Solar® Turbines
A Caterpillar Company

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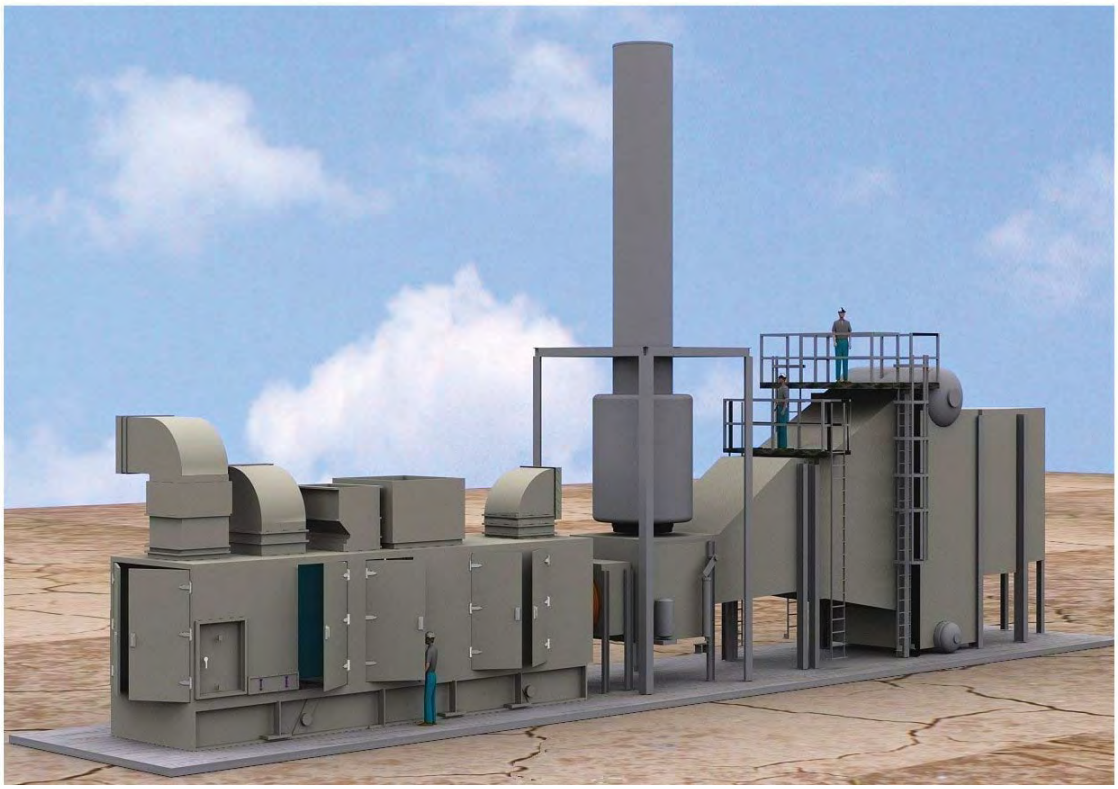

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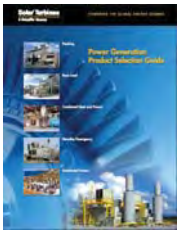
BASIC PACKAGE OVERVIEW

The basic gas turbine generator set is a completely integrated, fully operational package consisting of a gas turbine, gearbox, and generator, and all accessories and auxiliary systems necessary for normal operation when installed in suitable facilities.

Designed specifically for industrial service, the generator set is a compact product requiring high power density, and minimum floor space for installation. The generator set is a completely integrated package ready for installation.

Approximate overall weight/dimensions are:

Weight/Dimension Info:		
Weight (dry):	~136,214 lb	~61,755 kg
Length:	~36’ 3”	~11.05 m
Width:	~10’ 1”	~3.10 m
Height (enclosed)	~12’ 1”	~3.68 m



Solar’s Power Generation Product Selection Guide is available via www.solarturbines.com, and provides a handy reference to Solar’s broader product line, including weghts and dimensions.

The gas turbine generator set package includes:

- Industrial gas turbine with air inlet collector and exhaust diffuser
- Axially split compressor case in the vertical plane, housing an axial flow compressor with variable geometry control on the inlet guide vanes
- Reduction gearbox with accessory drive pads
- Generator and associated equipment
- On-skid *Turbotronic 4* control system with touch screen control panel
- Direct-drive AC start system
- Fuel system(s)
- Lubricating oil system

Baseframe. The above major components are installed on a heavy-steel base frame, also referred to throughout this document as the skid. The skid is a structural steel assembly with beam sections and cross members welded together to form a rigid foundation. Drip pans are welded within the base to collect any potential liquid spills, and four (4) lifting eyes are welded to the externally. Package connection points for fuel, lube oil, air, and water are conveniently located on the outer edge of the skid.

Gas Turbine Package Orientation:
Througout this proposal, all references to package orientation (left, right, clockwise, counterclockwise, etc.) are based on standing at the “aft” end of the package looking forward. The “aft” end of the package is always the same end as the turbine engine exhaust.

Electrical System. Electrical connections are made in onskid junction boxes. Machined mounting surfaces on the baseframe facilitate major component alignment. The gearbox is bolted directly to the engine and coupled by means of a splined interconnecting drive shaft that eliminates the need for field alignment. The gearbox and generator are connected by means of a flexible dry-disk, shear-type coupling enclosed in a spark-proof coupling guard. Jacking point are provided to facilitate alignment of the generator to the gearbox.

Scope Clarification:
Wiring methods used for field connections to the package shall be consistent with the gudelines for NEC Class I, Div 2 areas. Otherwise, sealing will be required for all the wiring as it enters the enclosure due to the change of the rating from unclassified/non-hazardous to Class I, Div 2.

Unless otherwise noted, package motors and heaters are rated for:

- 460 VAC / 60 Hz / 3 Phase

Unless otherwise noted, single phase package loads (such as lighting, space heater loads, etc.), and the off-skid battery charger are rated for:

- 120 VAC / 50/60 Hz

Specific package electrical loads are identified on the Utility List, beginning on page 73.

GAS TURBINE PACKAGE: *CODES, STANDARDS, and CERTIFICATIONS*

The gas turbine generator set package systems are designed in accordance with, and are tested to the applicable requirements for the following industry codes and standards:

AGMA 2001-C95: *Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth*

AGMA 6001-C88: *Design and Selection of Components for Enclosed Gear Drives*

AGMA 6011-G92: *Specification for High Speed Helical Gear Units*

AGMA 6025-C90: *Sound for Enclosed Helical, Herringbone and Spiral Bevel Gear Drives*

ANSI Z223.1: *National Fuel Gas Code*

ASME B31.3: *Process Piping*

Applicability:

- All piping with a diameter of up to 4" NPS are made of stainless steel. Package piping is designed and fabricated to ANSI B31.3.
- Piping with a nominal diameter of greater than 4 inches NPS may be carbon steel.
- All tubing is stainless steel; tube fittings are stainless steel with *Swagelok* compression fittings.

ASME Code Section VIII: *Pressure Vessel Design*

AWS D1.1: *Structural Welding Code – Steel*

Applicability:

- Structural Welding

Factory Mutual (FM)

Applicability:

- Fuel safety shutoff system.

IEEE 115: *Guide for Test Procedures for Synchronous Machines*

Applicability:

- Required by suppliers of generators to Solar for integration with the gas turbine generator set package.

NEMA MG1: *Motors and Generators*

Applicability:

- Generator construction
- Generator ratings

NFPA 12: *Standard on Carbon Dioxide Extinguishing Systems*

Applicability:

- Fire suppression system
- The CO2-based fire detection and supression system

> Scope Clarification:
> When the turbomachinery equipment described herein is installed inside of a building, additional devices/engineering may be required for full compliance with NFPA 12. This incremental scope of work and equipment is not provided by Solar.
>
> Reference Section 1.0: Fire Suppression System for additional information.

NFPA 37: *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*

NFPA 68: *Guide for Venting of Deflagrations*

NFPA 70: *U.S. National Electrical Code (NEC)*

Applicability:

- Electrical equipment contained within the gas turbine generator set package.
- Area classification:
  - ❑ The onskid electrical equipment is designed for installation in a Class I, Div 2, Group D hazardous location.

> Scope Clarification:
> The Buyer is responsible for working with the local authority to establish the proper area classification and for notifying Solar of the classification.

NFPA 72: *National Fire Alarm and Signaling Code*

Applicability:

- Fire suppression system

OSHA: *Occupational Safety and Health Administration*

Applicability:

- Where applicable to gast turbine generators sets

SSPC: *The Society for Protective Coatings*

Applicability:

- Implentation of Solar's Engineering Specification ES 9-58: *Standard Paint Program – Turbomachinery*

> Clarification:
> Solar cannot guarantee that the proposed equipment herein will comply fully with the broad requirements set forth by industry codes and standards, nor can we accept blanket clauses stating that, "where specific requirements listed by industry codes and standards contradict or overlap, the stricter of the two will apply." Instead, and where specifically requested by the Customer, Solar will review a requirement within a referenced code or standard, and issue a formal position relative to compliance.

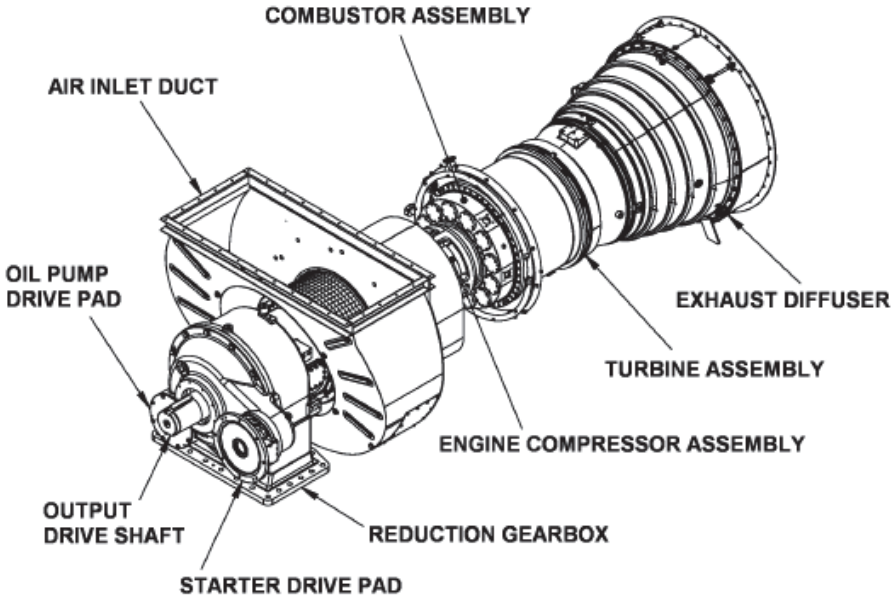
Gas Turbine Generator Set Package Certification

Solar Turbines is an Industry Standards Organization (ISO) 9000 company with ISO 9001:2008 certification. Several *Solar* gas turbine product models have received Type Certificates of Compliance issued by the Canadian Standards Association (CSA-International) to demonstrate the product's compliance with applicable North American Codes and Standards. CSA is a Nationally Recognized Testing Laboratory (NRTL) recognized by the Occupational Safety and Health Administration (OSHA) and the Standards Council of Canada to perform certification to U.S. and Canadian standards.

This package has received a Type Certificate of Compliance from CSA-International. Documentation includes a Certification Device List but not individual device certificates.

GAS TURBINE ENGINE

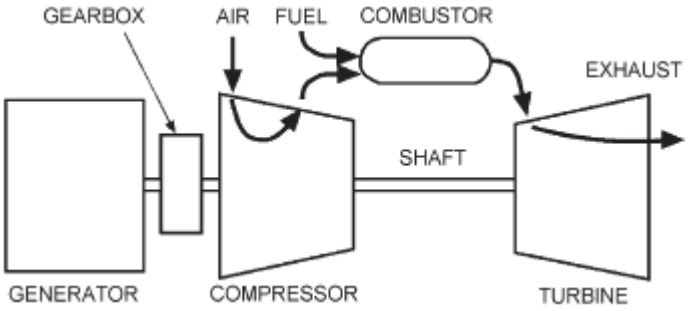
The *SoLoNOx* Taurus 70 is a self-contained, completely integrated prime mover of a single shaft, axial flow design. Its design embraces Solar's fundamental engineering principles of long life and low maintenance – qualities you'd expect in a product intended for industrial use.



Principles of Operation. The continuous power cycle and rotary motion of the single-shaft gas turbine provides several advantages over other types of engines. These advantages include:

- Low weight,
- Relatively vibration-free operation,
- Fewer moving parts (and correspondingly fewer wear points), and
- Higher quality AC power

Air is drawn into the air inlet of the gas turbine and is compressed by the multi-stage axial-flow compressor. The compressed air is directed into the combustion chamber at a steady flow. Fuel is injected into the pressurized air within the annular combustion chamber. During the gas turbine start cycle, this fuel/air mixture is ignited and continuous burning is maintained as long as there is adequate flow of pressurized air and fuel. The hot, pressurized gas from the combustion chamber expands through and drives the turbine section of the engine, dropping in pressure and temperature as it exits the turbine. Thus, the energy of the fuel is transformed into the kinetic rotational power of the turbine output shaft.



The turbine shaft is mechanically attached to both the compressor and turbine sections of the gas turbine to form a “solid” or “single” shaft configuration. This feature enhances speed stability and response under both constant and varying load conditions – a highly desirable feature in industrial power generation applications requiring precise frequency control.

For stoichiometric combustion, the gas turbine requires approximately one-fourth of the total air it compresses. The excess air is used to cool the combustion chamber and mixes with the combustion products to reduce the gas temperature at the inlet to the first turbine stage. The cooling air also keeps surface metal temperatures in the combustion chamber and turbine sections at required design levels to ensure long component lives.

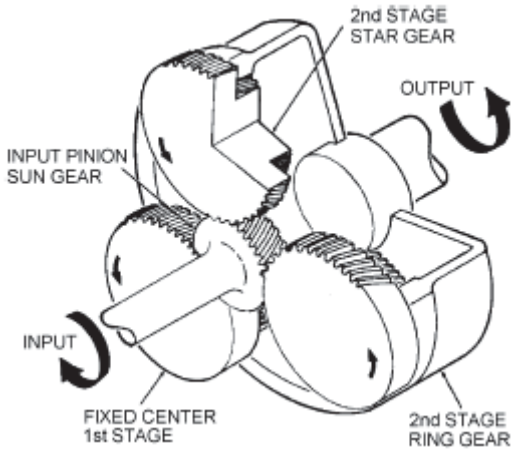
The *SoLoNOx* combustion system utlizes Solar’s proprietary lean-premixed dry emissions system to reduce the formation of criteria pollutant combustion products such as nitrogen oxides (NOx) and carbon monoxide (CO) by limiting peak flame temperature during combustion.

Titan 70 Gas Turbine Specifications:

Compressor	
Type:	Axial
Number of Stages:	14
Compression Ratio:	16.5:1
Combustion Chamber	
Type:	Annular; *SoLoNOx*
Ignition:	Torch
Number of Fuel Injectors:	12
Turbine	
Type:	Reaction, Axial Flow
Number of Stages:	3
Speed	15,200 rpm

SPEED REDUCTION GEARBOX

Reduction Gear. The reduction gearbox is a rugged industrial product designed by Solar. It is of the epicyclic "star compound" design, using fewer parts than conventional epicyclic gear designs, yielding higher reliability and ease of assembly/disassembly.



The gearbox is mounted to the oil tank on the baseframe, and the gas turbine is bolted directly to the gearbox. The gas turbine and gearbox are coupled by means of a splined interconnecting drive shaft, eliminating the need for field alignment.

The gearbox and generator are connected by means of a flexible gear, shear-type coupling enclosed in a spark-proof coupling guard. Jacking points are provided to facilitate alignment of the gas turbine and gearbox/generator combination. This close-coupled arrangement allows precision alignment, faciliated by jacking bolts. Alignment tooling is provided.

The gearbox includes accessory pads to accommodate the start motor, and lubricating oil pump.

Alignment Tool. One (1) set of alignment tooling is provided, per sales order, to align the reduction gearbox output shaft with the generator input shaft.

GENERATOR

Unless otherwise stated, the generator is rated per NEMA MG1 standards, and shall meet or exceed gas turbine performance over an ambient temperature range of 0 – 120°F (-18 – 49°C), and up to a maximum altitude of 3,281ft (1,000 m).

Please reference Solar Engineering Specification ES 2252. It establishes the physical characteristics and performance standards of alternating current generators for use with Solar Turbines Power Generation Market packages including:

- Centaur,
- Mercury,
- Taurus,
- Mars, and
- Titan

The Saturn package is not covered by this specification.

It is applicable to Open Drip Proof (ODP) and Totally Enclosed machines.

Design Specifications. For 60 Hz applications, the generator is constructed per NEMA MG 1. For 50 Hz applications, the generator is constructed per IEC 60034 or NEMA MG 1.

Generator Certifications. The equipment shall be in compliance with the Canadian Electrical Code (CEC), certified by an agency authorized by the Standards Council of Canada (e.g. CSA, UL) and National Electrical Code (NEC), certified by a Nationally Recognized Testing Laboratory (e.g. CSA, UL) for use in Class I, Division II hazardous locations, Groups B, C and D.

Standard Features. The synchronous brushless revolving field generator shall be of independent two-bearing design with a shaft extension suitable for direct drive by a gas turbine engine, and includes the following accessories:

- Permanent magnet alternator
- Anticondensation space heaters (see the Utility List on page 73 for specific loads)
- Terminal box for medium voltage terminations
- Permanently-affixed rating nameplate(s)

Generator and Associated Equipment Specifications:

Enclosure Construction	Open Drip Proof (ODP)
Generator	
Voltage Rating:	12,470 VAC; 60 Hz; 3 Phase NEMA Class H Insulation Class B (80°C) Rise. **See Note a**
kW	7,600 kW at 40°C
KVA	9,500 kVA at40°C
Number of Leads:	6
Connection:	Wye
Stator Windings:	2/3 Pitch, Form Wound
Overload Capacity:	110% Rated Current for Two (2) hrs 150% Rated Current for One (1) min
Overload Compliance:	NEMA
Short Circuit Capability:	300% for 10 sec
Overspeed:	125% of Rated Speed for 1 min
Wave Form Characteristics	
Maximum Deviation Factor:	10%
Harmonic Content Open Circuit L-L:	3%
Telephone Interference Factor:	
Balanced:	100
Residual:	75
Space Heater	
Voltage:	120 VAC
Frequency:	same as generator
Temperature Monitoring	
Generator Driven End Bearing:	One (1) 100 Ω at 0° C (32° F) platinum RTD
Generator Exciter End Bearing:	One (1) 100 Ω at 0° C (32° F) platinum RTD
Generator Windings (3 phases):	Two (2) 100 Ω at 0° C (32° F) platinum RTDs per phase
Rotor	
Rotor Type	4-pole (laminated), salient pole
Bearings	
Bearings	Two Bearing, Sleeve-type; Oil Lubricated
Lubrication	The Lubrication System is common with the gas turbine (see pg 25 for description). Lube oil is customer-furnished, quality must conform to Solar's Engineering Specification ES 9-224.
Vibration Monitoring	
Generator Bearing (driven end):	Two (2) Bently Nevada 3300 XL proximity probes, cables and proximitors designated "X" and "Y" in accordance with API 670
Generator Bearing (exciter end):	Two (2) Bently Nevada 3300 XL proximity probes, cables and proximitors designated "X" and "Y" in accordance with API 670
Generator Bearing (exciter end):	key Phasor

Notes:

(a) The 80°C (144°F) temperature rise is based on the generator NEMA nameplate rating at 40°C (104°F), and a power factor of 0.8 for continuous duty service.

Generator Terminal Box:

- Left Side Mounted Terminal Box, as viewed from Exciter End, with provisions for Top Lead Entry
- See page 43 for supplied transformers
- Surge Capacitor
- Lightning Arrestor

Generator Custom Features:

- #8 AWG CT wiring
- 2/3 Winding Pitch
- Generator removal tool hole pattern provisions

Generator Data Sheets:

- Provided upon request.

VOLTAGE REGULATION

Voltage Regulator Characteristics. The voltage regulator characteristics are as follows:

- Solid State
- Three-phase sensing (single-phase sensing can be accommodated)

Steady-state Stability. Steady-state voltage regulation is defined as constant frequency and load. When the generator is operating steady stat an any load, the generator voltage varies no more than ±0.1%

No Load to Full Load Accuracy. At constant frequency and at rated power factor, the voltage regulation varies no more than ±0.25%.

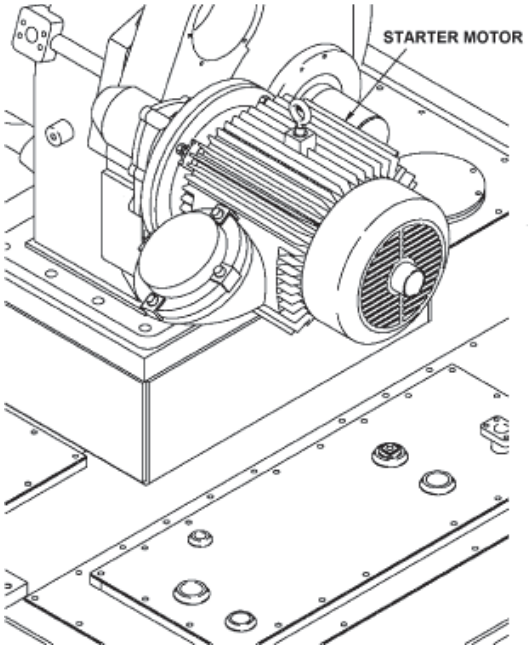
Voltage Drift. With the generator operating at rated voltage, and with a constant load between 0 – 100% at rated power factor, the change in the regulated ouput will not exceed 1.0% of rated voltage for any 30-minute period at a constant ambient temperature.

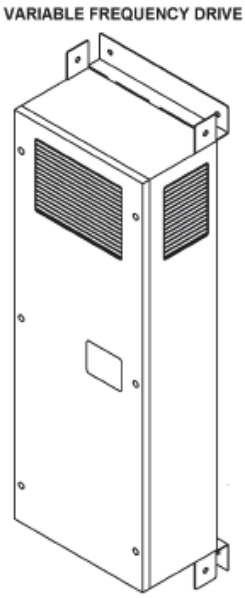
Automatic Voltage Regulator (AVR). The voltage adjustment range about the selected nominal value is ±10%. The resolution of the voltage is 0.1%. Voltage metering accuracy is ±0.2%

Field Current Regulator (FCR). The current regulation mode allows the operator to adjust the field current manually. This gives the operator a manual voltage regulator. During the FCR mode, the automatic voltage regulator is disabled. It is important to note that the FCR is not the equivalent of an independent manual voltage regulator, since it uses some of the same circuitry as the automatic voltage regulator.

