosure. The gas sensor is monitored by the fire and gas detection / release system.

The start signal is interlocked with the combustible gas monitoring system to ensure the atmosphere is clear prior to initiating turbine engine start. An alarm or engine shutdown is initiated if the gas monitor fails.

Inlet Ventilation Silencer. The enclosure ventilation openings are equipped with roof mounted straight-through type silencers.

Exhaust Ventilation Silencer. The enclosure ventilation openings are equipped with roof mounted straight-through type silencers.

Enclosure Lights. 220 VAC incandescent lights are provided inside the enclosure with an on/off switch located near the enclosure door.

Fire Cylinder Cabinet. A weatherproof cabinet is provided to house the CO₂ cylinders. The cabinet has manual pull levers mounted on the cabinet exterior.

CO₂ Isolation Valves, Pressure Switches, and Software. Two (2) 3-way bypass valves with limit switches for off-skid installation; two (2) pressure switches; and the software to control the off-skid CO₂ isolation valves are supplied as part of the Turbine Fire and Gas Detection and Control System.

Test Kit. A test kit is provided for the UV fire detector and gas monitor sensor. The fire and gas system test kit consists of:
• Combustible gas calibration equipment
• Fire system (UV) test light
• Carrying case for test equipment

**Equipment Handling Kit.** A turbine / component handling kit is provided consisting of following:

• External trolley beam extensions with support frame
• Movable chain fall hoists and lift attachments (shackles and lift strap)

**CUSTOMER SERVICES**

**Field Verification Test.** Concurrent with the start-up and commissioning, Solar will perform a site performance verification test of the turbine-generator set following the “Site Test Procedure for Solar PG Generator Sets”. This test is based on recorded data taken from the package instrumentation.

The field verification test confirms the factory engine performance. The results of the field test shall be considered to be a demonstration of the contractual site performance guarantees for:

• Gas Turbine Full Load Output Power
• Gas Turbine Heat Rate

To ensure accurate gas turbine engine performance measurements, the following conditions must be met:

• The Test shall be performed within 30 days of initial startup, and before accumulating 400 hours of operation
• A detergent wash shall be performed before testing
• Before the start of the test period, the gas turbine engine must have operated between 90% and 100% load for a minimum of 4 hours

The customer must provide the following:

• The gas turbine generator set must be completely installed and ready for operation
• The Solar representative shall have free, uninterrupted access to the site for one visit to complete the test procedure
• The capability to operate at 100% load
• A laboratory analysis of the fuel that includes the Lower Heating Value

**5-Day Operation & Routine Maintenance Course (O&M), Customized.** The Operation & Routine Maintenance course is developed as an introduction and orientation course that begins with the fundamentals of operation and routine maintenance of a typical Solar turbine package, and progresses through a functional description of each system and its components. The topics covered include: turbomachinery package description, turbine engine, start system, lubricating system, fuel system, generator operation, control system, safety, operating procedures, turbine performance, and routine maintenance.

A student workbook is supplied on the first day of class; and a Certificate of Completion is awarded to participants at the successful completion of each course.

This course is custom tailored based on a needs assessment discussion between the Customer and Solar, it takes into account the customer’s specific package configuration, and utilizes standard course content along with the use of the customer’s package drawings and set points, as well as other particular information unique to their application. The course is limited to 15 participants per session.
There are no prerequisites for taking this course.

The customer is responsible for contacting their local sales office to assess and discuss course content, location and schedules.

The customer also needs to confirm the booking and reservation for the customized class at least 60 days in advance, coordinating with the local Solar sales office; or directly with Solar’s Technical Training department by phone or fax to the Registrar located in San Diego, CA:

*The dates reserved are subject to rescheduling to mutually acceptable dates based on project progress, instructor availability and other factors.*

All registrations will be acknowledged upon receipt, then confirmed by the Registrar 30 days prior to the course date. Solar Turbines does not provide compensation for nonrefundable travel plans, including airline tickets, it is therefore recommended that the customer not commit to nonrefundable transportation arrangements until receipt of the 30-day confirmation.