START SYSTEM

The start system includes a direct-drive AC starter motor mounted to the reduction gearbox, driven by a solid-state variable frequency drive (VFD). The start system provides torque to initiate engine rotation, and to assist the engine in reaching a self-sustaining speed.





Functional Description. To begin gas turbine rotation, the VFD initially provides low-frequency AC power to the starter motor. The VFD gradually increases the speed of the starter motor until the gas turbine reaches purging speed. When purging is completed, the control system activates the fuel system. The speed of the starter motor is gradually increased until the gas turbine reaches starter dropout speed. The VFD then deenergizes the starter motor, and the motor clutch assembly is disengaged.

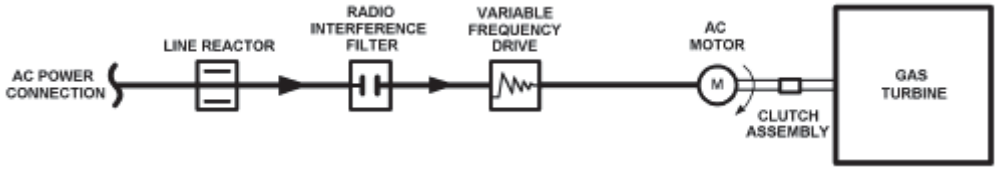
Starter Motor. The starter motor provides high breakaway starting torque and acceleration from standstill to starter dropout speed. Starting power is transferred to the gas turbie via the reduction gearbox and over-running clutch and shaft assemblies.

Variable Frequency Drive (VFD). The VFD is a motor speed controller that provides pulse-width modulated power with variable frequency and voltage to the starter motor. Controlled by the *Turbotronic 4*, the VFD regulates voltage and frequency to the starter motor.

Please reference *Product Information Letter (PIL) 149* in the Appendix for additional information describing Solar's Direct-drive AC start system using Rockwell Automation's PowerFlex VFD.

Scope Clarification:
The VFD cabinet is shipped loose, and designed for a wall-mounted installation in an appropriate non-hazardous, indoor location by Others. Electrical disconnects and over-current protection devices are not provided.

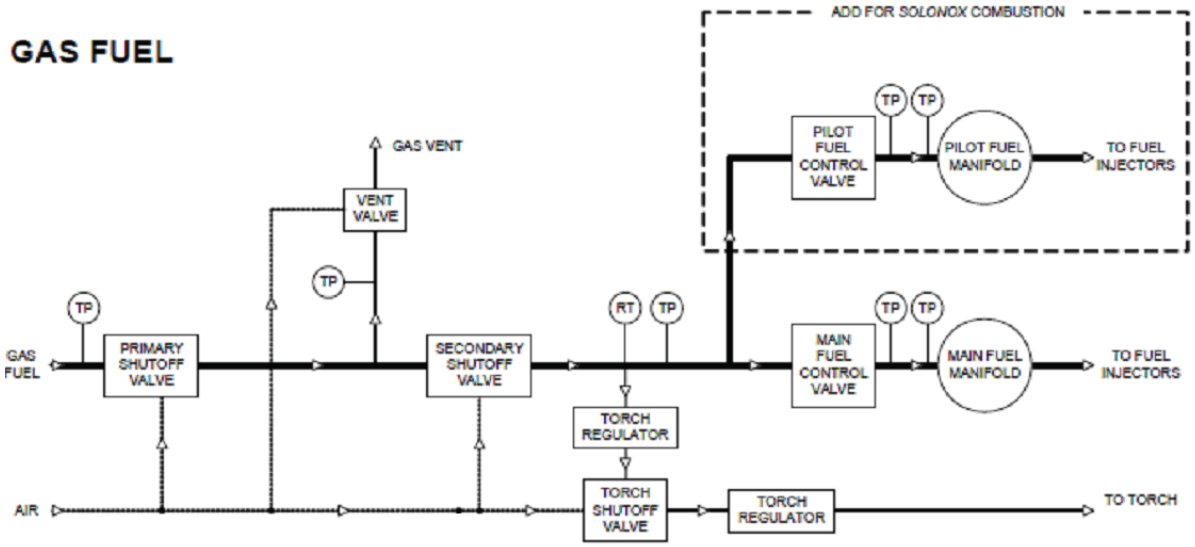
Power Wiring. The start system requires three phase AC input (by Others). The start contactor is not required for VFD operation. A fused disconnect (by Others) at the VFD input is recommended. Optional motor space heater wiring is available.



GAS FUEL DELIVERY SYSTEM (Design and Component Operation)

The fuel system, in conjunction with the control system includes all necessary components to control ignition and fuel flow during all modes of gas turbine operation. There are four available configurations, represented by the figure below:

- Gas Fuel – Conventional Combustion
- **Gas Fuel – *SoLoNOx* Combustion (Included in Base Bid)**
- Gas and Liquid (dual fuel) – Conventional Combustion
- Gas and Liquid (dual fuel) – *SoLoNOx* Combustion



This project is configured with the following fuel system:

Scope Exclusion:
The fuels specified in Section 2.0: Technical Specifications, Requirements, and Assumptions (inclusive of their required skid package skid edge pressures, temperatures, and flows), and all associated interconnecting fuel piping for the installation, testing, and operation of the gas turbine generator set is supplied by Others.

***SoLoNOx* Combustion System.** The *SoLoNOx* combustion system uses special fuel injectors with main and pilot fuel operation to maintain stable combustion and minimize the formaction of nitrogen oxides (NOx), carbon monoxide (CO), and unburned hydrocarbon (UHC) emissions. To further regulate emission levels, combustion airflow is regulated using a bleed valve mounted on the combustor case. The *SoLoNOx* combustion system also includes an additional inlet gas filter/coalescer for mounting offskid.

Please reference Section 3.0: Performance and Emissions regarding the specific emissions output for this project.

Scope Exclusion:
The offskid gas fuel filter/coalescer is installed by Others.

Gas Fuel System

The gas fuel system includes the following components:

- Skid edge gas fuel filter
- Supply pressure transmitter
- Air-operated primary gas fuel shutoff valve
- Air-operated gas vent valve
- Air-operated secondary gas fuel shutoff valve
- Torch with associated shutoff valves/regulators
- Electrically-operated main fuel control valve
- Electrically-operated pilot fuel control valve
- Main fuel manifold
- Pilot fuel manifold
- Fuel injectors

Gas Fuel System Component Operation. Pneumatically actuated primary and secondary gas fuel shutoff valves are controlled using pilot air pressure (see Utility List for specific requirements). For each valve, pilot air pressure is admitted to and exhausted from a pneumatic actuator through a solenoid valve. Fail-safe operation ensures both valves will close in case pilot air pressure is lost.

The gas fuel control valve and, when applicable, the *SoLoNOx* pilot fuel control valve, are powered by integrated DC motor-driven actuators. Integrated actuator electronics provide precise closed-loop valve control based on position command inputs versus position feedback outputs. Fail-safe operation ensures the valve(s) will close in case either the command signal, or control power is lost. During the start sequence prior to ignition, the control system will verify gas pressure and perform a gas valve check to verify proper operation of the gas fuel valve(s).

PRINCIPLES OF OPERATION

The previous section elaborated on the respective design and individual component operation of the gas fuel delivery system. The following section describes the principles of operation for the fuel described in Section 2.0: Technical Requirements, Specifications and Assumptions, inclusive of operating constraints.

Gas Operation

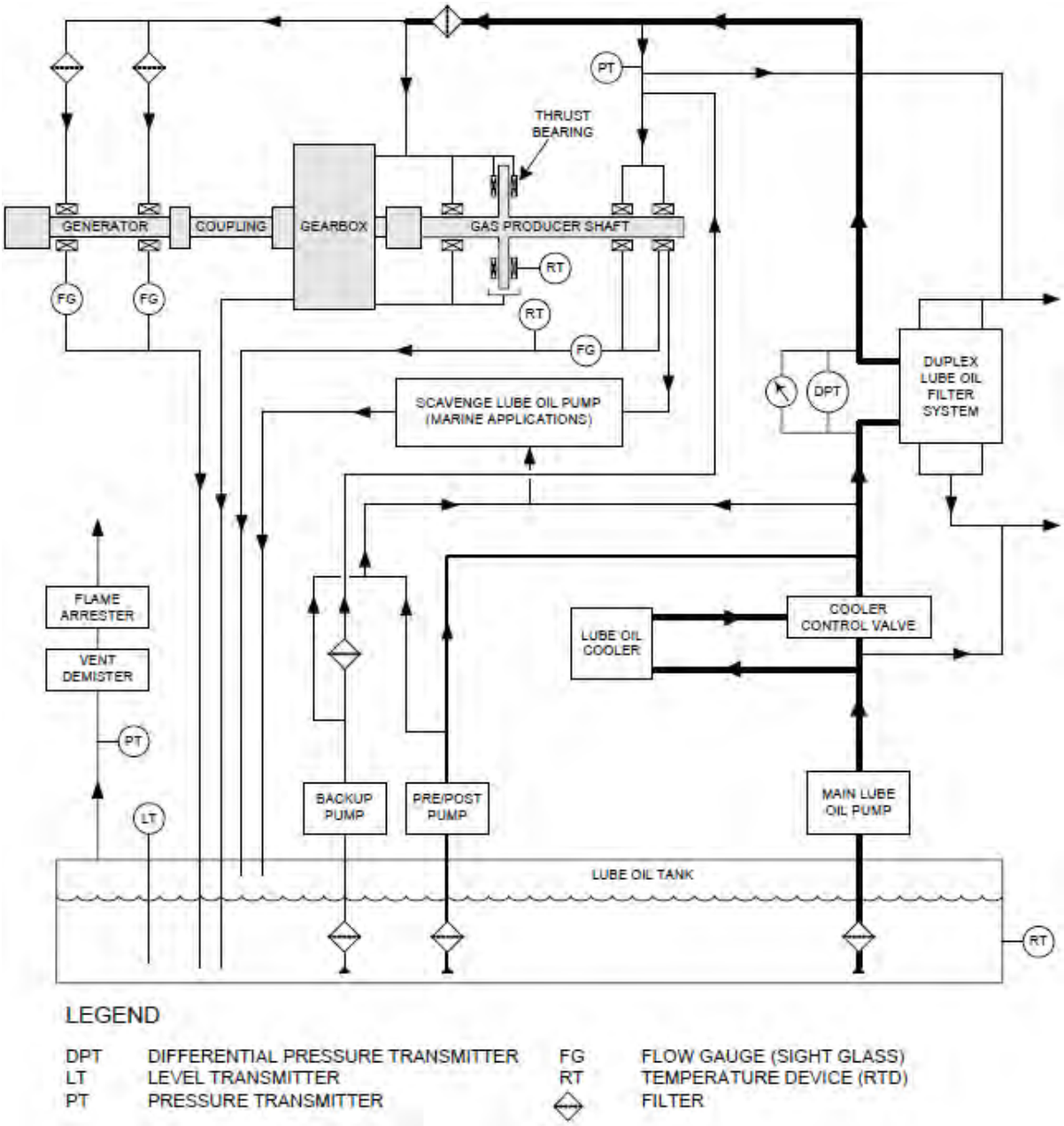
Start Requirements. Start-up of the equipment is facilitated as follows:

- The engine can be started on the Natural gas described in Section 2.0: Technical Requirements, Specifications and Assumptions

Gas Operation. There are no restrictions on steady state operation, based on the gas fuel composition described in Section 2.0: Technical Requirements, Specifications and Assumptions (subject to the corresponding fuel delivery requirements), and to the emissions operating constraints described in Section 3.0: Gas Turbine Performance and Emissions.

LUBRICATION SYSTEM

The lubrication system circulates oil under pressure to the gas turbine and driven equipment. Lube oil is supplied from the lube oil tank incorporated into the baseframe. Oil temperature is maintained at optimal levels by a thermostatic control valve, oil tank heater, and off skid oil cooler. Below is a schematic depicting a typical lube oil system:



The lubrication system incorporates the following major components:

- Oil tank (carbon steel construction)
- Lube oil
- Gas turbine-driven main lube oil pump
- AC motor-driven pre/post lube oil pump
- DC motor-driven backup lube oil pump
- Duplex lube oil filter system with replaceable elements
- Oil level, pressure, and temperature indications
- Pressure and temperature regulators
- Strainers
- Oil tank vent separator (shipped loose)
- Oil tank vent flame arrestor (shipped loose)
- Lube oil cooler (shipped loose)

Oil Tank. The carbon steel lube oil tank and tank covers are integral to the package base frame. A tank drain connection is plumbed to the side of the package base.

Lube Oil. The lube oil is customer-furnished, quality must conform to Solar's Engineering Specification ES 9-224. This project will be configured for synthesized hydrocarbon oil with an ISO viscosity grade of 32. It is rated for an ambient temperature range of -54°F to +115°F (-48°C to +46°C).

Per the referenced specification, it is required that the pour point must be at least 11°F (6°C) below the ambient air temperature surrounding the package, even in the coldest season. This requirement is to ensure oil flow at the start of the prelube cycle.

If a different type of lubricating oil, or viscosity grade is preferred by the Customer, this must be communicated to Solar for consideration.

Main Lube Oil Pump. The main lube oil pump is mounted on, and driven by the reduction-drive gearbox. This positive-displacement pump provides lube oil pressure during normal operation.

AC Motor-driven Pre/Post Lube Pump. The pre/post lube oil pump provides oil pressure during the package start sequence and after package shutdown to pretect the gas turbine and driven equipment bearings. Additionally, the pre/post lube oill pump provides lube oil pressure during a gas turbie roll down in the event the main lube oil pump has failed.

Scope Exclusion:
A blank plate is located on the side of the package enclosure, and intended for the routing of cable/conduit to the pre/post lube oil motor inside. This interconnection is supplied by Others.

DC Motor-driven Back-up Lube Oil Pump. The back-up lube oil pump provides lube oil pressure for post lube cooling of the gas turbine and driven equipment bearings in the event the pre/post lube oil pump fails. The back-up lube oil pump provides lube oil pressure during a gas turbine roll down in the event the main lube oil pump and pre/post lube oil pump have both failed. The back-up lube oil pump also provides lube oil pressure during an emergency condition such as a fire, control system failure, emergency stop, or if a turbine over speed is detected by the back-up system.

Power to the motor is provided by Solar's 120 VDC battery system.

Scope Exclusion:
A DC motor start contactor is provided by Solar as a shipped-loose component, and intended to be mounted in the MCC. The MCC is supplied by Others.
A blank plate is located on the side of the package enclosure, and intended for the routing of cable/conduit to the back-up lube oil motor inside. This interconnection is supplied by Others.

Duplex Lube Oil Filter. A duplex filter is supplied with a transfer valve and filter differential pressure indication with alarm to remove contaminants from the lube oil system. It is contained entirely within the enclosed package, and a filter drain connection is plumbed to the side of the package base.

Note that with a duplex configuration, the transfer valvel allows a filter transfer while the gas turbine is operating.

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.

Scope Exclusion:
The lube oil vent separator is a shipped-loose component to be installed by Others. This includes the separator support structure, as well as the interconnecting piping between the vent separator and the package flanges.

Lube Oil Vent Flame Arrestor. The lube oil vent flame arrestor prevents an ignition source from entering the lube oil tank.

Scope Exclusion:
The lube oil vent flame arrestor is not integral to the package, and is instead a shipped-loose component to be installed by Others.

Lube Oil Immersion Tank Heater. The lube oil tank immersion heater ensures the lube oil tank temperature remains above 10° C (50° F). It also facilitates a short lube oil temperature warm-up period after a cold start.

Scope Exclusion:
Electrical supply contactors are not supplied, or installed by Solar.

A blank plate is located on the side of the package enclosure, and intended for the routing of cable/conduit to the heater motor inside. This interconnection is supplied by Others.

Water/Oil Lube Oil Cooler. A water/oil lube oil cooler is provided and designed for off-skid installation. The water-cooled, tube-type cooler lowers the oil to operating temperature. Connections for lube oil supply to and from the cooler are located at the side of the package base.

Back-up Water/Oil Lube Oil Cooler. A back-up water/oil lube oil cooler is included. The back-up water-cooled, tube-type cooler is identical to the primary cooler as described above. Connections for lube oil

supply to and from the cooler are located at the side of the package base. Transfer valves and interconnect piping is not included.

Scope Exclusion:
The water/oil lube oil cooler is not integral to the package, and is instead a shipped-loose component to be installed by Others.

The maximum total design pressure drop of the off skid oil cooler loop including supply and return lines shall not exceed 50 psid (345 kPad) at the design flow rate and an oil viscosity of 60 SSU (10.5 centistokes). No check valves are allowed in the oil cooler loop. This is recommended for all applications (but mandatory for units in cold climates), oil cooler supply, return and optional vent lines must slope from the oil cooler to the turbine package to facilitate draining when the unit is not operating.

TURBOTRONIC 4 CONTROL SYSTEM

Solar's *Turbotronic 4* control system is used for sequencing, control, and protection of the gas turbine package, and for providing an extensive range of options for monitoring and plant control.

The control system is a digital, fully-integrated system utilizing an Allen-Bradley ControlLogix programmable controller configured to Solar's requirements. It provides an optimum combination of control and display features, reliability and maintainability, and is configured specifically for the control of turbomachinery and associated equipment.

The control system described herein incorporates a number of sensors, transducers, and monitoring devices for the purposes of data collection, which is accumulated by the programmable controller for computation and generation of required control actions and indications.

The programmable controller, in conjunction with the Combination Generator Control Module (CGCM), and the video display unit (VDU) permits a wide range of features. These include a variety of advanced software and control options, as well as condition and trend monitoring, and supervisory control.

The control system provides the operator with the necessary information for operation of the equipment, and offers a variety of communications options for data exchange with external plant distributed control systems.

> Please reference Solar document *SPTT-PG* included in the Appendix for additional, and more comprehensive information regarding the *Turbotronic 4* control system.

System Architecture

System Architecture. Key system components include:

- ControlLogix controller (Allen-Bradley)
- RSLogix 5000 programming software (Rockwell Automation)
- 1794 Flex I/O (input/output) modules (Allen-Bradley)
- Combination generator control module (Allen-Bradley/ Basler Electric)
- XM-120 Vibration Monitoring System (Rockwell Automation)
- ControlNet network (ControlNet International)
- TT4000S onskid local operator control panel (Solar Turbines)
- Independent back-up shutdown system (Solar Turbines)
- Fire and gas monitoring and control system (Detronics)

The ControlNet 1.5 network provides primary communications between components. Hardwire backup is provided for critical backups.

Standard Control System Component Hardware

Programmable Controller. The heart of the control system is the programmable controller. The programmable controller performs the following functions, in conjunction with the input and output signal modules:

- Sequencing of gas turbine and auxiliaries
- Control of turbine and driven equipment during start-up, loading, operation, and shutdown
- Protection of turbine from abnormal operating conditions
- Protection of driven equipment from abnormal operating conditions
- Response to commands from operator
- Analog and status outputs for display and monitoring

The programmable controller is programmed in a language called “relay ladder logic”, or in “function block diagram” programming.

Input/Output Modules. In order to perform many of its functions, the programmable controller must gather physical data. This is accomplished through I/O modules that gather either discrete or analog data. Discrete inputs are typically used for alarms, shutdowns, or status indications, while analog inputs are used for scalable functions.

Internal Communication. Communication between the programmable controller and the I/O modules is via redundant ControlNet 1.5, a high speed, deterministic, serial communications link.

Deterministic is the ability to reliably predict when data will be delivered.

Power Supply. The power supply system supplies power to the programmable controller, I/O modules, video display unit, and relay backup systems. It consists of independent, voltage converting, DC-to-DC isolating power suppliers. The system receives 120 VDC input from the battery system and converts it into a regulated and filtered 28 VDC power at a maximum of 20 amps.

Backup System. The basic control system is equipped with an independent relay backup system that serves to initiate emergency shutdown of the gas turbine, and to control the post-lube cycle. Critical input signals monitored by the backup system include the:

- backup power turbine overspeed monitor
- manual emergency stop switch
- programmable controller fail “watchdog” timer, and
- fire and gas monitoring system relay contacts

When activated by any of the above faults, the relay backup system initiates a safe shutdown of the turbine and driven equipment. The backup control system is a combination of instantaneous and time-delay relays.

Once a shutdown is initiated by the backup system, operation can only be restored manually, and locally by a dedicated backup system reset switch after all the faults have been cleared. This action re-energizes the master control relay and its associated relays and timers are restored to their normal position.

Vibration Monitoring System. The vibration monitoring system provides vibration indication and protection for the gas turbine, gearbox, and driven equipment. Depending on the unacceptable vibration level, either a warning is indicated, or a turbine shutdown is initiated. With the appropriate options, the system provides information that can be used to evaluate vibration problems and enable the user to trace the root cause before equipment availability is affected.

Solar has integrated Rockwell Automation's XM-120 product line principally due to its seamless integration with the existing ControlNet-based Flex I/O control system. By integrating the vibration system, the diagnostic informaiton is readily obtained through the existing network configuration, and allows more complete condition monitoring of the gas turbine system.

Please reference *Product Information Letter (PIL) 222* in the Appendix for additional information describing Solar's vibration system using Rockwell Automation's XM-120 product line.

Features. The XM system incorporates the following features:

Feature	What's Included	HMI Display
Overall vibration amplitude:	y-axis only	standard
Gap voltage:	y-axis only	standard
Discrete Band amplitude (four configurable bands)	y-axis only	standard
Discrete amplitude (1x, 2x, 3x) **See Note a**	y-axis only	standard
Discrete phase angle (1x, 2x) **See Note a**	y-axis only	standard
Spectum plot	y-axis only	optional upgrade
Time-Waveform plot	y-axis only	optional upgrade
Orbit plot	no	optional upgrade
Integrated Combustor monitoring	*SoLoNOx* only	*SoLoNOx* only
Historical logging	yes	optional upgrade

Notes:

(a) Refers to multiples of engine running speed

Governor

The “governor system” consists of various hardware and system integrated together to provide the governor function. The governor is a speed, load and temperature control system whose dominant signal depends on the mode of operation of the gas turbine generator set. Operating modes include:

- starting
- stopping
- operation in “island” mode
- operation in “parallel” with other units, or
- operating in “parallel” with a utility grid

The system consists of the turbine speed transducer (magnetic pick-up), the speed monitor, turbine T5 temperature thermocouples, temperature input module, electronic fuel valves, and the programmable controller software files.

The governor system maintains generator frequency and/or generator load distribution (when operating in parallel) by controlling turbine fuel flow. The system includes provisions for selection of isochronous or speed droop modes of operation. The transfer from droop to isochronous and isochronous to droop is bumpless. Speed setpoint adjustment is facilitated via “speed increase” and “speed decrease” momentary pushbuttons located at the local control panel.

Turbine engine temperature (T5) is also an input to the governor control. When turbine temperature exceeds factory-set levels, the limiter takes control of the throttle and prevents any further increase in temperature, and thus, speed or load.

In the case of a generator paralleled with an infinite bus (utility), the temperature control limits the load-carrying contribution of the unit to its rated full-load carrying capacity for the current ambient temperature conditions. With changes in ambient temperature (T1), the limiter adjusts the load to maintain a constant T5 temperature, and thus, automatically maintaining the unit at full site-rated load at all times.

Isochronous Mode operation:
Solar will require a kW setpoint by Others to prevent the gas turbine from loading to its full capability and have control on load contribution level.

Droop Mode operation:
No setpoint is required as the operator controls the amount of load manually.

When the generator is not paralleled with the utility, the temperature control is set to a higher temperature to allow momentary operation in excess of rated load during on-load transients.

Operator Interface

The control system operator interface has two major components:

- the NEMA 4 turbine control panel, and
- the “touch screen” video display unit (VDU)

Turbine Control Panel. The turbine control panel provides the essential controls to start or stop the turbine, to adjust the gas generator speed, and other optional control functions. Some typical gas turbine controls and indications that appear on the control panel include the following:

- Off/Local/Remote (control selector with lockable positions)
- Emergency Stop (shutdown without cool down)
- Normal Stop (shutdown with normal no-load cool down)
- Speed Control (increase/decrease)
- Start
- Horn Silence (audible alarm)
- Acknowledge (alarms and shutdowns)
- Backup System (Active/Reset)

Operation Inidication Lights:

- Starting
- Backup Active
- Stopping

Onskid Video Display Unit. The video display unit (VDU) is used to present an extensive selection of the turbomachinery operating parameters. The display system consists of several screens organized by systems and functions to allow the operator to easily locate and monitor a given parameter. It also includes a password protected screen, which allows the operator to input or modify certain values such as process control setpoints.

The onskid VDU makes use of Solar's TT4000S display and monitoring system, which performs several key functions to facilitate operation of the turbomachinery equipment through a user-friendly interface. The TT4000S system monitors the turbine and generator parameters, and offers basic control capabilities, as well as annunciating alarms, reporting on the running status of the equipment, and providing a comprehensive set of analysis tools.

Data storage consists of:

- discrete event log containing the last 5,000 events
- six (6) trigger logs containing 1 sec tag samples surrounding the last six (6) shutdowns, and
- an hourly log containing snapshot data for the last 24 months

The TT4000S display and monitoring system uses the Embedded Windows NT operating system, and offers the following industry-standard features:

- complies with TCP/IP
- supports Object Linking and Embedding for Process Control (OPC)
- supports ActiveX controls

The display screens listed below are for a typical package, and are provided as standard equipment for all turbine packages:

- Main Menu
- Operation Summary
- Engine Temperature
- Shaft and Bearing
- Lube System
- Generator Summary
- Bus Summary
- Generator Control Modes
- Generator Setpoints
- Gas Fuel System (as applicable)
- Liquid Fuel System (as applicable)
- Enclosure
- Alarm Summary
- Alarm Log
- Event Log
- Strip Chart
- Maintenance Modes
- VFD Configuration

Auxiliary Video Display Unit. The auxiliary VDU consists of an industrial desktop computer (with MS Windows XP operating system) and the TT4000 display and monitoring system. It has all the features of the standard skid-mounted VDU plus the following enhancements:

- Additional Historical Data, including:
  - > 2-minute Log. One month of daily files with data points taken every two minutes.
  - > 10-second Log. Data are read at 10-sec intervals for the last 14 days.
- Larger Trigger Log. The Trigger Log function stores up to 25 triggered files, each containing 6-minutes of 1-second data points (The onskid VDU stores five triggered files)
- Accommodates Additional Options, including:
  - > Gas turbine performance calculations
  - > Printer
  - > Remote VDU
- Higher resolution screen and graphics capability
- More memory, including RAM and non-volatile storage

The auxiliary VDU communicates with the onskid controller through ControlNet 1.5. The total cable run must be no longer than 2500 feet (750 meters). Cable run lengths for the auxiliary VDU vary from project to project depending upon how close the operator station/control room is to the gas turbine generator set package.

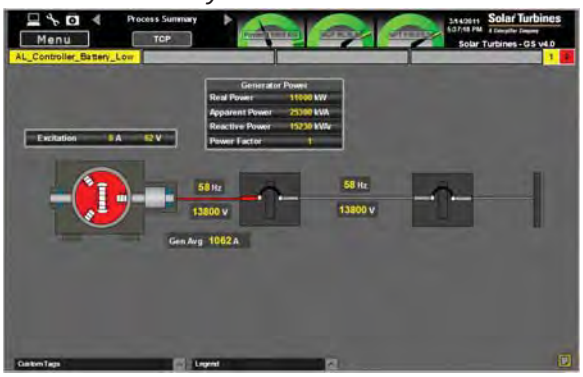
Note: These distances are reduced if high flex cable is used.

Scope Exclusion:
The interconnecting ControlNet cabling between the auxiliary VDU and the generator set package is supplied by Others.

Performance Map Display. A gas turbine performance map for the predicted rating of a gas turbine at standard conditions is displayed on the VDU. Algorithms convert site data to standard conditions and the operating point is displayed in real time on the map.

Sample Screens from the Video Display Unit. The following are sample screen shots for the VDU:

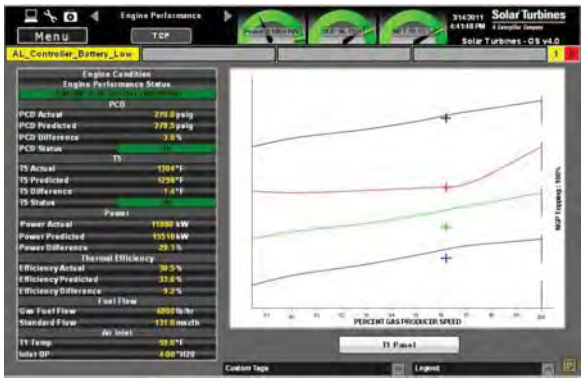
Process Summary



Operation Summary

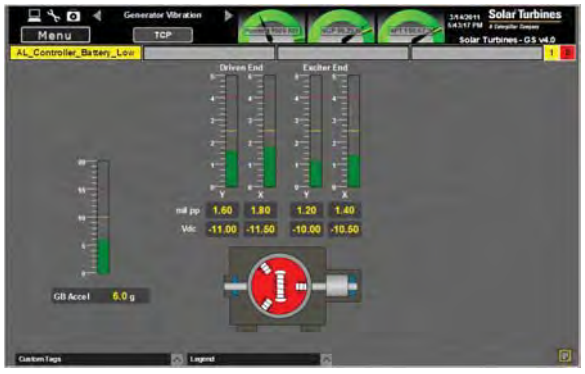
Engine Summary

Engine Performance



Generator

Generator Vibration



Note: Availability of some screens is dependent upon selection of corresponding gas turbine generator set configuration options.

Printer/Logger. A printer, cable and software are included to log events, print standard reports, and to print screens from the VDU. The following functions are included:

- Alarm and Shutdown Log. Prints one event per line with time/date stamp.
- Reports. One demand, prints current values of standard analog variables and calculated variables. Standard totalized variables may be printed also.
- Print Screen. On demand, prints any screen that is current being displayed.

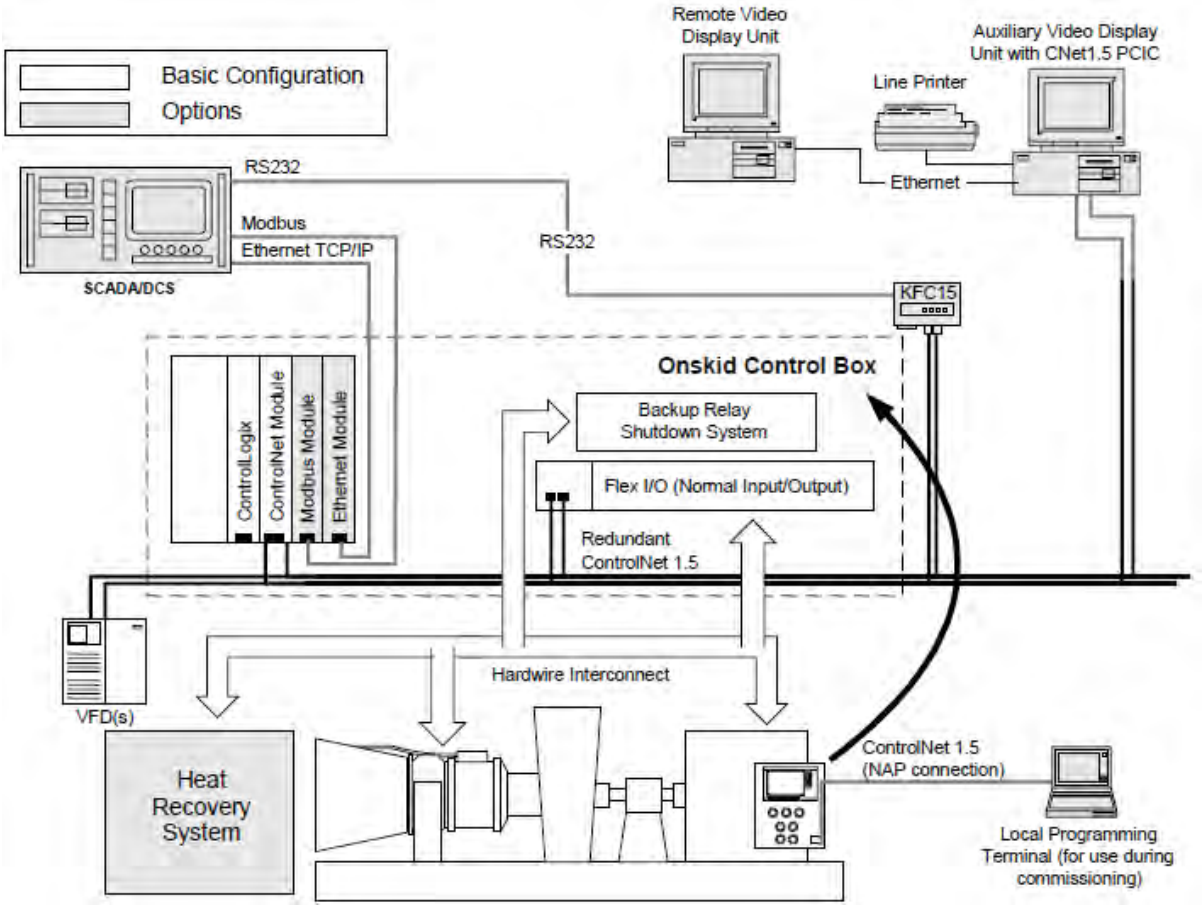
Engineering Units

The following engineering units will be displayed:

Type	Pressure	Temp	Length
English	psig	deg F	Inches

Communications: Turbine Control to Supervisory System

Communication between the gas turbine control system and the user's supervisory control and data acquisition (SCADA), distributed control system (DCS), or other supervisory syste is available. *Turbotronic 4* control systems can be provided with an interface that allows the supervisory system to communicate with the programmable controller, obtain data, and have the control capability required.



Data for Transmission. The following information from the turbine package is available to be accessed by the supervisory system:

- analog instrumentation values
- discrete status values
- discrete alarms and shutdowns

The following information can be sent by the supervisory system:

- discrete control commands (start, stop, acknowledge/reset, and change mode of operations)
- analog operating setpoints (kW control, speed, kVAR, pf, and voltage)

The specific addressing for the data transfer is provided for each turbine package.

Protocol. The communication language used between programmable controller systems usually follows a set of rules or format called a “protocol”. The protocol defines the sequence and organization of the transmitted data. The RSLogix controller uses an internal proprietary bus protocol called “control and information protocol”, or CIP. Communication modules allow different communication networks to interface with this internal bus. Certain arrays of information inside the controller can be configured to mimic PLC-5 data tables that support the DF1 protocol. The user’s supervisory system must be programmed to hand the CIP, DF1, or Modbus protocols. The Allen-Bradley communications software RSLinx provides all the necessary drivers to communicate with all turbine package control networks and network devices (except Modbus), and is required for most applications.

Supervisory Interface Options. There are many ways to interface with the gas turbine control system. The most common include serial communication (RS232, RS422, RS485), ethernet TCP/IP, ControlNet 1.5, and Modbus.

Each communication network has certain advantages and disadvantages that need to be considered when selecting a network for a particular application. For this application, we have proposed the following:

Ethernet TCP/IP. Data transmission rates are high, the communication is non-deterministic, and cabling and connectivity is well known throughout most industries (common office computer network technology).

- Physical media: twisted pair (10BaseT)
- Protocol: CIP over TCP/IP
- Topology: star
- Maximum distance (per Rockwell specifications):
  - 328 ft (100 m) to hub
- Maximum data transmission rate: 10 Mbps
- Maximum number of nodes: unlimited (8-24 nodes per hub typical)

Typical Application - Ethernet. The turbine package ethernet module is usually connected to a local hub that is connected to an ethernet backbone for data transfer to a remote supervisory system over longer distances. 10BaseFL fiber lines support 6560 ft (2000 m) segments.

ControlNet 1.5. This is an Allen-Bradley developed proprietary field bus network. Data transmission rates are high, the communication is deterministic, and all interface modules can be configured for redundant media.

- Physical media: quad shielded RG-6U coaxial cable
- Protocol: CIP
- Topology: Trunk line/drop line, star with repeaters
- Maximum distance (per Rockwell specifications):
  - 3,280 ft (1000 m) with 2 nodes
    - deduct 16 m for each additional node, up to a maximum of 48 nodes with 250 m ControlNet cable length
  - 820 ft (250 m) with 48 nodes
- Maximum data transmission rate: 5 Mbps
- Maximum number of nodes: 48

Typical Application - ControlNet. This is a control network used to connect to the distrubuted I/O modules to the controller for turbine control. Onsite, VDUs are typically connected directly to this I/O network via PCC or PCIC cards installed in the computer.

Supervisory interface (RS232C) with the turbine via ControlNet network is allowed only through a serial link connection module (KFC15), or a separate dedicated ControlNet network that is not directly connected to the turbine I/O network.

The maximum distance and number of nodes allowed for the network can be increased by adding repeaters and/or by using optical fiber media.

Field programming terminals can connect to the network via the network access port (RJ-type) located on the interface module or Flex I/O adapters. Current ControlNet 1.5 networks and network devices are not compatible with older ControlNet 1.25 networks (utilized on Allen-Bradley PLC5 controllers), or network devices.

Language

The turbomachinery package labels, control console labels, and video display unit (VDU) screen displays will be in English.

GENERATOR CONTROL AND PROTECTION

For generator control and monitoring, the *Turbotronic 4* control system incorporates a Rockwell Automation/Allen-Bradley combination generator control module (CGCM). The CGCM combines the following into one module:

- load sharing
- synchronization
- voltage control
- reactive power control, and
- generator protective functions

Three excitation control modes are available:

- Automatic Voltage Regulation (AVR) – a constant generator output voltage is maintained
- Power Factor (pf) control – a constant power factor is maintained when operating in parallel with a large power source.
- Reactive Power Control – a constant reactive load is maintained when operating in parallel with a large power source.

The following excitation control features are available:

- Under frequency limiting
- Over and under excitation limiting
- Reactive droop compensation
- Cross-current compensation
- Line-drop compensation

The protection functions are designed to diagnose and respond to the following events:

- Over-excitation voltage (59F)
- Generator over voltage (59)
- Generator under voltage (27)
- Loss of sensing (60FL)
- Loss of PMG (27)
- Loss of excitation (40Q)
- Over frequency (81O)
- Under frequency (81U)
- Reverse power (32R)
- Phase rotation error (47)
- Over current (51)
- Rotating diode monitor (58)
- Reverse VAR (40)

Scope Exclusion:
The protection features provided typically do not meet the requirements of power utility companies for the general protection of power distribution systems. The relay settings are standard (not as a result of a system study).

Protection of power distribution systems can only be done through the use of appropriately certified protective relay components with settings approved by qualified personnel based on a comprehensive analysis of the complete system. This scope is supplied by Others.

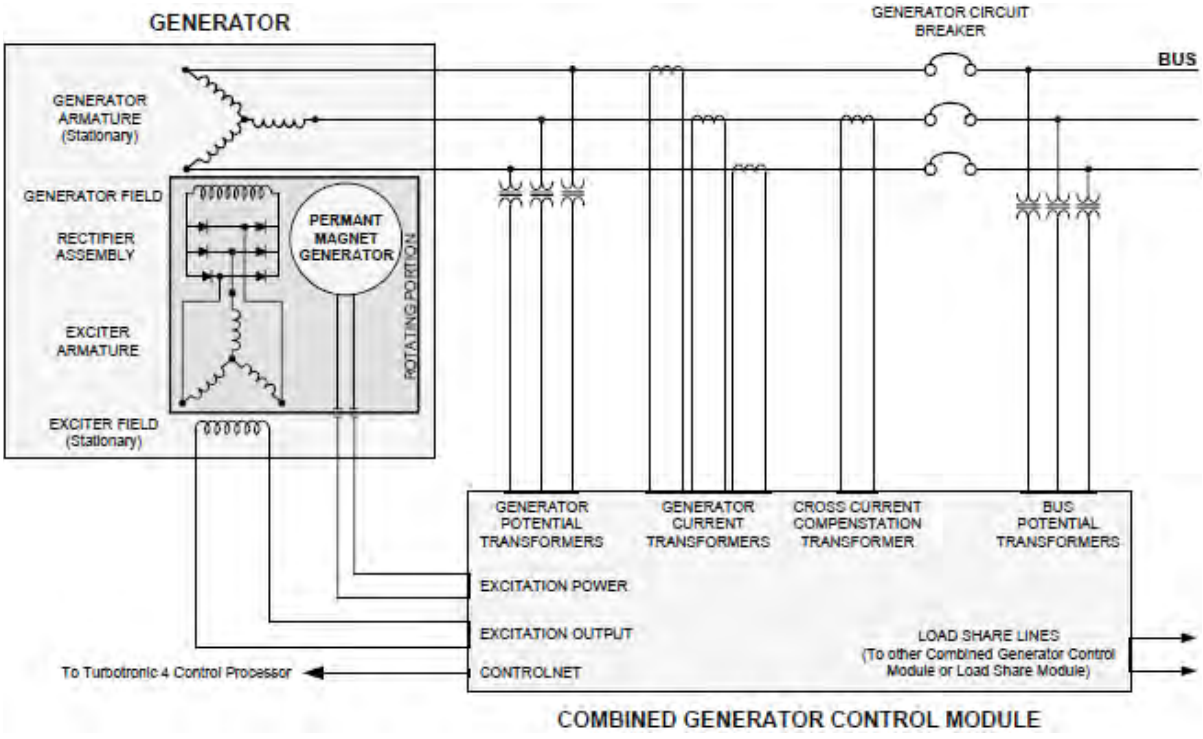
Functional Description

The *Turbotronic 4* control system, in compliance with the requirements of NEC Class I, Div II area classifications, workis in conjunction with the generator's excitation system to provide control, monitoring, and protection of the generator and its ouput. The key components are:

- Permanent magnet generator (PMG)
- Rotating armature-type AC exciter
- Full-wave rectifier assembly
- Combined generator control module (CGCM)

The figure below provides a simplified layout of these components. The exciter armature is mounted on the main generator rotor and generates an AC voltage as it revolves in the magnetic flux produced by the stationary field. The PMG consists of permanent magnets on the generator rotor and stationary armature.

The rotating rectifier assembly rectifies the exciter armature AC output to DC. In turn, the DC power is applied to the main generator rotating field windings. When the rotor operates at synchronous speed, the PMG provides power to the CGCM. The CGCM provides the appropriate exciter field current to control the exciter armature output, which is rectified to provide DC power to the main generator rotating field winding.



During initial turbine generator acceleration, the excitation power is switched off. At ~80% speed, the PMG output is connected to the excitation power contacts and voltage begins to build. The CGCM then provides controlled exciter field current at a level to maintain the generator terminal voltage at a predetermined value established by the operator. A potential transformer (usually supplied with the switchgear) provides a voltage level signal to the CGCM.
A cross-current compensating circuit is included to accommodate reactive load sharing between multiple turbine generators operating in parallel (instrumentation transformers are usually supplied with the switchgear).

Scope Exclusion:
Current, potential, and cross-current transformers required for input to the CGCM are not provided, unless otherwise indicated below.

The following transformers are included in Solar's scope of supply, and installed in the generator terminal box:

- No PTs provided; supplied by Others to be located in switchgear
- 3 DFCTs Model ITI780-122MR; Ratio: 600:5A
- 3 MCTs Model ITI780-122MR; Ratio: 600:5A
- 1 CCCT Model ITI780-122MR; Ratio: 600:5A
- 3 Lightning Arrestors
- 3 Surge Capacitors

Generator Control Modes

The following control modes are configured for this project:

Auto Synchronizing. The control system includes an auto synchronizer (a feature of the CGCM) for the closure of the unit circuit breaker. Once the unit reaches "ready to load" status, and upon sending an "initiate synchronization" discrete signal, the auto synchronizer brings the generator into frequency, voltage, and phase compliance and sends a signal to close the unit circuit breaker. The error signal for the voltage and phase comes from the CGCM. The communication between the CGCM and PLC is via ControlNet 1.5.

Auto Start and Synchronizing System. When the generator set is in a "standby" mode, the control system will automatically start the generator set upon receipt of a supervisory command – accelerating the engine to loading speed, and synchronizing the generator breaker to the bus. If the control system detects a hot bus, it will synchronize the generator to the bus and close the breaker. If the control system detects a dead bus, it will close the generator breaker without synchronization.

This option will provide one (1) synchronizing attempt, and if for any reason fails to synchronize within 30 seconds, wil will lock out and annunciate a "Sychronize Failure" alarm.

kW Import Control. The kW import control system controls the real load (kW) on a unit operating in parallel with a large source such as a utility. The import control monitors the load that is being imported from the utility source and adjusts the turbine generator output to maintain a preset amount of minimum load. The import control allows the import of unlimited power while maintaining the minimum power.

Scope Exclusion:
A feedback kW transducer is expected to be provided by the switchgear provider.

This control mode is for applications where it is desired to prevent any power from being 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.

kW Control. The kW control system controls the real load (kW) on a unit operating in parallel with a large source such as a utility. The control monitors the load carried by the turbine generator set and adjusts turbine fuel flow to maintain a constant load under conditions of varying infinite bus frequency.

Protection against excessive kW load while in parallel with a large source is provided by the control system T5 temperature limiter.

The kW control system provides additional operational flexibility by allowing unit kW load level to be set at any desired constant level within the capacity of the unit. In this mode, the unit may be carrying the entire load within the plant, while the remaining unit capacity is being exported to the utility.