The course can be conducted at the San Diego training facility which would include a factory site visit of Solar’s main packaging operations, located adjacent to the training facilities in San Diego. Arrangements can be made to conduct the training at alternate Solar training sites or at the Customer’s location.

All course materials and presentations are in English unless otherwise arranged.

Participant travel expenses, lodging, transportation and meals are not included.

For courses at the Customer’s site, the instructor travel and expenses are not included. They will be billed separately at cost.

**Start-up / Commissioning Consumable Parts with Hand Tool kit.** This start-up set includes parts that are most commonly consumed during the normal equipment start-up and commissioning process. It also includes a standard hand tool kit for remote or international sites where SAE hand tools are not available. The complete set is shipped to the customer site to be on hand at the time of start-up in order to provide for the immediate on-site availability of these parts, helping to minimize delays in the commissioning process. The parts included in this set are:

- One (1) spare hydraulic fitting kit
- One (1) set of lube-oil and fuel filtration elements for each package
- One (1) SAE hand tool kit
- An assortment of gaskets, o-rings, other sealing media, and miscellaneous electrical components

**Operation Consumable Parts - 1 Year.** A one-year supply of consumable parts routinely used during the operation and maintenance of the turbomachinery is supplied with this service parts set. The set includes lube oil and fuel filtration elements to support one (1) year of scheduled maintenance, as well as consumable items such as gaskets, o-rings, and other sealing media used to facilitate minor and routine operational maintenance tasks.

The turbine combustion air inlet elements are not included in this set. Insurance parts and other non-consumable items are not included in the price for operational consumables and can be quoted separately upon request from the customer after completion of project engineering and bill of material finalization.
SCOPE CLARIFICATIONS AND EXCLUSIONS

PACKAGE CERTIFICATION.

Solar is supplying a CSA certified NEC package. No modifications are included to comply with GOST or other Russian or European standards.

BASIC PACKAGE

The Customer is responsible for any and all civil works, including anchor bolts, above and below ground. The Customer is also responsible for the unloading, positioning, and installation of all equipment provided by Solar.

The Customer must provide site power, external cabling to and from specified limits of supply (as defined in Solar’s proposal), electrical assembly, local interconnections, external wiring, and electrical utilities necessary for construction, installation, and testing.

Solar is not responsible for distribution of water during construction; HRSG make-up water tanks, deaerators, and water treatment plants; external piping to and from limits of supply (as defined in Solar’s proposal); and mechanical assembly of interconnect piping; and water utilities necessary for construction, installation and testing. The Customer is also responsible for all potable water supplies, drainage and sewage systems.

Site facilities, such as maintenance structures, offices, sanitary facilities, storage rooms, etc. are the Customer’s responsibility. The Customer must also provide all external lighting, lightning arrestors, and earthing.

The Customer is responsible for all site preparation, waste removal, preparation of site access roads, and site permits and licenses (e.g. construction, air, fire, and working permits). All working visas, approvals and requirements of local authorities, taxes, duties, fees and custom clearance levied in the country of installation must be supplied by the Customer.

Electrical Systems. AC contactors and motor starters are not included.

Package Wiring Interconnection. The turbine-generator package includes blank plates for electrical interconnection. It is the Customer’s responsibility to penetrate these plates, supply the cables or conduits, and route them to the terminal boxes and/or motors within the package.

Package Grounding. The Customer is responsible for grounding each turbine-generator package per local and/or NEC codes. The panel instrument and physical grounds should have individual ground cables to the Customer ground. Installation looping or daisy-chain of grounds between packages is not permitted.

START SYSTEM

Direct Drive AC Start Motor. The direct drive AC start motor’s variable frequency drive (VFD) controller requires installation in a clean and dry environment by the Customer.
FUEL SYSTEM

The Customer must supply all fuels and interconnection fuel piping for the installation, testing, and operation of the gas turbine generator set at the required package skid edge pressures, temperatures and flows as defined by Solar. All fuels must meet the requirements of Solar Specification ES 9-98.