In addition, the kW control set point can be the manipulated variable in the process control loop. For example, to modulate steam production in a CHP application, the steam production control could modulate the kW control set point.

CONTROLS FOR HEAT RECOVERY STEAM GENERATOR APPLICATIONS

Heat Recovery Steam Generator (HRSG) System Interface

The *Turbotronics 4* gas turbine control panel interfaces with the heat recovery system, and receives the following hardwire signals:

- 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

The following hardwire signals are sent from the *Turbotronics 4* gas turbine control panel to the heat recovery system:

- Begin heat recovery system purge (Turbine 15% speed signal)
- Turbine running status
- Turbine 90% speed signal

In addition, the heat recovery system may use the turbine 90% speed signal as an indicator to begin its operation. The controls interface 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.

GENERATOR SET PACKAGE ENCLOSURE

The all-steel full-length enclosure is completely self-contained, weatherproof, insulated, sound attenuated, and assembled to mount on the generator set baseframe. It incorporates the following features:

- Standard Features
- Ventilation System
- Dust Protection
- Fire and Gas Detection and Monitoring System
- Fire Suppression System

Standard Features

Basic Construction. The sides of the enclosure consist mostly of doors supported by narrow panels to allow for access to major components. The engine can be removed from either side of the package after the doors and narrow panels are removed in that area. All maintenance enclosure doors include a stainless steel three-point heavy-duty door locking mechanism, handles, hinges, latching mechanism, internal lock override release, restraining device and attaching hardware.

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.

Sound Attenuation. The enclosure panels are treated with fiberglass material for sound attenuation and thermal insulation. Weather stripping is installed between all panels for sealing and sound attenuation. See Section 3: Near Field Noise Data for additional information.

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

Scope Clarification:
All electrical wiring and mechanical piping/ducting external to the generator set package enclosure is supplied by Others.

Enclosure Lights. Incandescent lights are provided inside the enclosure with an on/off switches located near the enclosure doors.

Equipment Handling System. An equipment handling system is provided, consisting of:

- Two external trolley beam extensions (one 9-ft and one 10-ft long) with support A-frame for turbine handling.
- One external (10-ft long) trolley beam extension with support A-frame for package component handling.
- One 6-ton and two 4-ton movable chain-fall hoists, trolleys and lift attachments (shackles and lift strap) for turbine and package component handling.

The trolley beam extensions allow turbine removal through the side of the enclosure. One end of each beam extension attaches to an inside trolley rail; the other end is supported by the floor standing A-frame. The gas turbine can then be removed through the enclosure side and placed on a truck bed or cart.

Scope Clarification:
This equipment is shipped loose to site.

Ventilation System

The enclosure ventilation system is provided by two (2) AC motors, direct-driven fan systems, one for the gas turbine section, and a second for the generator.

System Pressurization. The gas turbine section of the enclosure has a positive pressure to prevent the entry of potentially hazardous external atmospheres through the enclosure seams. If provided, the generator section of the enclosure has a positive pressure to prevent the entry of potentially hazardous external atmospheres. A differential pressure switch is provided to indicate an alarm when low enclosure pressure is detected.

Scope Clarification:
The ventilation system components are shipped loose for installation by Others.

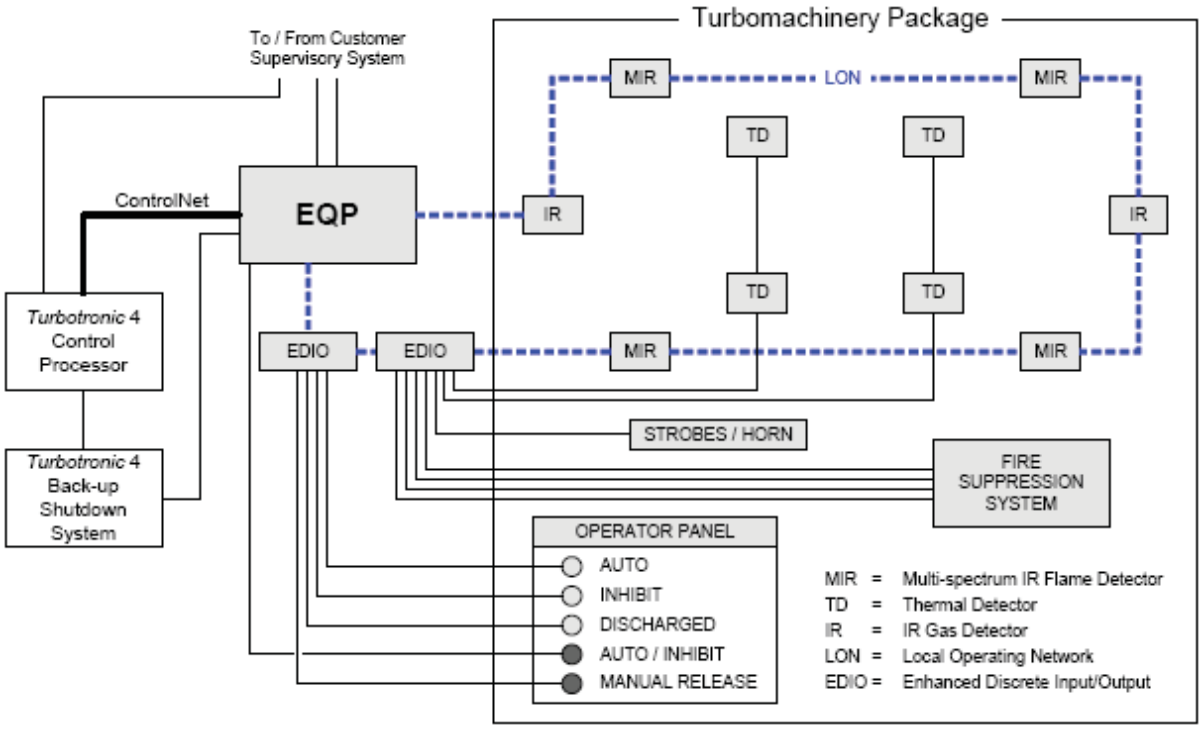
Dust Protection

Dust Protection System. The enclosure ventilation inlet is equipped with a single-stage, disposable, barrier type filter unit equipped with a delta-P alarm switch – one for the gas turbine section, and a second for the generator. Each ventilation exhaust opening is equipped with backdraft dampers to prevent ingress of dust when the unit is not running.

Fire and Gas Detection and Monitoring System

Fire and gas monitoring and detection are managed by a separate control system that interfaces with the main *Turbotronic 4* unit control system. It consists of a control unit, a local operating network and a number of sensors of different types that detect the presence of combustible gas, excessive heat, or flame. The detection of combustible gas concentrations above certain established levels generates an alarm or a package shutdown as appropriate. The detection of fire or excessive heat results in the immediate shutdown of the package and activation of the fire suppression system using carbon dioxide (CO2) as the extinguishing agent.

The following diagram outlines the typical Fire and Gas Detection and Monitoring System architecture (actual number of detection devices may vary).



Fire and Gas Control System. Monitoring and detection are provided by the Eagle Quantum Premier (EQP) controller manufactured by the Detector Electronics Corporation (Det-Tronics). It connects directly to the ControlNet network that connects the other key components of Solar's *Turbotronic 4* unit control system.

Eagle Quantum Premier Controller

Enhanced Discrete Input/Output Module (EDIO)

The EQP system combines fire detection, extinguishing agent release, and hazardous gas monitoring in one complete package. The system is designed for use in hazardous locations and it meets the requirements of approval agencies from around the world.

The heart of the system is the Controller. It coordinates system device configuration, monitoring, annunciation, and control. Field devices communicate their status and alarm conditions to the Controller

Field devices are tied either directly into a local operating network (LON) loop or to enhanced discrete input/output (EDIO) modules that reside on the same loop. Each device or module connected to the LON is assigned a unique identity by setting its address switches.

The standard flame-sensing device used with the EQP controller is the Det-Tronics X3300 series multi-spectrum infrared (MIR) detector. This is an advanced detector approved for use in hazardous areas. The MIR detector provides superior protection in enclosed gas turbine applications. It senses flame through three separate portions of the IR spectrum, to reduce the false trip rate, making voting between detectors unnecessary. Multi-spectrum Infrared detectors require less maintenance and are less susceptible to oil and smoke “blinding” than UV and UVIR devices.

The number of detectors on a package will vary with each application, but all will connect to the EQP system via the LON.

Thermal detectors (TDs) combine fixed temperature and rate-of-rise detection. They indicate if a specified temperature value is exceeded, or if a specified rate of rise in temperature is exceeded. The TDs connect to an EDIO module. Typically, two TDs are connected in series. The TDs are normally-open devices so closure of any one TD is detected by the EQP control unit.

IR gas detectors are used to measure the Lower Explosive Limit (LEL) of a gas mixture. In a typical package arrangement, one sensor is located in the enclosure ventilation air inlet, and one in the enclosure air exhaust.

The detector used with the EQP system is the Det-Tronics Pointwatch Eclipse. This is a diffusion-based, point-type infrared gas detection device that provides continuous monitoring of combustible hydrocarbon gas concentrations in the range of 0-100% LEL.

The detector supports standard and custom hydrocarbon gas detection. Standard selectable hydrocarbon gas configurations include methane, ethane, propane, butane, ethylene, and propylene. The gas detector can also be used for custom hydrocarbon gas detection by entering special gas coefficients into the device's configuration setup.

Packages with high hydrogen gas content in the fuel will require additional analysis to determine the proper gas and flame detection technologies.

Operator Interface. Each package has a standard set of indicators and operator switches mounted on the outside of the enclosure as follows:

Label	Type	Status / Function
AUTO	Light	System in automatic control mode
INHIBIT	Light	Automatic mode disabled
DISCHARGED	Light	Extinguishant discharged
AUTO / INHIBIT	Key Switch	Enables / disables automatic mode
RELEASE	Push Button	Manual release of extinguishant

***Turbotronic 4* Interface.** The EQP system includes a built-in ControlNet interface that allows it to interface easily with Solar's *Turbotronic 4* control system. Alarms and shutdown commands are communicated to the *Turbotronic 4* control processor so the appropriate action can be taken. In addition, a separate connection is hardwired from the EQP to the backup shutdown system in the *Turbotronic 4* system. This provides additional protection in the unlikely event of malfunction of the control processor.

The status of the discrete signals and the value of the analog signals (gas LELs) are automatically written to the *Turbotronic 4* control processor and are, thus, available for transmittal to a customer's supervisory control system.

Alarms and shutdown signals from the EQP must be reset at the EQP.

Configuration of the EQP system is also performed from the *Turbotronic 4* control processor. Changes to the configuration can be made in the field by properly authorized personnel.

Eagle Quantum Premier (EQP) Outputs. The EQP controller is programmed to initiate action when a hazardous condition is detected.

For combustible gas, alarm and shutdown levels are preset and the corresponding commands are sent to the *Turbotronic 4* control system to respectively display an alarm or to shut the turbine down.

If fire is detected, several actions occur simultaneously. A shutdown command is issued so that the *Turbotronic 4* control system shuts the turbine down. The package strobe lights, fire horn, and suppression system are activated. Depending on the suppression system design, commands are issued for primary release, extended release and, if applicable, subsequent release.

Shutdown commands are transmitted to the *Turbotronic 4* control processor via the ControlNet serial interface, and also directly to the *Turbotronic 4* backup shutdown system.

Please reference *Product Information Letter (PIL) 150* in the Appendix for additional information describing Solar's fire and gas detection and control system.

Fire Suppression System

CO2 Fire Suppression System. Carbon dioxide (CO2) is a proven fire fighting agent which has been in use for many years. The “fire triangle” has three components: fuel, oxygen, and an ignition source. Any fire suppression system must control one of these three components in order to be successful. Carbon dioxide works well on all fires because it displaces oxygen, thereby breaking one leg of the fire triangle. It is an effective fire fighting agent in tightly enclosed areas, leaves no residue, and is safe for electrical systems.

Since CO2 does not significantly reduce the temperature of the burning material, concentrations of CO2 must be sufficient to displace oxygen until the temperature of the burning materials drops below their ignition temperature; otherwise, the fire may flash back. To work effectively, the carbon dioxide must bereleased into an enclosed space; therefore, openings on an equipment enclosure can significantly reduce its effectiveness.

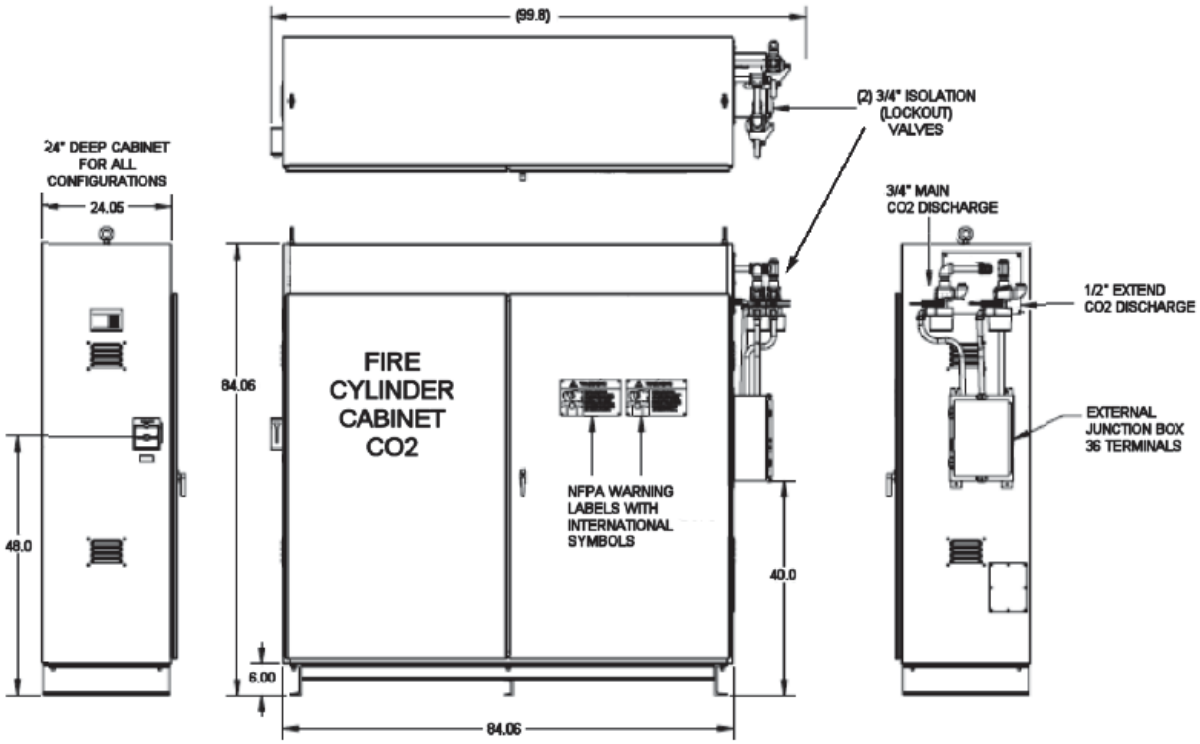
Accordingly, the enclosure is equipped with a CO2 fire suppression system consisting of a primary total flooding distribution system and a secondary metered distribution system to extend the design concentration of 37% CO2 for twenty (20) minutes.

On detection of fire, the detectors transmit an electrical signal via the fire control panel to activate the fire suppression system release solenoids located on the fire suppression skid. On receipt of this signal, the solenoid actuated control heads activate the discharge valves on the primary and extended extinguishing cylinders, releasing the extinguishing agent into the enclosure. CO2 pressure actuates the pressure trip operated dampers that close all vent openings. CO2 release control heads are also provided with manual release levers.

Solar’s scope of supply will include either a CO2 Fire Suppressant Cylinder Rack, or a CO2 Fire Suppressant Cylinder Cabinet, as further defined below. In each case, they include the following features:

- 100 lb CO2 bottles
- “fill status” indicator
- “single pull” manual activation
- externally mounted junction box for simplified wiring

CO2 Fire Suppressant Cylinder Cabinet. The weatherproof fire suppressant cylinder cabinet is sized to house the CO2 extinguishant cylinders, and is equipped with doors for servicing. The manual pull levers are routed, by cable, to break glass “pull” stations on the exterior wall of the cabinet.



Scope Clarification:
The cabinet assembly is shipped loose for installation by Others.

CO2 Isolation Valves, Pressure Switches, and Software. In accordance with paragraphs 4.5.4.11 and 4.5.5 of NFPA 12, manual lockout valves and pressure switches are required between the discharge bottles and the enclosure . These valves and pressure switches are integrally mounted to the side of the cabinet. Solar will also provide the software to control them.

Scope Exclusion:
Interconnecting wiring between the valves/pressure switches and the EDIO module is by Others.

The gas turbine fire and gas detection and suppression system described above is designed to substantially comply with the requirements of NFPA 12. Further clarification regarding site-wide compliance is provided as follows:

Scope Clarification:
Installation of the CO2 cabinet, and the supply and installation of interconnecting piping and cabling between the CO2 cabinet and the turbine package, and between the turbine package and any other remote devices is by Others.

The Solar supplied fire detection and suppression system is intended to form part of, and needs to be integrated by Others, into an overall facility fire detection and suppression system. The portions of such overall fire detection and suppression system supplied by Solar, when properly installed, comply with the requirements of NFPA 12.

It should be understood that the design of the overall fire detection and suppression system is not included in Solar's scope of supply, and may require additional equipment, such as:

- additional alarm annunciation devices and signage
- additional CO2 panel to tie in the alarm functions in cases where multiple gas turbine generator set packages are installed in a building

Solar will provide reasonable information relating to the Solar-supplied fire system components in support of such design and integration work, and the obtaining of fire permits and approvals.

It should further be understood that Solar is not responsible for obtaining fire permits and approvals, or for producing project specific fire drawings as may be required by some AHJs. Commissioning of the facility fire detection and suppression system, including the performance of a CO2 “total flooding” test of the system at site is by Others.

AIR INLET FILTRATION 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 Type Filter, Crossflow Type. A self-cleaning barrier type crossflow air filtration system with a back outlet is included. The crossflow filter is suitable for moderate environments. The filter elements are pulsed with air provided by the. Standard features include:

- D-Salt High Efficiency full Synthetic and Tetratex filter elements
- Differential pressure gauge
- Differential pressure transmitter
- Carbon steel construction
- Electrical connections pre-wired to a common junction box
- Electrical components that comply with the selected area classification
- Custom filter housing with side filter access per customer requirement

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 included. Additional lengths can be provided upon request.

- Unlined Duct, 6 ft x 6 ft, 3 ft Long; Qty. 5
- Unlined Duct, 6 ft x 6 ft, 3 ft Long with access panel; Qty. 1
- 90° Unlined Elbow, 6 ft x 6 ft; Qty. 1
- Flex Duct, 6 ft x 6 ft, 1 ft Long; Qty. 1

Turbine Air Inlet (TAI) Chiller Coils. A set of cooler coils is provided for installation in the turbine air inlet section to reduce turbine inlet temperature on hot days. Chiller performance is as follows:

Design Point (per ASHRAE):
86.7Fdb/77.6Fwb, 11 ft. above MSL;
100% water, 0.0005 fouling factor;
Coil Set: 8-row, 9-fin/inch, 2-serpentine;
57.27 lb./sec (moist air), 56.60 lb./sec (dry air):

EAT (per ASHRAE):	86.7 F db / 77.6 F wb (66.9% RH)
LAT:	62.4 F db / 62.0 F wb (97.9% RH)
Total capacity:	2,785,900 BTU/Hr
Sensible capacity:	1,246,700 BTU/Hr
Working fluid:	100% water – CAUTION, Freeze danger!
Fouling factor:	0.0005 (water-side)
EWT:	55.0 F
LWT:	62.6 F
Water delta-T:	7.6 F
Water flow rate:	736 GPM
Tube velocity:	6.1 ft./sec (max. allowed)
Water pressure drop:	20.6 ft. (coils ONLY)
Face velocity (act.):	505 ft./min
ACFM entering coils:	48,327
ACFM leaving coils:	46,020
Air pressure drop:	0.68" w.g. (coils ONLY)

Air Inlet System Scope / Process. Standard components and attaching hardware are provided, but system engineering is not included. Components are shown on the Mechanical Interface drawing as loose-shipped items. Flange patterns, footprints, and connection points will be provided when applicable. Warranty coverage applies to the individual components only and guarantees for overall noise and pressure drop are not provided.

EXHAUST SYSTEM

An exhaust system is provided and designed to ensure a smooth transition from the gas turbine to the heat recovery system (for CHP applications), or the exhaust silencer (for simple cycle applications). In either case, proper considerations should be taken into account, which are dependent on the nature of the installation.

Design Considerations:

- Avoid exhaust/ducting configurations that may lead to recirculation of exhaust products through the gas turbine, such as through the turbine air inlet filter, enclosure ventilation inlet filter.
- Avoid configurations where hot gas turbine exhaust products could impede performance of the lube oil cooler.
- Where two (2) or more units exhaust into a common header, provisions must be made to prevent hot gases from flowing into the non-operating unit.
  Note: This practice is not recommended.
- Capability to purge the complete exhaust system prior to light-off of the gas turbine. The following minimum purge times are recommended:
  - At least three (3) volume changes for simple cycle applications
  - At least five (5) volume changes for applications with waste heat recovery equipment
- Relative height of the exhaust stack above the turbine air inlet
- Building roof design (if applicable)
- Direction, and intensity of prevailing winds, and
- Proximity to adjacent structures

For simple cycle applications with exhaust silencer:

- Provisions must be made to adequately mount and support the equipment, and limit the exhaust silencer pressure loss, with no loads transmitted to the turbine exhaust.

No exhasut components are included in Solar Turbines Incorporated scope of supply.

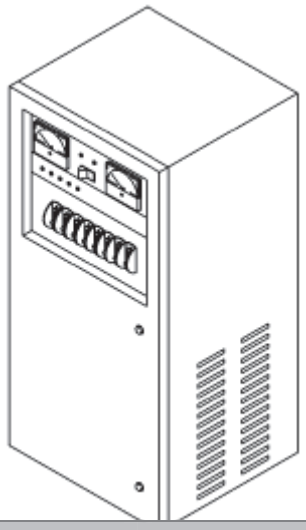
ACCESSORY EQUIPMENT

Battery Charger System

The battery charger system consists of a battery charger and batteries to provide 120V DC emergency back-up power to the:

- control system (**See Note a**),
- fuel valve,
- engine bleed valve,
- inlet guide vane actuator, and the
- back-up post-lube oil pump

A back-up battery charger is include.



Battery Charger System Specifications	
Charger Type:	See Utility List
Supply Voltage:	See Utility List
Output:	See Utility List
Operating Temperature Range:	14-122° F -10-50° C
Approximate Measurements:	
Height	35.5 in (90.2 cm)
Width	15.9 in (40.4 cm)
Depth	15.6 in (39.7cm)
Weight	125 lb (56.7 kg)
Ampere Hours:	
Valve Regulated, Lead Acid	155 AH

Notes:

(a) The control system includes a 120V to 24V DC to DC converter

Scope Clarification:
The battery charger system is designed for indoor installation in a non-hazardous area.

Batteries. Valve Regulated, Lead Acid (VRLA) batteries are mounted on a freestanding, two-tier, two-row rack. They are shipped fully charged, and ready for use.

24 Hour Battery. An 155Ah battery and associated charger will be provided for a combined DC post-lube operation and NFPA 72 compliance (24 hour + 5 minutes standby power to fire and gas system).

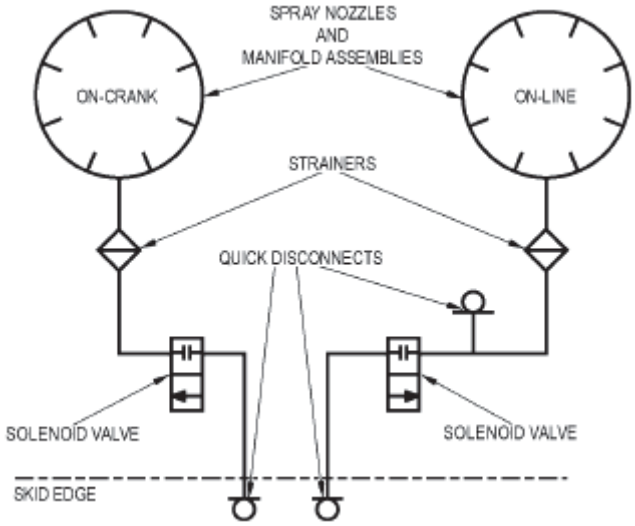
Turbine Cleaning System

A portable engine cleaning cart is provided to facilitate periodic cleaning of the gas turbine compressor. The gas turbine generator set incorporates two separate, and independent cleaning systems:

- On-Crank cleaning system
- On-Line cleaning system

Each cleaning system includes:

- a distribution manifold with pressure-atomizing spray nozzles in the gas turbine air inlet collector,
- onskid piping,
- strainer, and
- solenoid shutoff valves



Please reference Engineering Specification ES 2416 in the Appendix for additional information describing Solar's requirements for cleaning solutions used for engine cleaning.

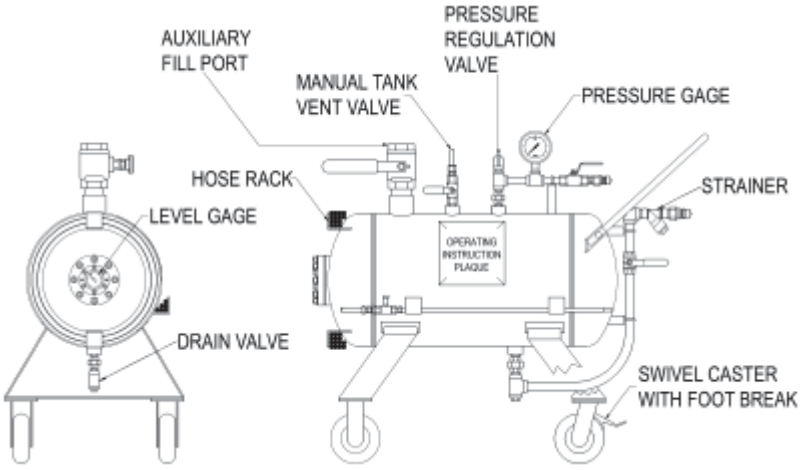
Turbine Cleaning System Specifications	
Water/Solvent Supply Pressure:	See Utility List
Water/Solvent Min Supply Temperature:	See Utility List
External Air Supply:	See Utility List
Air Supply Pressure:	See Utility List
On-Crank Water/Solvent Flow Rate:	See Utility List
On-Crank Propulsion Air Flow Rate:	See Utility List
Package On-Crank Triple-stage Strainer:	300/200/100 micron
On-Line Water/Solvent Flow Rate:	See Utility List
On-Line Propulsion Air Flow Rate:	See Utility List
Package On-Line Triple-stage Strainer:	300/200/100 micron

On-Crank Cleaning System. The on-crank cleaning system only operates at gas turbine cranking speed with the fuel system and ignition system deactivated. The gas turbine cranking and cleaning solution activation can be initiated from either the Onskid Video Display Unit (VDU), or the Auxiliary Video Display Unit.

On-Line Cleaning System. The on-line cleaning system only operates when the gas turbine speed is between 90-100% gas producer speed and with or without load. Cleaning solution activation can be initiated from the Onskid Video Display Unit (VDU), or the Auxiliary Video Display Unit. This system is intended to supplement the on-crank system by increasing the time intervals between periodic on-crank cleaning.

Turbine Cleaning Cart. A portable engine cleaning cart is provided to supply cleaning fluid to the connection at the generator set package skid edge. The cleaning tank can be used to mix, hold, and pressurize the turbine cleaning solution. The tank comes with wheels that are removable for stationary installation.

Unless otherwise indicated, a quantity of one (1) cart is provided per project.



Turbine Cleaning Cart Specifications	
Capacity:	See Utility List
Tank Discharge Strainer:	See Utility List
Approximate Measurements:	
Height	35.5 in (90.2 cm)
Width	15.9 in (40.4 cm)
Depth	15.6 in (39.7cm)
Weight	125 lb (56.7 kg)
Tank Material:	300/200/100 micron
Online Water/Solvent Flow Rate	See Utility List
Online Propulsion Air Flow Rate	See Utility List
Package Online Triple-stage Strainer	300/200/100 micron

Scope Clarification:
The turbine cleaning cart is certified consistent with the American Society of Engineers (ASME), or Pressure Equipment Directive (PED) as applicable for pressure vessels in this product category.

QUALITY ASSURANCE

In recognition of its commitment to quality, Solar has received Manufacturing Resource Planning (MRP) II Class A certification, and the Malcolm Baldrige National Quality award. Consistent with that ongoing commitment, Solar has developed acceptance criteria for key processes such as:

- engineering requirements,
- manufacturing and assembly standards, and
- test procedures

All testing operations are conducted under the direct control of Solar's Quality Assurance (QA) department, which ensures compliance with specified test procedures. In addition to in-plant testing of the finished gas turbine generator set package, quality control engineers survey the manufuacture of all purchased parts and subassemblies, and are responsible for functional tessting of all incoming components. The same rigid standards applied to manufactured parts are also applied to purchased parts.

INSPECTION AND TEST PLAN

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

All products are tested by qualified personnel throughout the manufacturing process to verify their design integrity. In addition to factory testing, Quality Control engineers maintain surveillance over purchased parts and sub-assemblies so that the same rigid standards applied to parts manufactured by Solar are also applied to our suppliers. Once package assembly is complete, the assembled turbomachinery system is tested (including the control system, fuel, lube and start systems) to ensure compliance with specified test procedures.

FACTORY TESTING

Factory testing is performed in accordance with Solar's test specifications, and as generally outlined below. The customer, or customer's designated representative can observe factory production tests in accordance with the production and testing schedules. However, production tests will not be delayed due to the unavailability of the customer or customer's representative. Doing so would cause a cascading delay for successive gas turbine packages in the production schedule.

Test Facilities

Solar's production test facilities each are equipped with computer-controlled data acquisition systems that collect real-time raw digital and analog data from the gas turbine package. The system is used to establish specified test conditions consistent with the performance guarantee (see Section 3.0: Performance and Emissions) by keying in calibration coeffients, constant and operating limits. In this regard, operating site conditions are simulated in the test cell.

When performance levels have been achieved, the test technician initiates a command to capture all instrumented points. At this time, performance computations are also executed, and the results saved for permanent record.

Testing

The gas turbine generator set testing usually consists of a separate test of the gas turbine, followed by a package test with the gas turbine mounted on the package.

Gas Turbine Acceptance Test. The gas turbine is tested in accordance with Solar's test specifications either on a "slave" test stand and generator, or on the "contract" gas turbine package depending on production schedules and test cell limitations. The gas turbine is tested at incremental speeds and loads up to and including full speed and power to verify functional and structural integrity and performance standards. Turbine power is absorbed by a high speed dynamometer, enabling all aspects of gas turbine operation and peformance to be measured.

The acceptance test generally includes the following:

- Bearing oil flows, pressures and temperatures
- Seal airflows and pressure
- Vibration levels and signature
- Gas turbine power and heat rate
- Gas turbine temperature measurements
- Adjustment of variable guide vanes and bleed valves

Generator Testing. The generator is tested in accordance with the Institute of Electrical and Electronics Engineers (IEEE) standard specifications and Solar's specifications at the manufacturer's respective production facility. These tests satisfy requirements for both NEMA and Solar. Supplier testing is under periodic quality control review by Solar to ensure conformity.

Generator Set Acceptance Testing. If the Gas Turbine Acceptance Test is performed on a “slave” test stand and generator, the Generator Set Acceptance Testing is generally performed statically, meaning without an operating gas turbine. Otherwise, the two tests will be performed simultaneously and the package assembly, including gas turbine, gearbox, generator, and package-mounted accessories, together with the control panel, will tested as a complete system. In either case, the objective is to ensure proper integration and function of the total package in accordance with Solar’s applicable test specifications. Results are recorded and maintained by Solar.

The acceptance test generally includes the following:

- Starting and combustion cycles
- Lubricating oil system flow, temperature and pressure measurements
- Vibration measurements
- Power and heat rate measurements at partial and full load under ambient conditions with a unity power factor of 1.0
- Gas turbine and generator temperature measurement
- Fuel transfers (for dual fuel units)
- Load/speed transient testing
- Malfunction and safety devices testing
- AC metering and control circuitry testing (if AC metering is supplied), calibration of AC metering circuits is performed by bench testing

Items excluded from standard package testing are “contract” inlet and exhaust system ancillary equipment (such as filters, silencers, and ducting), battery system, oil coolers, package enclosure, switchgear, and any customer-furnished hardware.

After static package tests are performed, the “contract” generator will be mounted, aligned on the package and dynamically tested.

Performance Review

Acceptance Test Data. Acceptance test data are reviewed and approved by Product Engineering, Test Engineering, Quality Engineering, and the project manager prior to submittal to the customer. With this review and approval cycle, the test data are furnished approximately four (4) weeks after completion of acceptance testing. The report provides test results and compares the results to Solar's acceptance test specification requirements by means of calculations, graphs, strip charts, and descriptions. Data are provided for each gas turbine generator set on the order. The acceptance test report generally includes the following:

> Gas turbine fuel consumption rates – a comparison of measured fuel consumption versus specified fuel consumption showing correlation of fuel consumption, power output, and turbine temperature at full load.
> Voltage and frequency transients – strip chart traces are provided that show voltage and frequency deviations during load transients
> Operating values – a chart that includes the following operating parrmeters at each step load from no load to full load:
  - Lubricating oil pressure, temperature and flow
  - Package temperatures
  - Generator power
  - Generator voltage, amperage, and frequency
  - Engine compressor discharge pressure
  - Package vibration levels

PREPARATION FOR SHIPMENT

The package is prepared for shipment with short-term preservation per Solar Specifications ES 9-248-1 and ES 9-249 in accordance to our preservation and packaging guidelines in *Product Information Letter (PIL) 097*.

OPERATION AND MAINTENANCE INSTRUCTIONS (OMI) MANUALS

The turbomachinery technical manual is provided in a four (4) volume set that includes descriptive and instructional information for operating and servicing the gas turbine generator set. Each volume of the set stands alone, and is described as follows:

Volume I: Systems Operator's Guide
Volume I is for equipment operator use. Locations and descriptions for all operator controls and indicators are provided. Procedures for starting, stopping, and operating the equipment are also included.

Volume II: Maintenance Instructions
Volume II is for maintenance and field service personnel use. The functions of major systems and subsystems are described, and component descriptions are included. Maintenance instructions, and alignment and checkout procedures are provided. The introduction chapter provides maintenance schedules, torque tables and maintenance information for the mechanical systems on the package.

Volume III: Supplementary Data
Volume III is a collection of standard, copyrighted documents that cover supplier-provided components and assemblies. These documents, passed on by Solar Turbines from its suppliers, are only available in the English language; therefore, these documents cannot be translated into other languages. Documents in this volume are arranged and tabbed alphabetically by the names of the suppliers, as listed on the Supplementary Data sheet furnished at the front of the volume.

Volume IV: Illustrated Parts List
Volume IV lists part numbers, part names, quantities required, reference designators, and drawings to locate parts used in the turbine package. Various indices are provided to aid the user in locating piece parts within the package.

Digital Photos
For general reference, Solar provides digital photos captured during the manufacture/assembly of the gas turbine generator set package(s).

The OMI manual is presented in English on one (1) CD-ROM in Adobe Portable Document Format (.pdf) format, enabling use of the search features within Acrobat Reader. Two (2) individual CD-ROMs will be provided. Additionally, and electronic copy is uploaded to Solar's Electronic Document Control workspace referenced earlier in this proposal under Section 7.0: Drawing Schedule.

In addition to electronic distribution, Six (6) hard copies of the OMI manuals will be provided.

For your reference, a copy of the typical cover sheet for the OMI Manual is listed on the following page.

Scope Exclusion:
To the extent it is applicable, Balance of Plant (BOP) scope is excluded from the OMI manual. That information will be bundled by Solar from each of the respective sub-suppliers, and provided under separate cover.

Typical Cover Sheet: Operation and Maintenance Instructions (OMI) Manuals

Solar Turbines
A Caterpillar Company

User Instructions

System Requirements

Operating System:	Windows® 98 or higher
Software:	Adobe® Acrobat® Reader 6.0 or higher
Hardware:	CD-ROM drive reader, 4X speed or higher

Installation

To view the electronic manual with optimum functionality, *Adobe Acrobat Reader* 6.0 or higher must first be installed on your computer. *Adobe Acrobat Reader* has been provided on this CD-ROM for your convenience.

If *Adobe Acrobat Reader* is not installed, go to your CD-ROM drive directory and locate the Adobe Acrobat folder. Double-click the executable file inside to launch the *Acrobat* installation.

To update your *Adobe Acrobat Reader* to a later version, you must uninstall your previous version before installing the new version. Go to the Start menu and choose Settings, Control Panel, Add/Remove Programs. Select the earlier version of *Adobe Acrobat Reader* and click the Remove button. Install the updated version as described above.

Operation and Maintenance Instructions

(Click on the links below to view the manual)

Systems Operator's Guide

Maintenance Instructions

Supplementary Data

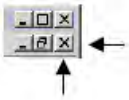
Illustrated Parts List

Digital Photos

Viewing and Navigation Instructions

Navigation Toolbar – The Navigation toolbar can be found at the bottom of your *Adobe Acrobat* viewing window. The toolbar contains the following buttons and features from left to right: Go to First Page, Go to Previous Page, Select Page Number, Go to Next Page, Go to Last Page, Previous View and Next View.

Closing Sub-Documents – Clicking on one of the blue links above will launch a section or volume of the technical manual. To return to the main menu, locate and click the lower Close Document button, resembling an "x", located in the upper right side of the *Adobe Acrobat* viewing window. TIP: "Ctrl+W" will also close any active sub-documents in your viewing window.



Section 2.0

Technical Requirements, Specifications, and Assumptions

GAS FUEL COMPONENT ANALYSIS

The fuel composition below is based on the information provided to Solar. Also below are the corresponding fuel characterics defined by that composition. The skid edge pressure requirements outlined in the next section, as well as the generator set performance outlined in Section 3.0 of this proposal are based on these characteristics.

It is the responsibility of the Buyer to confirm that the actual gas composition is consistent with this presumption. Deviations may adversely affect generator set performance.

Molar Analysis of Gas Fuel

	-- FEED	---- LIQUID ----		---- VAPOR ----	
COMPONENT	**% OF TOTAL**	**% OF TOT**	**% OF L**	**% OF TOT**	**% OF V**
METHANE	95.5359	0.0000	0.0000	95.5359	95.5359
ETHANE	2.2050	0.0000	0.0000	2.2050	2.2050
PROPANE	0.2670	0.0000	0.0000	0.2670	0.2670
I-BUTANE	0.0380	0.0000	0.0000	0.0380	0.0380
N-BUTANE	0.0500	0.0000	0.0000	0.0500	0.0500
NITROGEN	0.6650	0.0000	0.0000	0.6650	0.6650
I-PENTANE	0.0160	0.0000	0.0000	0.0160	0.0160
N-PENTANE	0.0110	0.0000	0.0000	0.0110	0.0110
CARBON DIOXIDE	1.1880	0.0000	0.0000	1.1880	1.1880
N-HEXANE	0.0160	0.0000	0.0000	0.0160	0.0160
N-HEPTANE	0.0080	0.0000	0.0000	0.0080	0.0080
SULFUR DIOXIDE	0.0001	0.0000	0.0000	0.0001	0.0001
WATER	0.0000	0.0000	0.0000	0.0000	0.0000
TOTAL	100.00	0.0000	100.00	100.0000	100.00
H, BTU/MOLE	5409.8	0.0	5409.8		

Gas Fuel Characteristics

Calculated Results

LHV BTU/LB: 20538.6	**LHV BTU/SCF:** 915.1	**Wobbe Index:** 1197.7
Molecular Wt: 16.909	**Specific Gravity:** 0.5838	**Corrected Wobbe Index:** 1197.7
Min Fuel Supply Temp(NGL,°F): -3.5	**Min Fuel Supply Temp(H20,°F):**	**Adiabatic Flame Temperature(°F):** 4198
NEC/CSA Gas Group: D	**IEC Gas Group:** IIA	**MESG(Maximum Experimental Safe Gap):** 1.1348

Warnings

Traces of SO2
SO2 is toxic. Remove the water. Precautions must be taken to detect leaks.

Theoretical Hydrocarbon Breakdown Used
The supplied fuel composition demonstrated atypical hydro carbon breakdown.
A theoretical breakdown has been used for all hydrocarbons heavier than C5.

ES9-98 Compliance
Strict compliance with Solar specification ES 9-98 regarding air, water, fuel filtration and handling is required.
Contamination allowed to enter the engine impacts performance, accelerates degradation, and puts the unit at risk.
Reference PIL 162 for fuel handling guidelines.

Fuel Superheat Requirements
The fuel temperature must be 50°F above NGL dew point and 20°F above H2O dew point.
If the surrounding temperature is less than the minimum supply temperature, the customer must pre-heat the supply line to ensure liquids do not form in the gas, particularly when the line is not flowing.
A liquid trap with a drain is required at the skid inlet. Lines should be pitched away from the skid.
The skid inlet piping must be heated by one or more of the following methods:
- Heat tracing and/or insulating supply lines.
- Recirculating or venting hot gas in the supply line prior to starting.
- Locate flowing hot gas supply line next to Solar skid.
- Heat entire area

Please reference *Product Information Letter (PIL) 162* in the Appendix for additional information complementing Solar specification ES 9-98. Specifically regarding gas fuels, this PIL prescribes the following:

Gaseous fuels can vary from poor quality wellhead gas to high quality consumer or “pipeline” gas. Typically, the major sources of contaminants in these fuels are:

- Solids
- Water
- Heavy gases present as liquids
- Oils typical of compressor oils
- Hydrogen sulfide (H2S)
- Hydrogen (H2)
- Carbon Monoxide (CO)
- Carbon Dioxide (CO2)
- Siloxanes

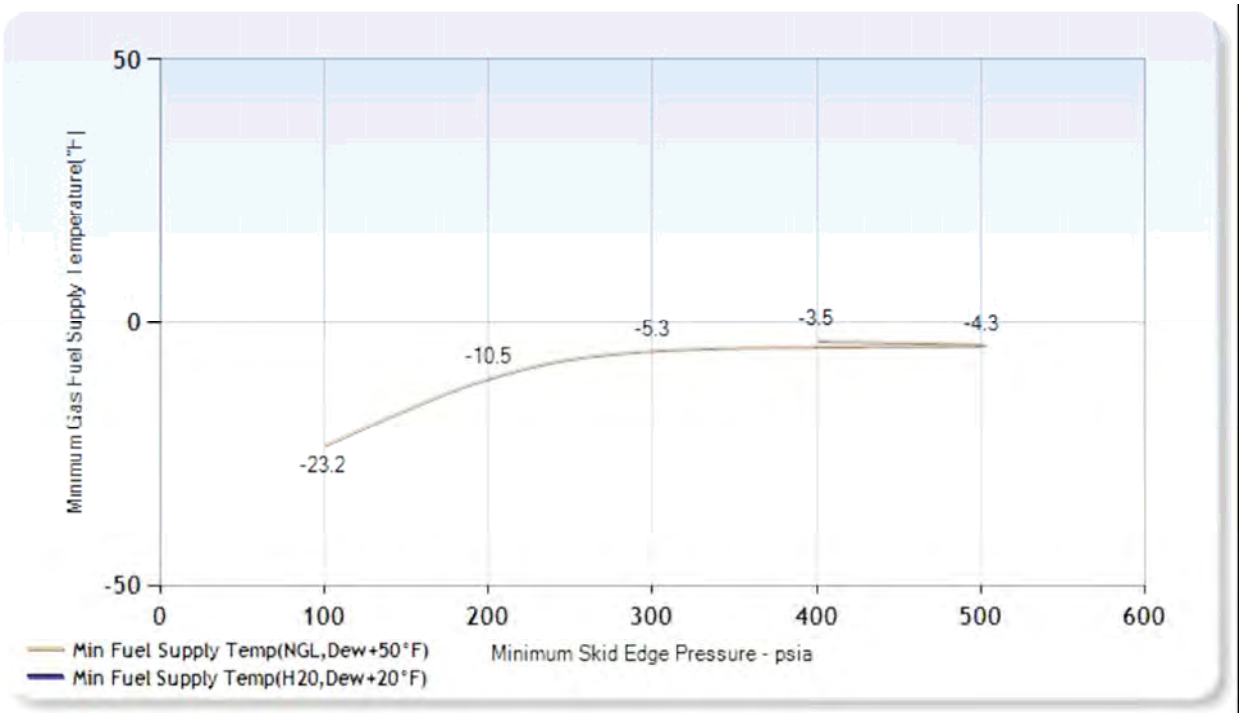
This PIL further describes the issues, symptoms and solutions for these contaminants in gaseous fuels.

Fuel quality is a critical factor in gas turbine operation. Owners and operators of gas turbines are responsible for ensuring that fuel entering a turbine meets the applicable specifications. PIL 162 complements ES 9-98 by summarizing the contaminants that may be found in gaseous fuels, as well as recommendations for protection against these contaminants. The fuel delivery systems described by this PIL should allow operation with minimum fuel-related issues, provided proper maintenance procedures are followed.