LUBE OIL SYSTEM

Lube Oil Vent Separator. A separator support structure, and the interconnect piping between the package flanges and the lube oil vent separator must be supplied by the Customer.

Lube Oil Cooler. The Customer must supply all interconnect piping between the generator set skid edge flanges and the lube oil cooler. The piping must be heat traced.

Lube Oil Cooler Motor. The lube oil cooler motor's variable frequency drive (VFD) controller requires installation in a clean and dry environment by the Customer.

Lube Oil. The Customer must supply all lube oil required for the operation of the turbine-generator set. All lube oil must meet the requirements of Solar Specification ES 9-224.

CONTROL SYSTEM

Auxiliary Desktop Computer and Monitor. The Customer must supply the wiring from the generator set package to the auxiliary desktop computer.

Ethernet Network Supervisory Interface. The Customer is responsible for providing the hardware and software interfaces to the system.

Heat Recovery Interface and Diverter Valve Control. The turbine control does not provide control for the duct burner or other components in the heat recovery system.

GENERATOR CONTROL AND MONITORING

Sync Check and Generator Protective Relays. Utility grade approved generator protection relays are not provided, and must be supplied by the Customer.

Motorized Voltage Adjust. An additional raise / lower switch is not provided to adjust the voltage set point from a remote location.

Manual Synchronization Panel (Multiple Breakers). For each circuit breaker, a dedicated utility grade sync check relay is required and must be supplied by the Customer.

ACCESSORY EQUIPMENT

Compressed Air for Self-Cleaning Filter. The Customer must provide compressed air for use in the self-cleaning turbine air inlet filter, and the interconnect piping between the compressed air source and the self-cleaning filter.
MISCELLANEOUS

CD-ROM Operation and Maintenance Instruction Manuals. The CD-ROM manual set requires a computer provided by the Customer with the following minimum requirements:

- Processor: 486 mHz or better
- Operating System: Windows® 3.1, 95 or higher or NT®, UNIX® or Macintosh®
- RAM: 16 MB or better
- Available hard disk space: 9 MB or more
- CD-ROM reader drive speed: 2X or faster
- Software: Netscape Navigator™ Version 4.0 or higher or Internet Explorer™ 4.0 or higher

EXHAUST SYSTEM

For projects where ducting is supplied by the Customer and not Solar, it must be ensured that the components supplied by others are capable of handling high temperature gases on the order of 1000°F (540°C). Specific exhaust flow rate and temperature data is included with the performance data in this proposal.

Exhaust Silencer. The Customer must support the exhaust silencer independent of the enclosure.

Exhaust Ducting. All exhaust ducting must be supported by the Customer independent of the enclosure to maintain loads on engine exhaust within the limits set by Solar’s Mechanical Installation drawing. The Customer must also supply personnel protection, insulation and/or lagging.

ENCLOSURE

Exterior Connections. Connections for oil tank vent line, ventilation fan wiring, CO2 fire suppression systems, and turbine air inlet and exhaust are terminated outside of the enclosure. All electrical wiring and mechanical piping external to the generator set package to these connections must be supplied by the Customer.

CO2 Isolation Valves, Switches, and Software - Off-skid. Our standard offering will NOT provide the interconnecting CO2 piping between the bottles and the enclosure, the wiring to the switches and valves, the installation of the switches, valves, piping, nor the on-site "total flooding" dump test.

The fire and gas detector and suppression system is designed to substantially comply with NFPA-12 (2005).

- NFPA-12 (Paragraph 4.5.4.11 & 4.5.5) requires manual "isolation" lockout valves and pressure switches between the CO2 discharge bottles and the enclosure.
- Solar provides the valves and pressure switches per NFPA-12 (2005) par. 4.5.4.11 & 4.5.5. The hardware will be provided as loose ship hardware and not installed. [Solar will provide “end-of-line” resistors to install in the circuit]
- NFPA-12 (2005) requires a “total flooding” test of the system at site. This is not provided by Solar.