Wobbe Index
The Wobbe Index range shall vary by no more than +10% from the value identified in the Gas Fuel Characteristics section above. Variation beyond this range may void either or both the guaranteed gas turbine performance, or the warranted gas turbine emissions, as applicable.

Minimum Fuel Superheat Temperature Curves
Consistent with the requirements of ES9-98, the gas fuel supply temperature at the skid edge must be the higher of dew point temp for natural gas liquids + 50°F, and dew point temp for water + 20 °F to ensure no liquid condensation.

Based on the fuel gas composition defined above, the chart below illustrates the minimum fuel gas supply temperature. Recall that the requirement is for the higher of the two.

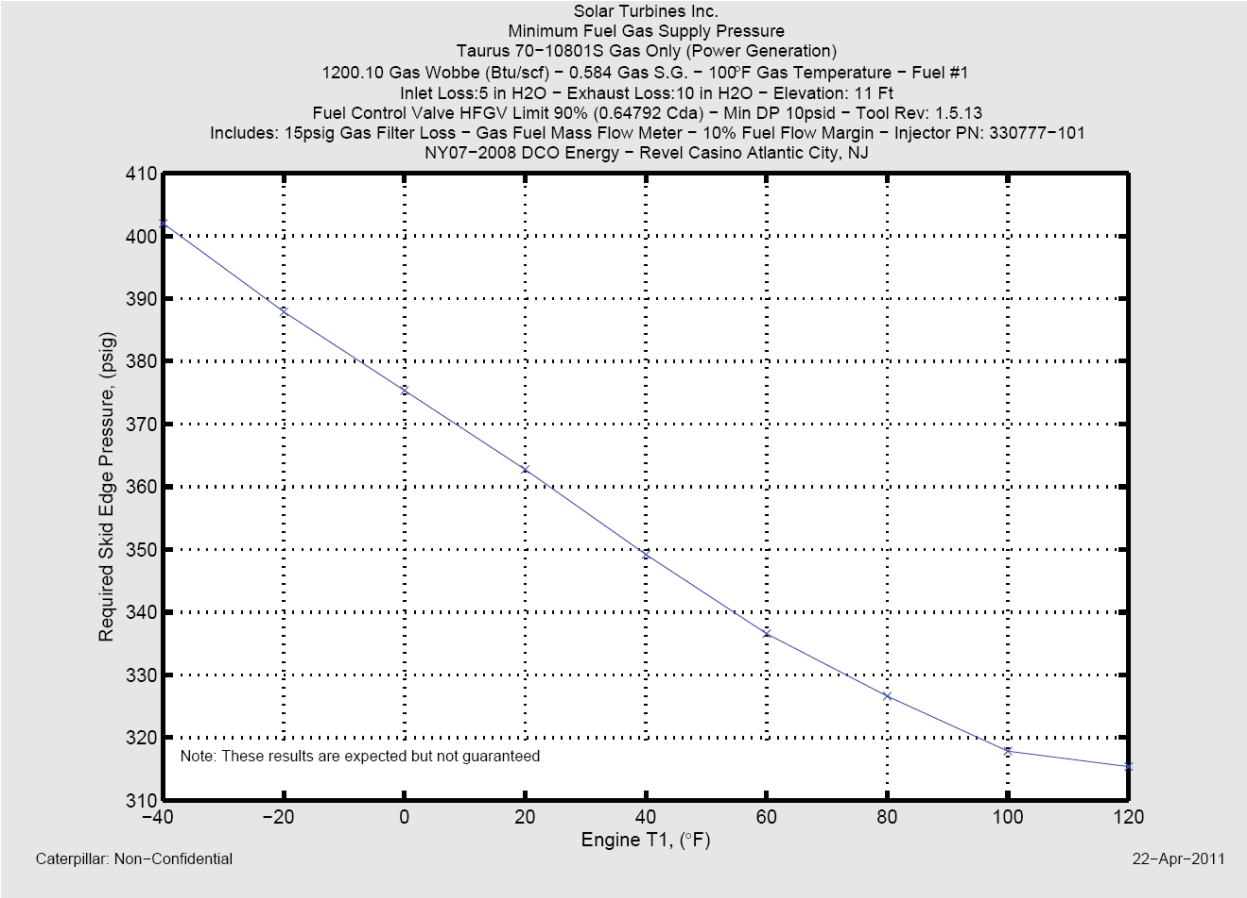


Package Gas Fuel System Rating:

- Supply temperature -40°F (-40°C) min; 200°F (93°C) max

GAS FUEL PRESSURE REQUIREMENTS

The following curve represents the minimum presure requirements at Solar's skid edge based on the component analysis referenced in the previous section; and on the ambient and performance conditions specified on the chart below[1].



[1] Ambient temperature range for T1 is subject to the rating of the supplied equipment.

Package Gas Fuel System Rating:

- Supply pressure 500 psig (3450 kPag) max

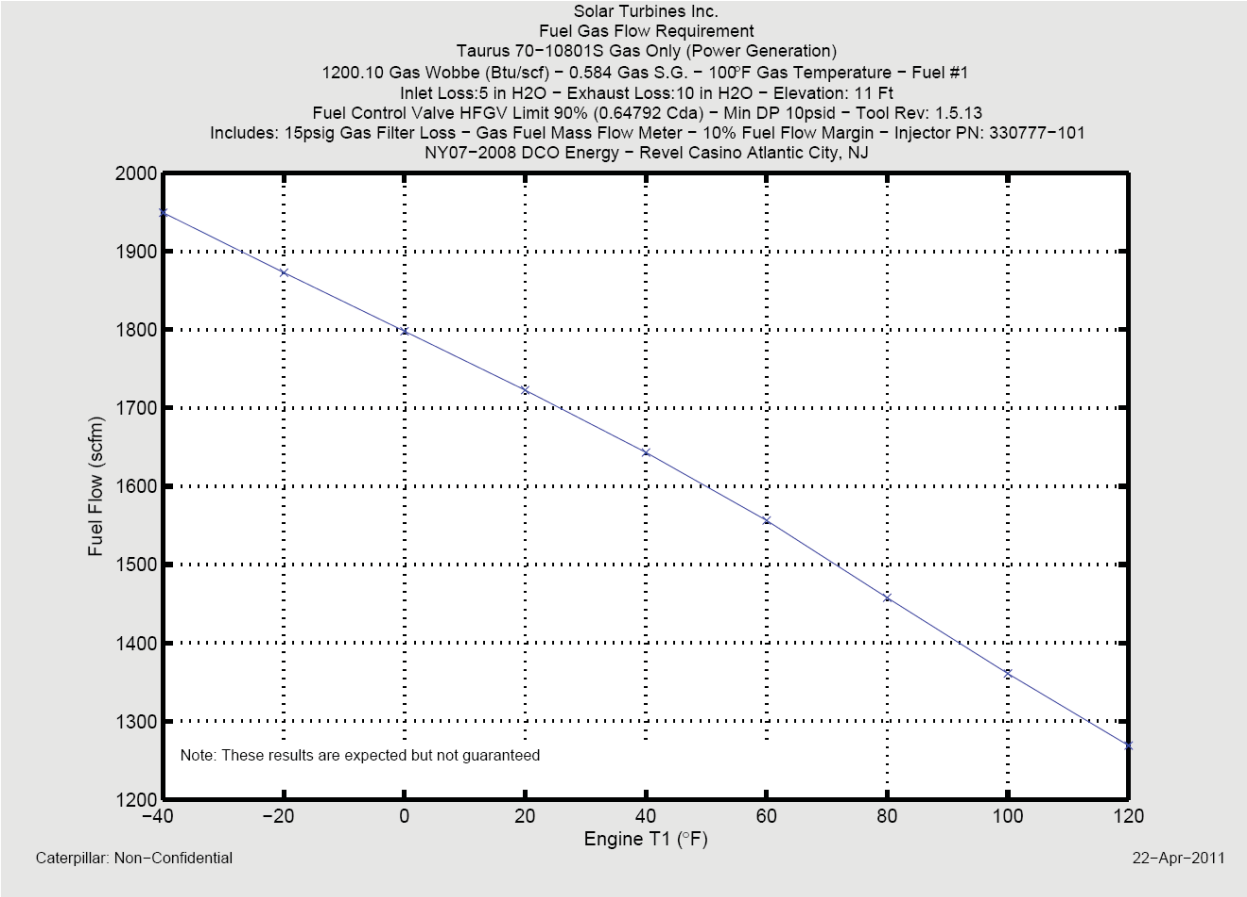
Gas fuel must be supplied between the minimum pressure (prescribed by the Minimum Fuel Pressure Curve above) and the maximum rating of the fuel system.

Note:
The above skid edge pressure requirement curve is current as of the date of this proposal. Over time however, the requirements may change. As a buffer (and as indicated in the notes on the graph above), Solar has included margin in the requirement including a 15 psid across the gas fuel filter, and 10% additional fuel flow.

Prior to negotiating a fuel supply contract with your gas utility, or specifying a fuel gas compressor (if not supplied by Solar), we recommend you re-confirm the skid edge pressure requirements above.

GAS FUEL FLOW REQUIREMENTS

The following curve represents the expected gas fuel flow required per the gas composition referenced in the previous section; and on the ambient and performance conditions specified on the chart below[1].



[1] Ambient temperature range for T1 is subject to the rating of the supplied equipment.

UTILITY LISTS

ELECTRICAL SYSTEM

3-Phase AC Power Rating. Unless otherwise noted, all 3-Phase AC power is rated as follows:

Voltage / Frequency	460 VAC / 60 Hertz

1-Phase AC Power Rating. Unless otherwise noted, all 1-Phase AC power is rated as follows:

Voltage / Frequency	120 VAC / 50-60 Hertz

GENERATOR

Space Heater Power	2.02 kW, 1-Phase

START SYSTEM

Starter Motor

Type	AC Motor with Variable Frequency Drive
Motor Power, Continuous Duty Rating	110 kW (150 hp), 3-Phase
Motor Power, Peak	250 kW (335 hp), 3-Phase
VFD Rating, Input Current (max)	463 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 (min, ISO)*	*See Gas Fuel Pressure Requirements
Gas Fuel Supply Pressure (design max)	500 psig (3450 kPag)
Gas Fuel Flow Demand Rate (max)*	*See Gas Fuel Flow Curve
Gas Fuel Supply Temperature (min/max)	-40 to 200°F (-40 to 93°C) and at least 50°F (27.8°C) above fuel dewpoint
Fuel Quality	See Solar Specification ES 9-98

*These numbers are provided only as a guideline. The actual required gas fuel supply pressure and flow rate are dependent on the final composition of the fuel gas and the operating temperature range. The customer must provide this information so that Solar can determine the values needed for successful operation of the turbine. The ISO values given apply only to full power operation with 59°F (15°C) turbine air inlet temperature, San Diego natural gas at 100°F (38°C), 4 in. (10 cm) H_2O inlet and 8 in. (10 cm) H_2O exhaust losses.

Natural Gas Fuel Pilot Air Valves

Air Supply Pressure (min/max)	100 to 200 psig (690 to 1379 kPag)
Air Flow Demand Rate (max)	70 SCFM (1.9 Nm^3/min)
Air Consumption per Start	6 SCF (0.17 Nm^3)
Pilot Vent Back Pressure (max)	5 psig (34 kPag)

LUBE OIL SYSTEM

Pre-Post Lube Oil Pump

Type	AC Motor-Driven
Motor Power	2.25 kW (3.0 hp), 3-Phase
Space Heater Power	60 W, 1-Phase
Lube Oil Quality	See Solar Specification ES 9-224

Backup Lube Oil Pump

Type	120 VDC Motor-Driven
Motor Power	0.746 kW (1.0 hp)
Space Heater	None

Lube Oil Tank Heater

Motor Power	15 kW (20.1 hp), 3-Phase

DESKTOP DISPLAY & PRINTER

Auxiliary Desktop Display

Phase / Amperage	1-Phase at 20 Amps

Printer / Logger

Voltage / Phase / Frequency	120 VAC / 1-Phase / 50-60 Hertz

BATTERY SYSTEM

Battery

Type	120 VDC, Valve-Regulated Lead Acid
Rating	155 Ampere-Hours

Charger

Type	Wall-Mount
Charger Input Power	3.8 kW (5.2 kVA), 1-Phase
Charger Output Current	20 Amps DC

Note:
The unit 24 VDC control system includes a converter to reduce the 120 VDC supply to 24 VDC.
Battery system meets 24 hour battery requirement poer NFPA 72

AIR INLET SYSTEM (If Purchased)

Inlet Chiller Coils

Entering Water Temp (EWT)	55°F
Leaving Water Temp (LWT)	62.6°F
Water Supply Flow Rate(min/max for 100% water)	736 GPM
Water Supply Pressure (min/max)	150 psig (1034 kPag)
Air Pressure Drop	0.88" (22.4mm) H2O (with transistion ducts)

Section 3.0

Performance and Emissions

GUARANTEED GENERATOR SET PERFORMANCE

Site Conditions

Altitude	11	FASL
Ambient Temperature	60	deg F
Relative Humidity	60%	

Performance Conditions (See Note a)

Inlet Pressure Drop	5.0	in W.C.
Exhaust Pressure Drop	10.0	in W.C.
Turbine Operating Level	100%; Continuous Duty	

Power Output and Heat Rate (See Note b)

Gas Fuel

Output Power	7,432	kW
Heat Rate	10,505	Btu/kW-hr (LHV)

Notes:

(a) Generator set performance is guaranteed on the basis of the pressure drops indicated for the inlet and exhaust systems. Deviations from these values will have a corresponding impact on performance observed at the project site; Guarantee Performance is verified based on a standard San Diego factory test, corrected to these stated inlet/exhaust loss conditions.

(b) Power Output and Heat Rate is guaranteed on the basis of the Site and Performance Conditions listed above, and by the Fuel Component Analysis referenced in Section 2.0 of this proposal;
Electric power is measured at the generator terminals;
Guarantee Performance is verified based on a standard San Diego factory test, corrected to these stated conditions.

(c) Exhaust Energy is guaranteed based on the Site and Performance Conditions listed above, and by the Fuel Component Analysis referenced in Section 2.0 of this proposal.

EMISSIONS OUTPUT

The following turbine output emissions are warranted by Solar Turbines subject to the conditions indicated below, and through the warranty period indicated in Section 7.0.

Gas Fuel Operation (per the Gas Fuel Component Analysis in Section 2.0):

NOx	25 ppmv
CO	50 ppmv
UHC	25 ppmv

Operating Conditions for the above emissions are as follows:

Ambient Temperature range: 0 - 120°F (-17 - 48° C)
Operating Range: 50-100%

(Emissions rates in ppmv; measured at steady state operation; and corrected to ISO conditions -- 15% O_2 dry, 59°F, 14.696 psia, 60% relative humidity)

Notes/Clarifications:

> The emissions cited above are applicable only for steady-state conditions and does not apply during start-up, shutdown, malfunction, or during transient events.
> Emissions listed above are factory tested in accordance with Solar's Engineering Specification ES 9-97.

Particulate Matter Emissions

The following PM10/2.5 particulate matter emission factors are warranted subject to the same operating conditions referenced above under Emissions Output, inclusive of ambient temperature and load range; and to the warranty period indicated in Section 7.0.

Gas Fuel Operation (**See Note a**): 0.021 lb/MMBtu (HHV)

Notes:

(a) The emission levels cited are only for engine operation of the fuels defined in Section 2.0: Technical Specifications, Requirements, and Assumptions. Other fuels may not yeld similar results.

Test Method Recommendation. Solar recommends the following:

- EPA Methods 201/201A be used to measure the “front half”. “Front half” represents filterable particulate matter.
- EPA Method 202 (with nitrogen purge and field blanks) shoul be used to meaure the “back half”. “Back half” measurements represent the condensable portion of particulate matter.
- EPA Method 5, which measures the front and back halves may be substituted (e.g. where exhaust temperatures do not allow the use of Method 202).
- Testing shall include three test runs for a minimum of four hours each
- All three test runs should be completed within a five calendar day period.
- In the event that PM10 test levels exceed those warranted, Solar Turbines must be notified and given the opportunity to review the test results and to participate, at its option, in any retest.

Scope Exclusion:
Solar does not conduct PM10/2.5 testing. Any required testing is to be conducted by Others at the project site.

Scope Clarification:
In the event that PM10/2.5 test levels exceed those warranted, Solar Turbines must be notified and given the opportunity to review the test results. Additionally, and at its option, Solar must be allowed to participate in any retest.

Please reference *Product Information Letter (PIL) 171* in the Appendix for additional information describing Solar’s position on PM10/2.5 emission factors.

NEAR FIELD NOISE DATA

This package is offered with an acoustical enclosure designed to maximize noise reduction. The A-weighted sound level at full load operation, when installed in a free field, is estimated to meet an average of 85 dBA at 1 m (3 ft) from the package enclosure and at a height of 1.5 m (5 ft) above the bottom of the skid. This sound level is measured at points spaced typically 1.5-3.0 m (5-10 ft) apart on each side of the enclosure, and at one position on each end of the enclosure on the longitudinal axis.

These sound levels are exclusive of piping, other equipment, reflected sound, or other contributing site conditions.

Scope Exclusion:
The gap between the bottom of the skid and the mounting surface must be sealed with a non-hardening caulk. This activity is performed by Others.

Scope Clarification:
When enclosed packages are installed on elevated mounts, such as anti-vibration mounts, the gap between the bottom of the skid and the mounting surface is typically between 305-355 mm (12-14 in), which is too large to seal by caulking. In such cases, 85 dBA can only be obtained through the use of skirts that extend from the botton of the skid to the mounting surface. Skirts are not included in the base proposal.

Please reference *Product Information Letter (PIL) 058* in the Appendix for additional information describing Solar's guidance on sound levels for turbomachinery packages.

Solar's Noise Prediction: Guidelines for Industrial Gas Turbines handbook is available via www.solarturbines.com, and provides an in-depth reference to:

- Noise Criteria
- Noise Sources
- Physical Properties of Sound
- Noise Data
- Sample Calculations, and
- Source Sound Power Levels

EXPECTED GENERATOR SET PERFORMANCE

The following generator set performance is expected, but not guaranteed. The "Run" numbers correspond to different operating points and/or ambient conditions.

	Run 1	*Run 2*	*Run 3*	*Run 4*	*Run 5*	
Site Conditions						
Altitude	11	11	11	11	11	FASL
Ambient Temperature	0	20	40	60	62.4	deg F
Relative Humidity	60%	60%	60%	60%	98%	
Performance Conditions						
Inlet Pressure Drop	5.0	5.0	5.0	5.0	5.0	in W.C.
Exhaust Pressure Drop	10.0	10.0	10.0	10.0	10.0	in W.C.
Turbine Operating Level	100%	100%	100%	100%	100%	load
Power Output and Heat Rate						
Gas Fuel						
Output Power	9,057	8,646	8,197	7,662	7,584	kW
Heat Rate	9,959	9,996	10,057	10,190	10,230	Btu/kW-hr (LHV)
Thermal Efficiency	34.3%	34.1%	33.9%	33.5%	33.4%	
Fuel Flow	90.2	86.4	82.4	78.1	77.6	MMBtu/hr (LHV)
Exhaust Energy						
Gas Fuel						
Exhaust Flow	231,244	225,451	218,573	210,092	208,043	lbm/hr
Exhaust Temp	940	943	949	958	961	deg F

EXPECTED GENERATOR SET PERFORMANCE (cont'd)

The following exhaust gas analysis is expected, but not guaranteed. The "Run" numbers correspond to the same operating points and/or ambient conditions indicated on the previous page.

Exhaust Gas Analysis

Run #1	Argon	CO2	H2O	N2	O2		
	0.90	3.31	6.46	75.50	13.83	100.0	vol %, wet
	0.97	3.53	0.00	80.72	14.78	100.0	vol %, dry
	2,921	11,782	9,425	171,283	35,828	231,239	lbm/hr

Run #2	Argon	CO2	H2O	N2	O2		
	0.90	3.25	6.47	75.45	13.93	100.0	vol %, wet
	0.96	3.47	0.00	80.67	14.89	100.0	vol %, dry
	2,846	11,282	9,207	166,912	35,199	225,446	lbm/hr

Run #3	Argon	CO2	H2O	N2	O2		
	0.90	3.19	6.63	75.28	14.00	100.0	vol %, wet
	0.96	3.41	0.00	80.62	14.99	100.0	vol %, dry
	2,756	10,745	9,148	161,590	34,330	218,569	lbm/hr

Run #4	Argon	CO2	H2O	N2	O2		
	0.90	3.12	7.04	74.91	14.02	100.0	vol %, wet
	0.96	3.36	0.00	80.59	15.09	100.0	vol %, dry
	2,640	10,143	9,362	154,831	33,111	210,087	lbm/hr

Run #5	Argon	CO2	H2O	N2	O2		
	0.89	3.11	7.81	74.30	13.89	100.0	vol %, wet
	0.96	3.37	0.00	80.59	15.07	100.0	vol %, dry
	2,601	10,027	10,313	152,528	32,569	208,038	lbm/hr

Section 4.0

Site Testing

FIELD PERFORMANCE VERIFICATION TESTING

The objective of site testing is typically to determine that the equipment furnished meets, at a minimum, the guaranteed performance claimed by the manufacturer. At Solar Turbines, we take this very seriously. In Section 1.0: Factory Testing of this proposal document, our comprehensive test procedures were described, including:

- Test Facilties
- Gas Turbine Acceptance Test
- Generator Testing
- Generator Set Acceptance Testing

With the availablility of dynamic Generator Set Acceptance Testing of the generator set package, in an instrumented and calibrated test cell, and a corresponding test report; this might well be considered an alternative to site testing.

However, where endurance testing of the installed equipment is desired, or site performance verification testing is otherwise required, Solar offers a service product to meet your specific needs.

Field Performance Verification Test Procedure

The declared Solar gas turbine generator set performance, and reference conditions associated with such performance are specified in Section 3.0: Performance and Emissions, of this proposal. These performance values are demonstrated during factory testing, and in instances where Solar has guaranteed performance, compliance with such guaranteed performance is evaluated based on the factory test results.

Customers frequently request that performance values demonstrated during the factory tests be verified through field testing at site, and this document defines the test objectives and procedures for such field testing, to verify the Output Power and Heat Rate performance of the Solar gas turbine generator set(s).

Solar Turbines has participated in the start up and site performance verification on thousands of gas turbine generator sets. This procedure has proven to be an effective way to verify proper package performance (Output Power and Heat Rate) for both the customer and Solar.

Test Description

Test Conditions. Engine performance testing at Solar's factory allows the engine to be operated in steady, closely controlled conditions with redundant, calibrated instrumentation. Factory testing performed by Solar typically allows the most accurate evaluation of engine performance. The field tests described herein are intended to provide a site verification of the declared performance values for Output Power and Heat Rate, based on data obtained from the permanently installed package instrumentation, and other sources, such as Customer instrumentation. Other factors affect the field verification test results, such as power transformer (PT) and control transformer (CT) accuracy, the accuracy of the fuel analysis, etc.; many of which are beyond Solar's scope of control. This results in a field test with an inherently lower accuracy than the factory test, and an allowance for this uncertainty must therefore be considered when evaluating the field test results as further explained herein.

It is also unlikely that actual site conditions during the test will duplicate the reference conditions associated with the declared performance. Solar will perform the necessary data reduction and correction to provide equivalent performance values based on the actual conditions during the test, such as:

> ambient temperature (T1)
> barometric pressure, or site elevation
> relative humidity
> inlet and exhaust duct loss

such that the results obtained during the test can be compared with the declared values. The data correction will include performance calculations for the actual site test conditions based on Solar's FASTE or ENGPERF performance programs. FASTE is Solar's on-line performance program, whereas ENGPERF is a portable version of the Solar performance program that allows Solar's Field Service Representative (FSR) to make field performance calculations, without having to access FASTE.

A Solar representative, usually a Field Service Representative (FSR), must participate in the test, either as a witness, or assisting with the performance of the test. The Customer must also be present. Operation of the engine and other plant equipment during the test is by the Customer's operator.

The engine must be in an "as new" condition with a recent compressor detergent crank wash, and the test must be completed within the first 30 days after initial start up, and within 400 fired hours of operation.

The Customer is responsible to provide all fuel, electrical load and electrical metering for the test and to heat soak the equipment prior to the test data being recorded. A full fuel analysis must be provided by the Customer to verify compliance with Solar specification ES 9-98, and confomance with the fuel compositions identified in Section 2.0: Technical Requirements, Specifications and Assumptions of this proposal.

Note:
Should the site fuel analysis deviate from either ES 9-98 or the composition cited in this proposal, a corresponding correction to Solar gas turbine generator set(s) performance may be required.

At the conclusion of the test, Solar will provide a test report including the final performance evaluations, observations during the test, and the acceptance criteria similar to the one below.

Sample Test Report:

Table 1 - Full Load Test Results

	Test Results									
Data Point	1	2	3	4	5	6	7	8	9	Average
Date										
Time										
Barometric Pressure (inHg)										
T1 (Deg F)										
T5 (Deg F)										
Inlet Diff Press (inH2O)										
Exhaust Diff Press (inH2O)										
Relative Humidity (%)										
PCD (psig)										
Gen Power Output (Kw)										
Voltage (kV)										
Frequency (Hz)										
Power Factor										
Fuel Flow (mmBth/h)										
	Power Analysis (test conditions)									
FASTE / ENGPERF predicted power [kW]										
Site Test Power [kW]	0	0	0	0	0	0	0	0	0	0
Test Power – Predicted Power	0	0	0	0	0	0	0	0	0	0
Percent Delta (positive is favorable)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
	Heat Rate Analysis (test conditions)									
FASTE / ENGPERF predicted fuel flow [mmBtu/h]										
FASTE / ENGPERF predicted power [kW]	0	0	0	0	0	0	0	0	0	0
FASTE / ENGPERF predicted HR [Btu/kWh]										
Site Test fuel flow [mmBtu/h]	0	0	0	0	0	0	0	0	0	0
Site Test Power [kW]	0	0	0	0	0	0	0	0	0	0
Site Test HR [Btu/kWh]	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Test HR – Predicted HR	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Percent Delta (negative is favorable)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Comments / Remarks: -
<> Engine hours at start of test. Water wash performed / not performed.
No fuel LHV provided by customer, so default 18,330 Btu/lb, and SG 0.85 used.
Barometric pressure and RH reading from <> Airport used.

Equipment and Methods. The following data shall be measured/recorded:

- Temperature of the air at the inlet to the engine compressor (T1), and of the combustion gas in the gas turbine hot section (T5)
- Static pressure at the engine compressor discharge (Pcd)
- Pressure loss across the turbine air intake system
- Pressure loss across the exhaust system (provided by the Customer)
- Fuel flow
- Barometric pressure
- Speed of rotation of the gas producer, and of the power turbine -- if applicable
- Fuel gas composition – if applicable (provided by the Customer)
- Liquid fuel analysis – if applicable (provided by the Customer)
- Electrical power output at the generator terminals

Measurement of Temperatures. The permanently installed thermocouples and RTD's forming part of the gas turbine package instrumentation shall be used. The signal from the RTD or thermocouple shall be transformed into a digital signal by package control system programmablel logic controller (PLC).

Measurement of Static Pressures. Inlet system pressure loss is not monitored by the gas turbine package instrumentation. This measurement should be across the inlet to the gas turbine air inlet filter and the inlet collector integrally mounted to the gas turbine engine. If the Customer is unable to provide measured data, Solar will use assumed values in the performance calculations.

Exhaust system pressure loss is not monitored by the gas turbine package instrumentation. Instead, the Customer must provide this data for use in the performance calculations. For most combined heat and power (CHP) applications, this measurement would be across the exit of the gas turbine package and the stack exit. This data may be available on the HRSG control system, or Customer DCS, otherwise temporary instrumentation should be installed by the Customer. If the Customer is unable to provide measured data, Solar will use assumed values in the performance calculations.

Gas/Liquid Fuel Composition. The chemical composition of gas fuel shall ideally be determined at regular intervals during the testing, using recognized methods of analysis. Solar uses the "PIPELINE" program to calculate gas properties from the gas composition. In the event a gas composition is used in the performance calculation that has been determined at a time other than during the tests, and to the extent that it deviates from the gas fuel composition identified in Section 2.0 of this proposal, additional test uncertainty shall apply. If the gas fuel contains condensable fractions, care shall be taken that the analyzed gas represents the gas consumed.

The properties of liquid fuel shall ideally be determined by analysis of samples taken at regular intervals throughout the testing using recognized methods of analysis. In the event a liquid fuel analysis is used in the performance calculation that has been determined at a time other than during the tests, and to the extent that it deviates from the liquid fuel analysis identified in Section 2.0 of this proposal, additional test uncertainty shall apply.

Measurement of Fuel Flow. To measure gas and/or liquid fuel flow, the Solar supplied mass flow meters forming part of the permanent plant instrumentation shall be used. The fuel LHV shall be taken from the Customer's fuel analysis, and programmed into the gas turbine package control system PLC, so that the package human/machine interface (HMI) displays fuel flow in MMBtu/hr.

In the case of gas fuel, where the Customer's fuel analysis takes the form of a gas composition, Solar shall determine the LHV based on the "PIPELINE" program. The gas fuel must be homogenous (no liquids) – see Section 2.0: Technical Requirements, Specifications and Assumptions for clarifying information.

See note above regarding deviations from the fuel compositions identified in Section 2.0 of this proposal.

Measurement of Barometric Pressure. If the plant is equipped with a Customer supplied digital barometer, barometric pressure shall be recorded for each test point, provided the instrument is located at the same elevation as the engine, supported on a wall or solid structure free of vibration, and vented to ambient atmosphere.

If a barometer is not available at site, barometric pressure information from a nearby airport or the actual site elevation shall be used in the performance calculations. This is accounted for in the allowance for test uncertainty.

Measurement of Roational Speed. The engine must be operating at full rated speed during the test. The speed of rotation shall be measured using the magnetic speed pickups on the gas producer and, if applicable, the power turbine. The signal from the magnetic speed pickup or key phasor shall be transformed into a digital signal by the gas turbine package control system PLC. The frequency of the electrical output may also be recorded.

Output Power. Readings of voltage, current and power factor may be used to determine the electrical output power, or readings may be taken from power/energy meters. The output power guarantee value is based on power at the generator terminals. The allowance for test uncertainty is based on CTs and PTs, and electrical metering having 0.5% or better accuracy class. In the event that the PTs and CTs are remote from the generator (e.g. in a switchgear room), additional losses may need to be considered.

Test Uncertainty. Owing to the very nature of physical measurements, it is impossible to measure a physical quantity without error, or in fact, to determine the true error of any one particular measurement. All measurements have errors. Those errors are the difference between the actual measurement and the true value. These errors can be broken down into two components:

> Random Error, and
> Bias Error

Random Error (Precision Error): Random Error, or Precision Error, is characterized as follows:

- Repeated measurements of a given performance parameter do not, and are not expected to agree exactly. There are always numerous effects that cause random scatter of the measured data.
- There is inaccuracy of the measurement of the control parameter (e.g. Turbine Rotor Inlet Temperature, or TRIT)
- There is also the variation with time in either the performance parameter, or the control parameter (also called the “set point”).

Bias Error (Fixed Error): Bias Error, or Fixed Error, is characterized as follows:

- Bias error is a systematic error. It results from several individual bias errors, which have to be estimated.

In a field test, random error and bias error cannot be distinguished, and are thus combined and treated as a single error.

Factory testing of a gas turbine is almost always “Zero Tolerance Testing”, in which the minimum factory acceptance value includes any test uncertainty. In other words, the manufacturer includes the test uncertainty in the performance rating. So, the margin between nominal and minimum performance includes not only the manufacturing variations but also the variations in the measurement accuracy of the standard factory test.

Field performance testing inherently has additional uncertainty, which does not exist in factory testing. For example, the airflow of the gas turbine cannot be measured accurately in the field, and therefore certain engine performance parameters cannot be determined with the same factory test cell accuracy. Field test measurements are based on the permanently installed package instrumentation, and measurements from other sources, such as customer instrumentation. The permanently installed package instrumentation is typically not to the same accuracy standard as test cell instrumentation, and the measurements/data taken from other sources are beyond Solar’s control. The possibility for other losses also exists when testing at site, such as cable losses between the generator and PT/CT locations for power measurements.

Solar does not perform detailed test uncertainty calculations for field verification of data obtained through factory testing. Experience has shown that it is possible to estimate a representative deviation of the measured value from the true value, such that it can be asserted with a certain degree of confidence that the true error is less than or equal to said deviation. The value of such a deviation (the 95% confidence interval) constitutes a criterion for the accuracy of the test, and the value used for test uncertainty in field verification tests that are based on package and Customer instrumentation is 3%. This is defined as the maximum likely deviation of a measured or computed parameter from the actual value of said parameter, such that it can be said with at least 95% confidence that the measured or computed value does not deviate from the actual value by an amount greater than 3%. The test uncertainty is a measure of the quality of the test and not a measure of the quality of the machine, which has already been demonstrated through factory testing. The 3% uncertainty value is therefore an estimate of the possible error in a measurement, or more precisely, an estimate of the range of values that contain the true value of a measured quantity. A typical report of sample test uncertainty is shown below.

Sample Test Uncertainty Report:

Parameter	Units	Uncertainty	Nominal Value	Pbaro	Air Inlet D"P"	LSM	PT's	CT'S	PF	P_flow	T_flow	DP Orif	Pipe ID	Orifice ID	SG	k50	k300	pcp	pct
Barometric Pressure	inHg	1.00%	29.92	30.22	29.92	29.92	29.92	29.92	29.92	29.92	29.92	29.92	29.92	29.92	29.92	29.92	29.92	29.92	29.92
Air Inlet Δ"P"	inH'O	3.00%	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
LSM	KW	2.00%	10743	10743.30	10743.30	10958.17	10743.30	10743.30	10743.30	10743.30	10743.30	10743.30	10743.30	10743.30	10743.30	10743.30	10743.30	10743.30	10743.30
PT's	Volts	0.30%	13800.00	13800.00	13800.00	13800.00	13841.40	13800.00	13800.00	13800.00	13800.00	13800.00	13800.00	13800.00	13800.00	13800.00	13800.00	13800.00	13800.00
CT'S	Amps	0.30%	500.00	500.00	500.00	500.00	500.00	501.50	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
PF	Degrees	1.00%	0.90	0.90	0.90	0.90	0.90	0.90	0.81	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
P_flow	psia	1.00%	380.00	380.00	380.00	380.00	380.00	380.00	380.00	383.80	380.00	380.00	380.00	380.00	380.00	380.00	380.00	380.00	380.00
T_flow	DegF	1.00 F	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	71.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
ΔP Orif	inH2O	1.00%	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.55	55.00	55.00	55.00	55.00	55.00	55.00	55.00
Pipe ID	inch	1.00%	3.000	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.03	3.00	3.00	3.00	3.00	3.00	3.00
Orifice ID	inch	0.01	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.79	1.78	1.78	1.78	1.78	1.78
SG		1.00%	0.6882	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.70	0.69	0.69	0.69	0.69
k50		0.10%	1.310	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31
k300		0.10%	1.239	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24
pcp	psia	0.10%	676.05	676.05	676.05	676.05	676.05	676.05	676.05	676.05	676.05	676.05	676.05	676.05	676.05	676.05	676.05	676.79	676.05
pct	DegR	0.10%	350.91	350.91	350.91	350.91	350.91	350.91	350.91	350.91	350.91	350.91	350.91	350.91	350.91	350.91	350.91	350.91	351.36
Z_orif			0.9476	0.9476	0.9476	0.9476	0.9476	0.9476	0.9476	0.9471	0.9480	0.9476	0.9476	0.9476	0.9476	0.9476	0.9476	0.9477	0.9475
Fb			694.0	694.0	694.0	694.0	694.0	694.0	694.0	694.0	694.0	694.0	691.9	702.0	694.0	694.0	694.0	694.0	694.0
b			0.0554	0.0554	0.0554	0.0554	0.0554	0.0554	0.0554	0.0554	0.0554	0.0554	0.0545	0.0557	0.0554	0.0554	0.0554	0.0554	0.0554
Y			0.9980	0.9980	0.9980	0.9980	0.9980	0.9980	0.9980	0.9980	0.9980	0.9980	0.9980	0.9980	0.9980	0.9980	0.9980	0.9980	0.9980
Fuel Flow	mmBtu/Hr		118.07	118.12	118.07	118.07	118.07	118.07	118.07	118.65	117.94	118.66	117.72	119.44	117.49	118.07	118.07	118.07	118.08
Heat Rate	BTU/KWH		**10990**	10778	10990	10990	10958	10958	10982	11044	10978	11045	10958	11117	10936	10990	10990	10990	10991
Δ(Heat Rate)	BTU/KWH			-213	0	0	-33	-33	-109	54	-12	55	-33	127	-55	0	0	0	1
Δ(Heat Rate)^2	BTU/KWH			45209	0	0	1081	1081	11841	2915	154	2978	1064	16100	2975	0	0	0	1
(Heat Rate) Uncertainty	BTU/KWH		**292**																
Test Uncertainty			**2.66%**																
Power	Kw		**10743**	10959	10743	10743	10776	10776	10851	10743	10743	10743	10743	10743	10743	10743	10743	10743	10743
Δ(Power)	Kw			216	0	0	32	32	107	0	0	0	0	0	0	0	0	0	0
Δ(Power)^2	Kw			46630	0	0	1039	1039	11542	0	0	0	0	0	0	0	0	0	0
(Power) Uncertainty	Kw		**245**																
Test Uncertainty			**2.28%**																

Preparation and Performance of Test

Pretest Procedures. After the gas turbine package and all related systems are installed and operational, Solar will assign a Field Service Representative (FSR) who will either participate in, or conduct the test. The test will occur at a time mutually agreed upon by Solar and the Customer, subject to time/schedule constraints expressed above under, Test Conditions.

Prior to running the performance tests, the following checks and preparatory items must be completed:

- Verify that the unit, as installed, has been proven suitable for continuous operation.
- The gas turbine compressor must be thoroughly detergent washed (on-crank).
- Sufficient fuel and site load must be available for continuous full load operation.
- Air inlet filter panels should be inspected and cleaned if required.
- Visually verify the IGV settings and that the bleed valve is fully closed at full load.
- Verify all sensors are reading accurately.
- Verify that instrumentation pressure lines are not leaking or pinched.
- Perform a visual walk-around of the package to identify sources of hot air ingestion, or recirculation.

Engine Stability. Site conditions must provide a stable load for the generator at maximum engine output during the entire test. The test shall be conducted with the power factor as close to unity as possible, unless an alternative value is specified in the purchase agreement with the Customer.

The generator set must be thermally stable before recording data. From a cold start, the engine must be maintained at full load for at least one and a half (1-1/2) hours before taking any data. From a hot restart, the engine must be at full load for at least 45 minutes before taking any data. In any event, the engine must be thermally stabilized before commencement of the test. Solar's FSR will determine when the engine has reached thermal stability, based on the following checks:

Parameter	Criteria
T5:	Average should not vary by more than ±9° F (5° C)
Oil Temperature:	Drain temperature should be within ±5° F (3° C) in a 2-minute period
Exhaust Temperature (T7):	Average should not vary by more than ±9° F (5° C)
Fuel Actuator Command:	Should be steady within 0.2 mA
Generator Load:	<1% fluctuation
Generator Voltage Fluctuation:	Line voltage fluctuation <1%
Generator Freq Fluctuation:	<0.2 Hz

Test Data Gathering. The test shall be performed over a two (2) hour period, with readings taken at fifteen (15) minute intervals. If a dual fuel unit, separate tests shall be run for each fuel type. Ideally, and if the available instrumentation permits, one data point should consist of a sample taken once a second for ten seconds, and then averaged.

The following list summarizes the data required to evaluate the engine performance:

- Barometric pressure
- Gas Turbine inlet loss
- Gas turbine exhaust loss
- Air inlet temperature (T1)
- Power turbine inlet temperature (T5)
- Fuel flow measurement
- Fuel gas composition – if applicable (provided by the Customer)
- Liquid fuel analysis – if applicable (provided by the Customer)
- Engine compressor discharge pressure
- Rotational speed / Frequency
- Generator power output

If requested, upon completion of the test, copies of all data collected during the test shall be provided to the Customer.

Gas Turbine Performance Evaluation. Field test data will be evaluated against the declared performance values using Solar's FASTE or ENGPERF performance program. The data obtained during the field test, including the site conditions at the time of the test, shall be input to the FASTE or ENGPERF program, and the output from the program printed and attached to the test report. The FASTE / ENGPERF program performs data correction to take into account the difference between the reference conditions associated with the declared performance values, and the actual test conditions. It is preferable that test conditions be as close to the reference conditions as possible, although it is highly unlikely that they will be identical. The FASTE / ENGPERF performance program provides guaranteed performance values that are referenced to the actual test conditions, and can therefore be compared directly to the test results.

The procedure for evaluating the full load test results is as follows:

a. The test yields full-load power and heat rate for the site ambient conditions and a defined power turbine speed
b. Use FASTE or the ENGPERF program to calculate the guaranteed performance values of a "reference" engine under the conditions prevailing during the test.
c. Calculate the percent difference between the test results for power and heat rate in (a) and the reference results in (b). Neither FASTE nor ENGPERF adjusts the results for test uncertainty. The allowance for test uncertainty is only applied when evaluating the FASTE / ENGPERF results in the test report.

For plants with two or more units installed, the overall evaluation of the acceptance criteria will be the average of the installed units.

Gearbox Losses

The absorbed gearbox losses shall be based on theoretical, calculated gearbox losses. The gearbox losses will be added to the calculated absorbed power by the driven equipment to yield the shaft power of the engine.

Test Report

At a reasonable time after receipt of the field test data, Solar Turbines will submit a formal test report containing the test logs, test data reduction, and a statement regarding performance verification. The test report shall consist but not be limited to the following items:

a. Customer Name
b. Date and Time of Test.
c. Equipment Configuration with Serial Numbers
d. Performance Summary / Performance Compliance Statement
e. Gas Composition and / or Liquid Fuel Analysis (as applicable)
f. Output reports from FASTE or ENGPERF program.
g. Test Procedure

Please reference a typical *Field Performance Verification Test Report* in the Appendix.

Section 5.0

Response to Customer Documentation

RESPONSE TO CUSTOMER DOCUMENTATION

No customer specifications have been provided.

Solar's base bid is per Energy LOC dated 31 March, 2011, which is based on NY07-02011 MARINA scope of supply per Solar Proposal NY07-02011 dated 25 September, 2009. Several scope changes were made to the MARINA project after Letter of Commitment, during project execution. These changes have been discussed and agreed upon in Customer Kick of Meeting (CKOM) on 3 May, 2011. Final Pricing in Section 7.0 reflects the final scope of supply as duscussed in the CKOM.

Terms and Conditions are per the Terms & Conditions agreed upon for NY07-02011 MARINA Thermal. See Terms and Conditions in Section 7.0 of this proposal. Expanded warranty, 12/18 with Parts, Labor and One-way Freight is not required, and was specifically excluded from the Terms & Conditions per CKOM held on 3 May, 2011. Customer will address Long Term Service Agreement (LTSA) and expanded warranty in a separate contract.