Total compliance to NFPA-12 requires collaboration between the customer and the AHJ (authority having jurisdiction). Solar can provide technical support.
CUSTOMER SERVICES

Travel and daily subsistence costs have not been included for the work done at the sites. This includes site testing and site training.

ROSEMOUNT TRANSMITTERS

Rosemount smart transmitters cannot be swapped out in place of our standard transmitters.
1.3 Utility Requirements.

The following project utility requirements are preliminary and subject to change after receipt of order.

COLD WEATHER MODIFICATIONS

The customer must maintain an above 0 deg F temperature inside the room when the gas turbine(s) are shut-down. In addition, it is the customer’s responsibility to keep the temperature inside the gas turbine enclosure above 0 Deg F. This will require heating the ventilation air.

PACKAGE CERTIFICATION

Solar is supplying a CSA certified NEC package. Customer confirmed NEC is acceptable and that no efforts are required to comply with Russian or European standards.

ELECTRICAL SYSTEM

3-Phase AC Power Rating
Unless otherwise noted, all 3-Phase AC power is rated as follows:
Voltage / Frequency 380 VAC / 50 Hertz

1-Phase AC Power Rating
Unless otherwise noted, all 1-Phase AC power is rated as follows:
Voltage / Frequency 220 VAC / 50-60 Hertz

GENERATOR

Space Heater Power 1 to 3 kW, 1-Phase

10.5 kV, 50 Hz, B Rise GENERATOR
Abb is the preferred supplier due to the extreme temperatures.

START SYSTEM
**Starter Motor**

- **Type**: AC Motor with Variable Frequency Drive
- **Motor Power**: 93 kW (125 hp) ea of 2 motors, 3-Phase
- **VFD Rating, Input Current (max)**: 570 Amps
- **Space Heater Power**: 200 W, 1-Phase
- **Additional Start System Requirements**: See Solar Publication PIL 149

**NATURAL GAS FUEL SYSTEM**

**Natural Gas Fuel Requirements**

- **Gas Fuel Supply Pressure (ISO) (i)**: 338 psig (2330 kPag)
- **Gas Fuel Supply Pressure (min/max)**: 255 to 382 psig (1758 to 2634 kPag) at 130 to -40°F (54 to -40°C) Ambient
- **Gas Fuel Supply Pressure (design max)**: 500 psig (3448 kPag)
- **Gas Fuel Flow Demand Rate (max)**: 3225 SCFM (86 Nm³/min)
- **Gas Fuel Supply Temperature (min/max) (ii)**: -40 to 200°F (-40 to 93°C)

Please refer to fuel pressure curves provided for site minimum pressure requirements.

**Note:**

(i) Pressure required for full power, gas only, SoLoNOx turbine operating on San Diego natural gas at sea level, 3" inlet and 3" exhaust losses, 60% relative humidity, and at ISO air inlet conditions, 59°F (15°C), 14.696 psia (101.325 kPa). Consult Solar Engineering for fuel requirements operating on other fuel types and engine configurations.

(ii) And at least 50°F (27.8°C) above fuel dewpoint.

**LUBE OIL SYSTEM**

**Pre-Post Lube Oil Pump**

- **Type**: AC Motor-Driven
- **Motor Power**: 5.6 kW (7.5 hp), 3-Phase
- **Space Heater Power**: 25 W, 1-Phase
- **Lube Oil Quality**: See Solar Specification ES 9-224

**Backup Lube Oil Pump**

- **Type**: 120 VDC Motor-Driven
- **Motor Power**: 0.75 kW (1 hp)
- **Space Heater**: None

**Lube Oil Tank Heater**

- **Motor Power**: 20 kW (27 hp), 3-Phase

**Air / Oil Cooler**

- **Type**: AC Motor-Driven
- **Motor Power**: 7.5 kW (10 hp), 3-Phase
- **Space Heater Power**: 25 W, 1-Phase
- **Air Supply Temperature (max)**: 110°F (43°C)

**LUBE OIL COOLER**

A custom lube oil cooler will be provided for the site's ambient.
CONTROL SYSTEM

Local Control Panel
Type On-Skid
Voltage / Amperage 24 VDC at 30 Amps
Voltage / Amperage 120 VDC at 10 Amps

Note:
The console 24 VDC power is supplied from the package 120 VDC control/accessory battery system.

Auxiliary Desktop Display
Phase / Amperage 1-Phase at 20 Amps

RUSSIAN / ENGLISH SCREEN AND LABELS

All display screens, package labels and console labels will be in RUSSIAN AND ENGLISH language.

SUPERVISORY INTERFACE

Confirm supervisory interface at kick off meeting.

ENGINEERING UNITS

Confirm engineering units at kick off meeting

RUSSIAN / ENGLISH SCREEN AND LABELS

All display screens, package labels and console labels will be in RUSSIAN AND ENGLISH language.

Printer / Logger
Voltage / Phase / Frequency 240 VAC / 1-Phase / 50-60 Hertz

ISLAND MODE INSTALLATION

Units will initially be installed in island mode; but will be grid connected at a future date.

MANUALS

The manuals, drawings and other documention (other than that specified) will be provided in English only.

AIR INLET SYSTEM

Self-Cleaning Air Inlet Filter
Type Updraft, Back Outlet, 1-Phase
Air Flow Demand Rate 9 SCFM (0.24 Nm³/min)
Air Supply Pressure (min/max) 80 to 100 psig (552 to 690 kPag)
Filter Pressure Drop, Clean 1 in (25.4 mm) H₂O
AIR INLET FILTER SYSTEM LEG KIT

Leg Kit to support filter

Solar will provide a leg kit for the self cleaning barrier filter. Leg kit will include a maintenance platform consisting of an access ladder, platform, railings, and grading. Installation of this equipment will be by others at the site.

CUSTOMER TO ADVISE AIR INLET SYSTEM CONFIGURATION

The customer needs to advise Solar of the air inlet system configuration. At this time 1 x 10 ft air inlet duct is provided.

ENCLOSURE SYSTEM

Package Enclosure
Type Complete Package Enclosure
Sound Attenuation Average 85 dBA at 3ft (1m) from the enclosure, at a height of 5 ft (1.5 m), when installed in a free-field

Enclosure Ventilation Fan
Type AC Motor-Driven
Motor Power 22.4 kW (30 hp), 3-Phase
Space Heater None

Enclosure Lights
Type AC, Incandescent
Power 1000 W (200 W per fixture), 1-Phase

COLD WEATHER MODIFICATIONS
Cold weather modifications to include enclosure exhaust recirculation, space heaters, etc. need to be considered.
TITAN 130 FUEL PRESSURE CURVE-ELEVATION 50 FT
Titan 130 T20501S SoLoNOx
4.5 in H2O Inlet loss - 10 in H2O Exhaust Loss - Elev 50 ft

Engine Inlet Air Temperature T1 [Deg F]

Minimum Skid Edge Pressure [psig]

Fuel Gas
Wobbe = 1212.3
S.G = 0.5643
Temperature = 60 Deg F
Includes 15 psi for Gas Fuel Filter
TITAN 130 FUEL PRESSURE CURVE-ELEVATION 850 FT
Titan 130 T20501S SoLoNOx
4.5 in H2O Inlet loss - 10 in H2O Exhaust Loss - Elev 850 ft

Fuel Gas
Wobbe = 1212.3
S.G = 0.5643
Temperature = 60 Deg F
Includes 15 psi for Gas Fuel Filter
Section 4.0

Available Services and Agreements

(not included in Bid)
AVAILABLE SERVICES

TOTAL SUPPORT CAPABILITIES

Solar Turbines Incorporated, as the Original Equipment Manufacturer (OEM) solution provider, stands behind each of our customers with uncompromising commitment to the success of their turbomachinery installations throughout the equipment’s entire life-cycle. Solar maintains its own worldwide Customer Services organization, which offers a direct single-point contact to meet customer needs for the complete turbomachinery system throughout its operational life. This may include responsibility for installation assistance, start-up/commissioning service, asset management, contract maintenance programs, technical training, service parts, package refurbishment and overhaul services.

INSTALLATION AND COMMISSIONING

In general, the customer's contractor or Solar's Construction Service organization is responsible for the installation of the turbine generator package and its related equipment, depending on project complexity, customer preference and experience. It is not uncommon for Solar's Customer Services/Field Service organization to become involved at various times throughout the installation phase (as opposed to being involved only in the Start-up / Commissioning phase) of the project. Customers and contractors may experience difficulties to some degree and require advice and assistance regarding such areas as interpretation of drawings and installation instructions, identification of support equipment, additions or deletions of hardware, and re-sizing or re-routing of lines or wires. Complex projects have realized a considerable reduction in installation time by assigning a designated Solar Field Service Representative (FSR) on a continuous basis throughout the installation.

Since the amount of time required for installation assistance can vary significantly depending upon customers and contractors, as well as size and complexity of the job, it is generally desirable and necessary to quote at the standard daily rate for the estimated number of days required. A flat fee or lump sum is appropriate only for large complex projects where planning reflects the use of FSRs continuously during installation. Fixed price quotations for a large project can be supplied upon request.

**Installation Supervision.** Solar's Technical Representative will provide the supervisory assistance necessary or requested for the installation and interconnection of Solar's turbomachinery and its support systems with either the site process equipment, the power distribution equipment, and other turbine package related ancillary equipment, heat recovery equipment, and emissions reduction systems.

Solar's Technical Representative normally acts in an advisory or consulting capacity. Labor, material, fabrication and installation tools, lifting equipment, etc., should be furnished by the customer, customer's representative (contractor) or Solar's Construction Services organization as applicable.
**Commissioning Assistance.** Solar's Technical Representative can provide the supervisory assistance and guidance necessary to ensure that the equipment has been properly installed, interconnected with other equipment, calibrated and is operated in accordance with Solar's specifications and good engineering practices. This can improve equipment reliability and help reduce the potential for subsequent operational problems due to poor installation or operating practices. The equipment will also be tested statically and operationally to the customer's satisfaction at the completion of the commissioning phase.

**ENGINE OVERHAUL, EXCHANGE, AND REPAIR**

Solar offers comprehensive overhaul and repair support for its entire gas turbine product line. A Solar gas turbine major overhaul consists of a complete refurbishment of the gas turbine in order to ensure that performance can be restored to Solar's current production standards for mechanical configuration and aerothermal performance. As part of the overhaul program, Solar offers an exchange fleet with major assemblies and entire engines available to keep customer downtime to a minimum.

**EXTENDED SERVICE AGREEMENTS**

In order to better serve our customers, Solar Customer Services, offers Extended Services Agreement. Extended Service Agreement (ESA) enhances the machine availability, reduces equipment life cycle cost and offers planned regular, predictive, and proactive maintenance service to the customer. ESA absorbs the risk of equipment failure and as an option offers availability guarantees. The following briefly describes the ESA options currently available. Table 1 below shows in greater detail the coverage provided by each offering. The shaded cells highlight the coverage’s that differ from Level I.

**ESA – Extended Service Agreement** (Long Term Service Agreement) provides for overhauls and repairs as required. The term for Level I can be from 5-15 years. Renewal is available at the price of current agreement with set escalations.

**Technical Education Services and Training** consists of the development of personnel. Agreements can optimize this investment for our customers through programs designed to meet customer personnel training objectives. The main programs include standard or customer tailored classroom training, on-the-job training, and vocational skills development programs.