Section 6.0

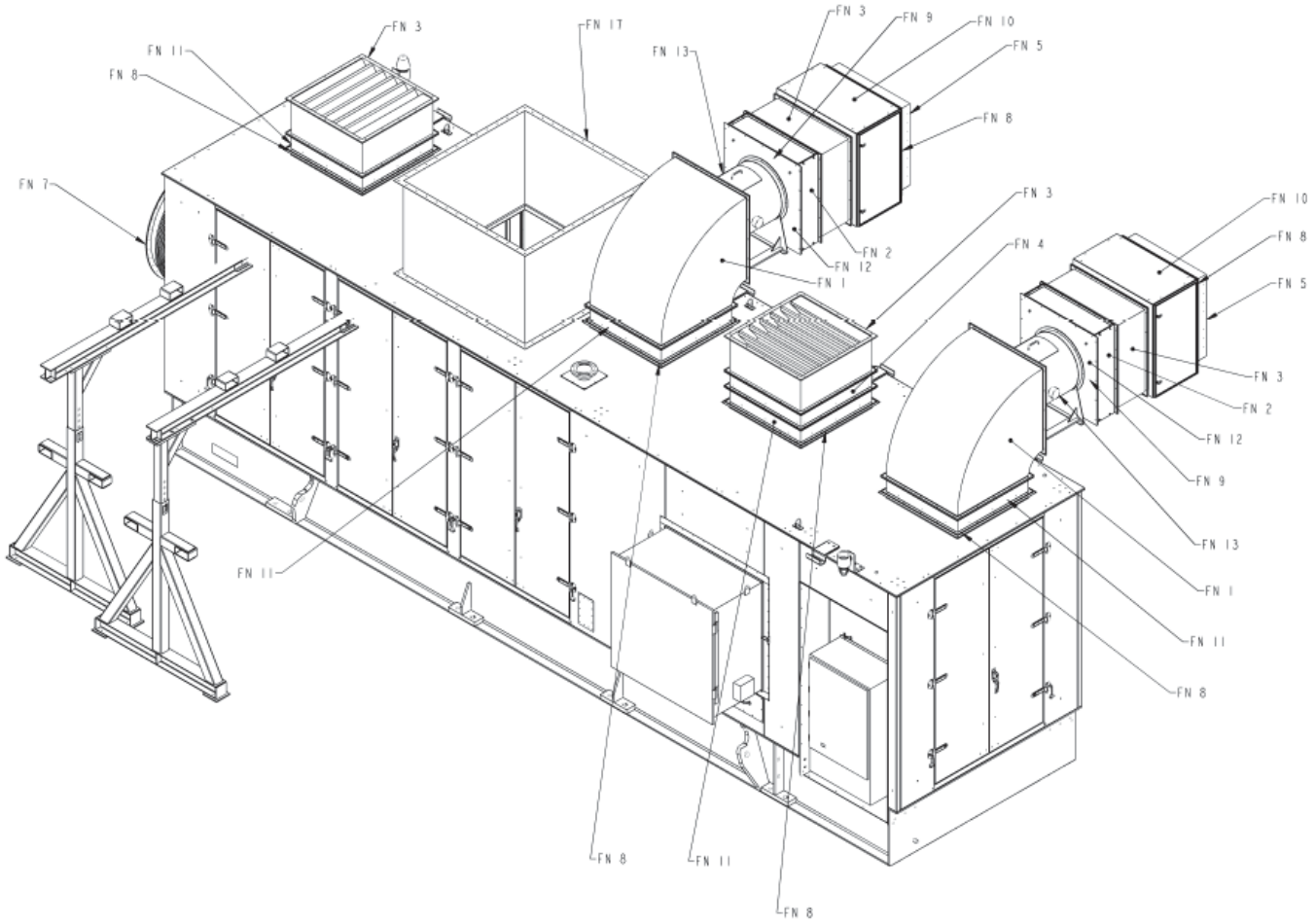
Typical Drawings

FOR REFERENCE ONLY

GENERAL NOTES:

1. ENGLISH UNITS (INCHES) ARE PRIMARY AND METRIC CONVERSIONS (MILLIMETERS) SHOWN IN BRACKETS ARE DERIVED FROM THE ENGLISH UNITS. ALL DIMENSIONS SHOWN ARE NOMINAL AND SHOULD BE USED FOR GENERAL LAYOUT REFERENCE ONLY. DO NOT PROCEED WITH CONSTRUCTION BASED ON THIS DRAWING. ALL INFORMATION CONTAINED IN THIS DRAWING IS PRELIMINARY AND IS SUBJECT TO CHANGE.
2. IF NOT SUPPLIED BY SOLAR, SUPPORTS WILL BE REQUIRED AS INDICATED. OVERALL DIMENSIONS SHOWN AND COMPONENT WEIGHTS INDICATED IN THE PROJECT SPECIFIC DRAWINGS SHALL BE USED TO DETERMINE THE RELEVANT LOADS AT THE INTERFACES.
3. CUSTOMER SUPPLIED DUCTING SHALL COMPLY WITH SOLAR ES 1733, ES 2253, AND SMACNA (SHEET METAL AND AIR CONDITIONING CONTRACTORS NATIONAL ASSOCIATION).
4. THE ENCLOSURE AND THE ENCLOSURE VENTILATION SYSTEM MAY REPRESENT OPTIONAL CONFIGURATIONS.
5. INLET SYSTEM DESIGN FLOWRATE: 45,000 ACFM. EXHAUST SYSTEM DESIGN FLOWRATE: 124,000 ACFM.
6. STANDARD ANCILLARY SYSTEMS INCLUDE STAINLESS STEEL FLANGE HARDWARE, INLET DUCTING SEALANT, AND EXHAUST GASKETS.
7. ALL COMPONENTS EXTERIOR OF ENCLOSURE ARE LOOSE SHIPPED.

STANDARD ANCILLARY ARRANGEMENT
T70 OS OS
E 66195 1091742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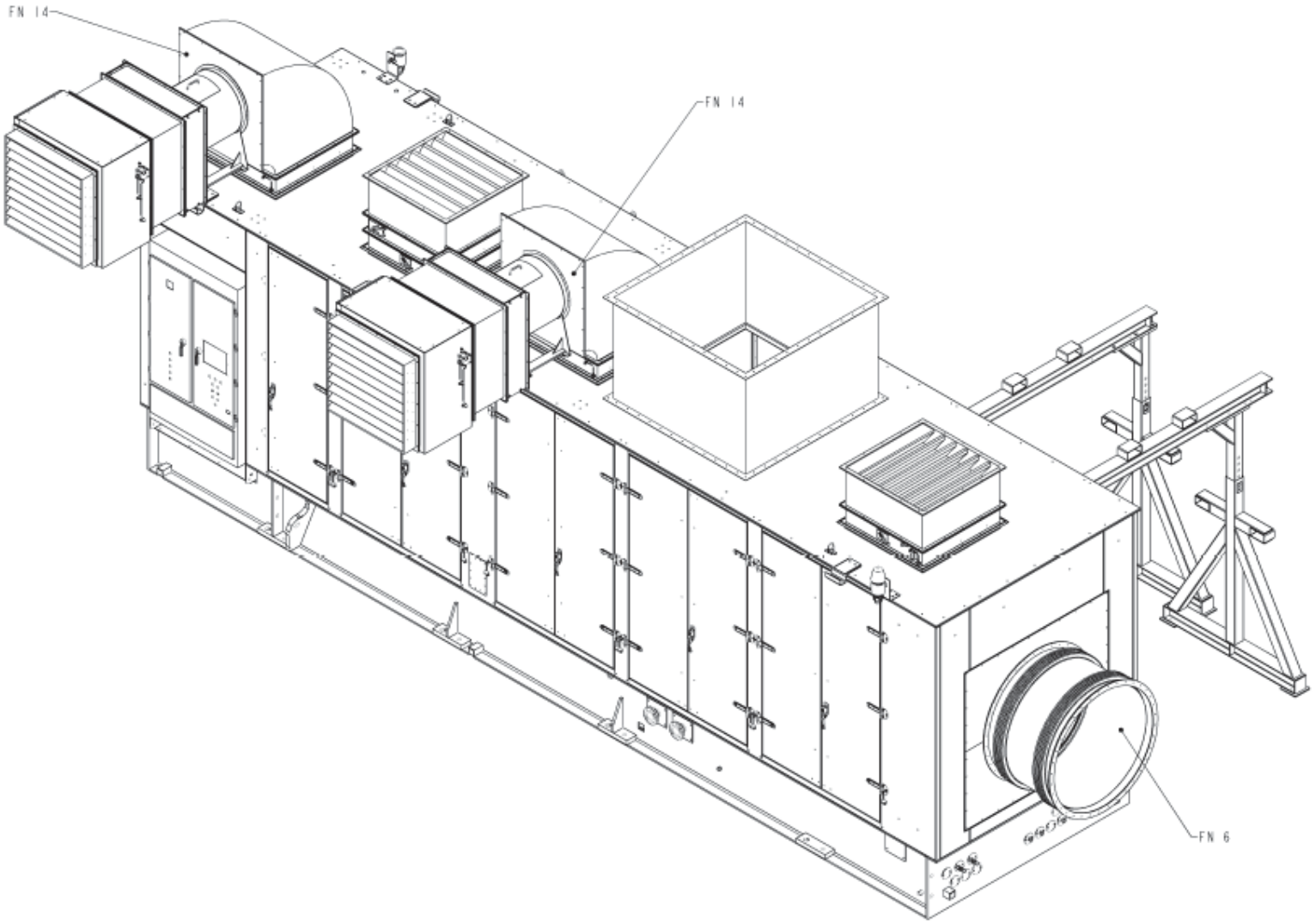
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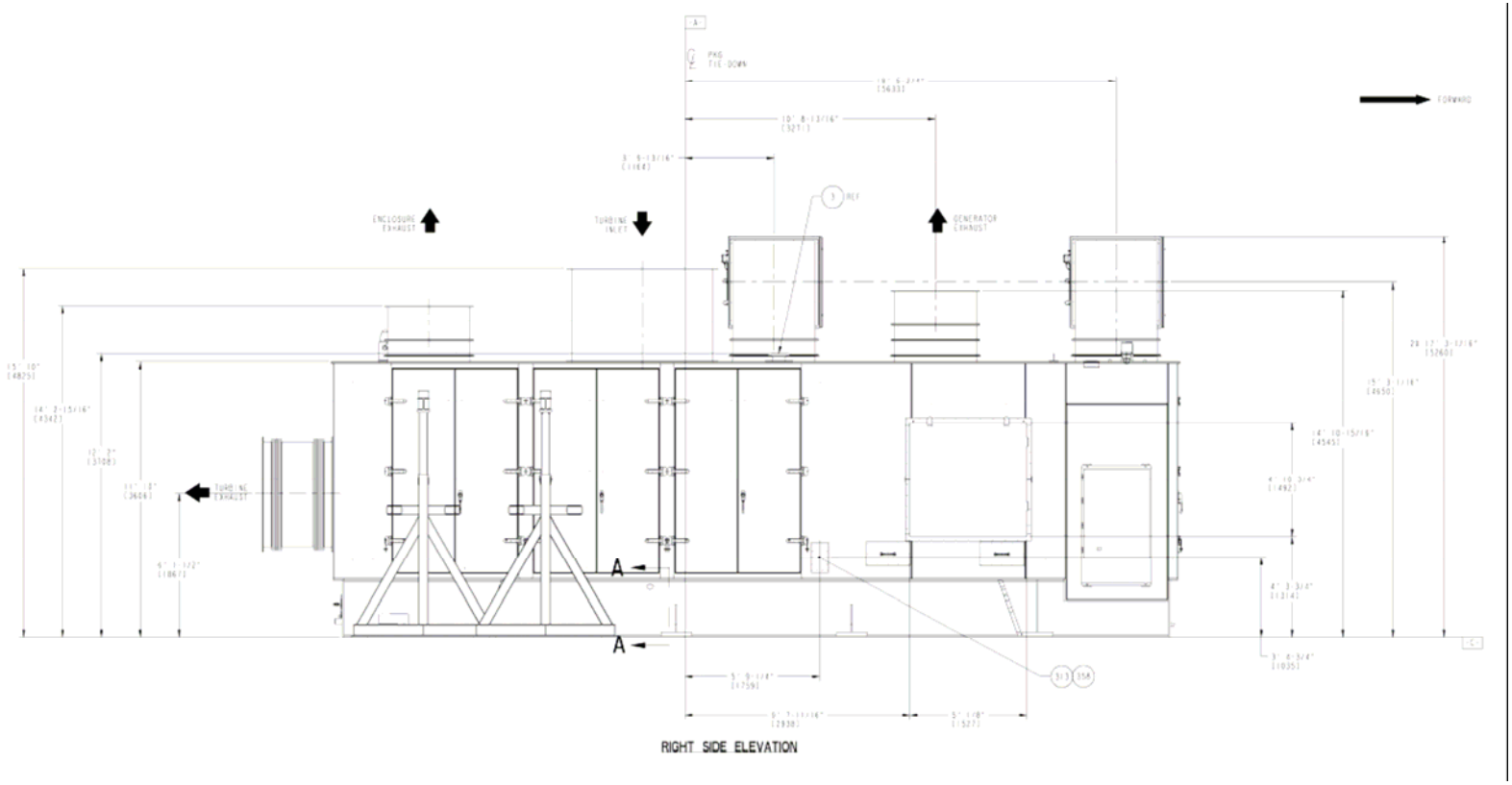
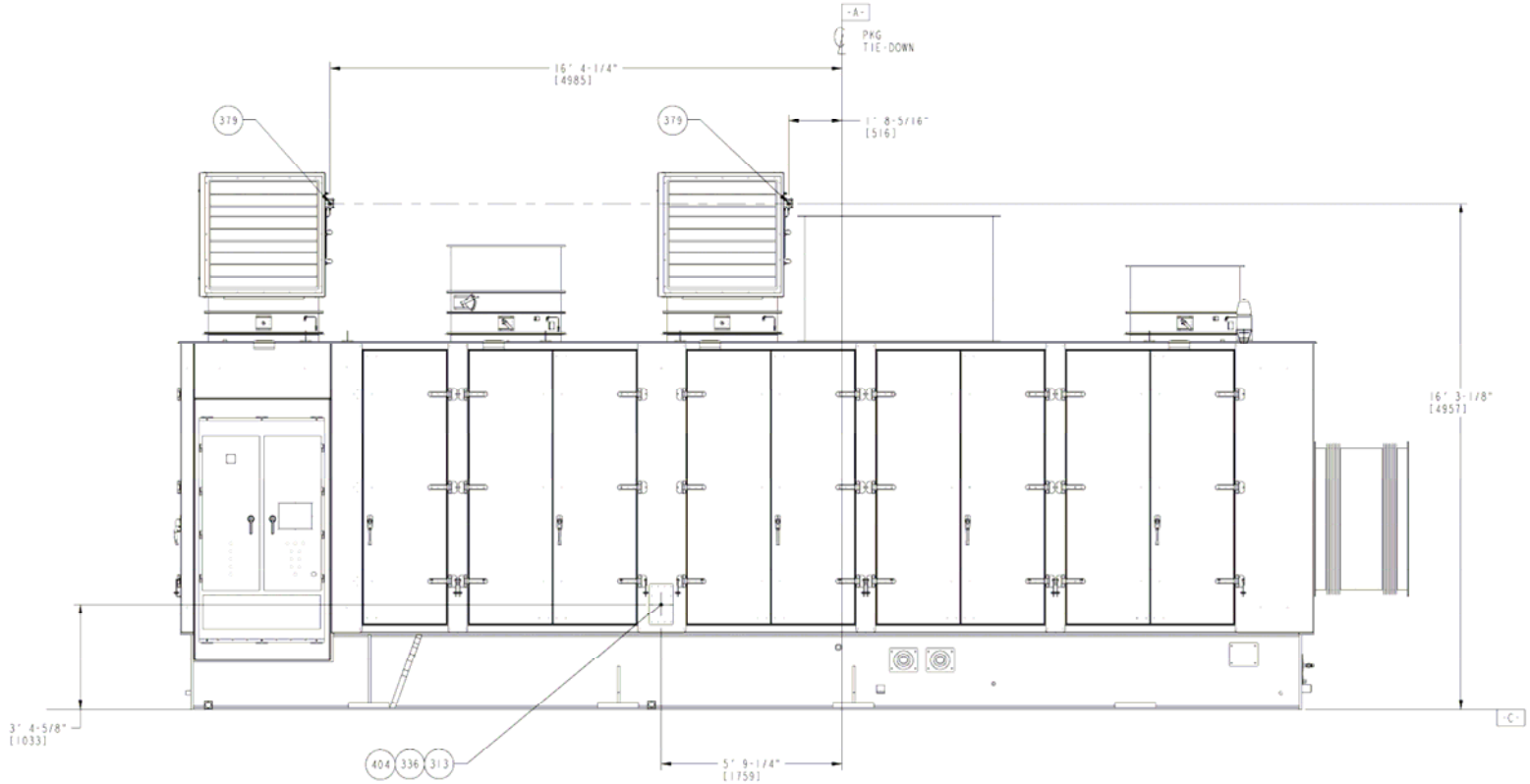
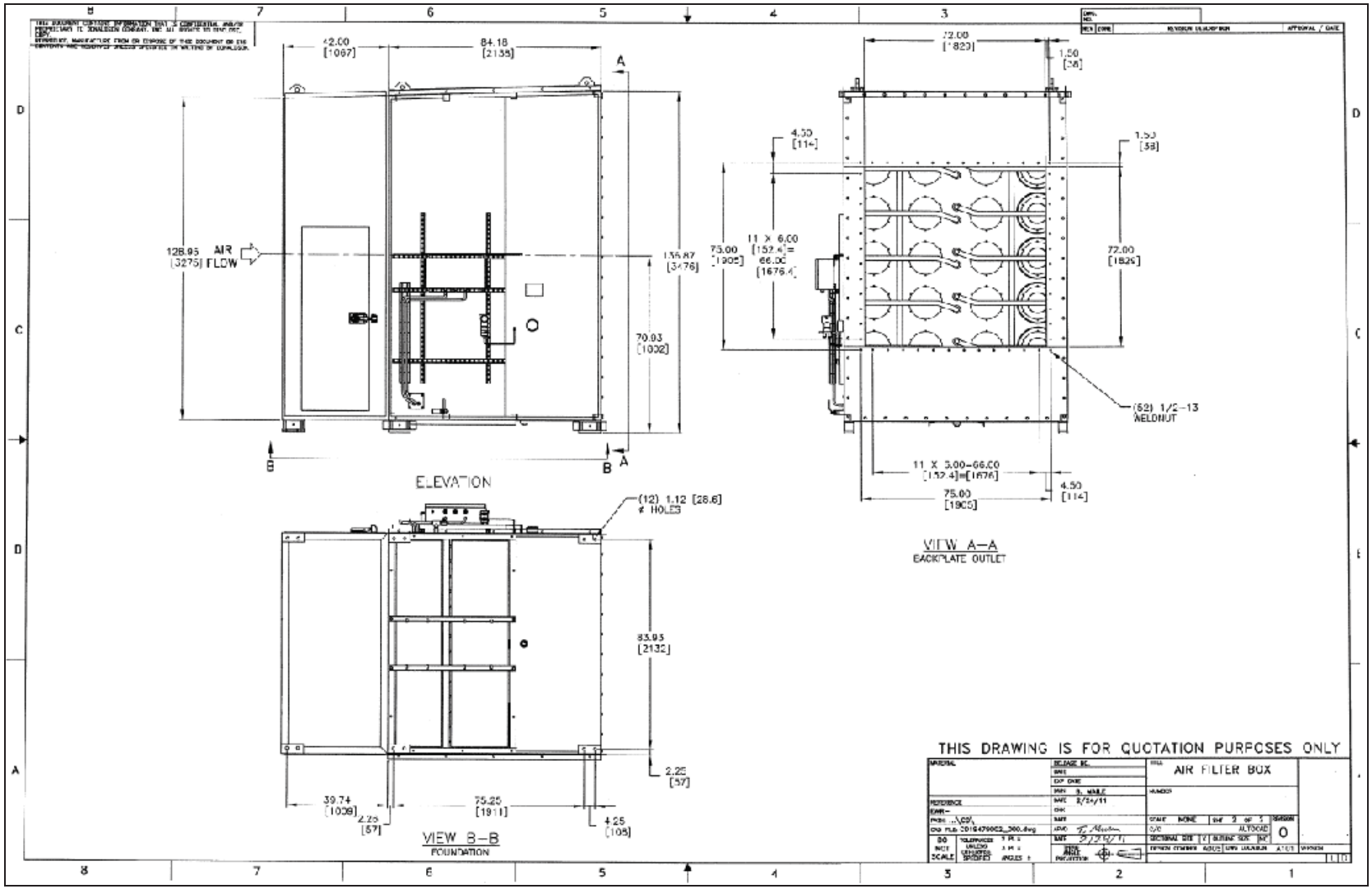


RIGHT SIDE ELEVATION

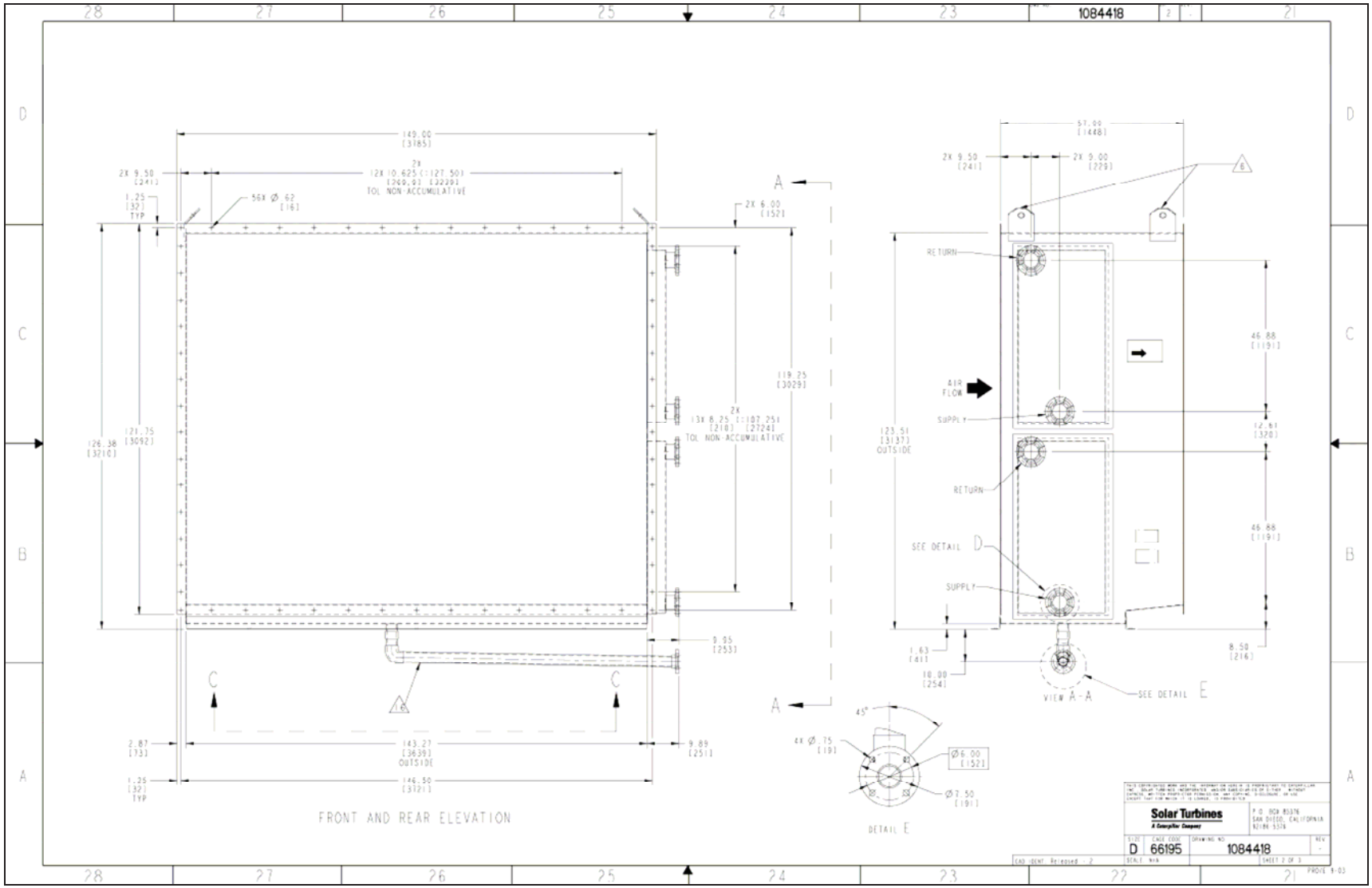


LEFT SIDE ELEVATION

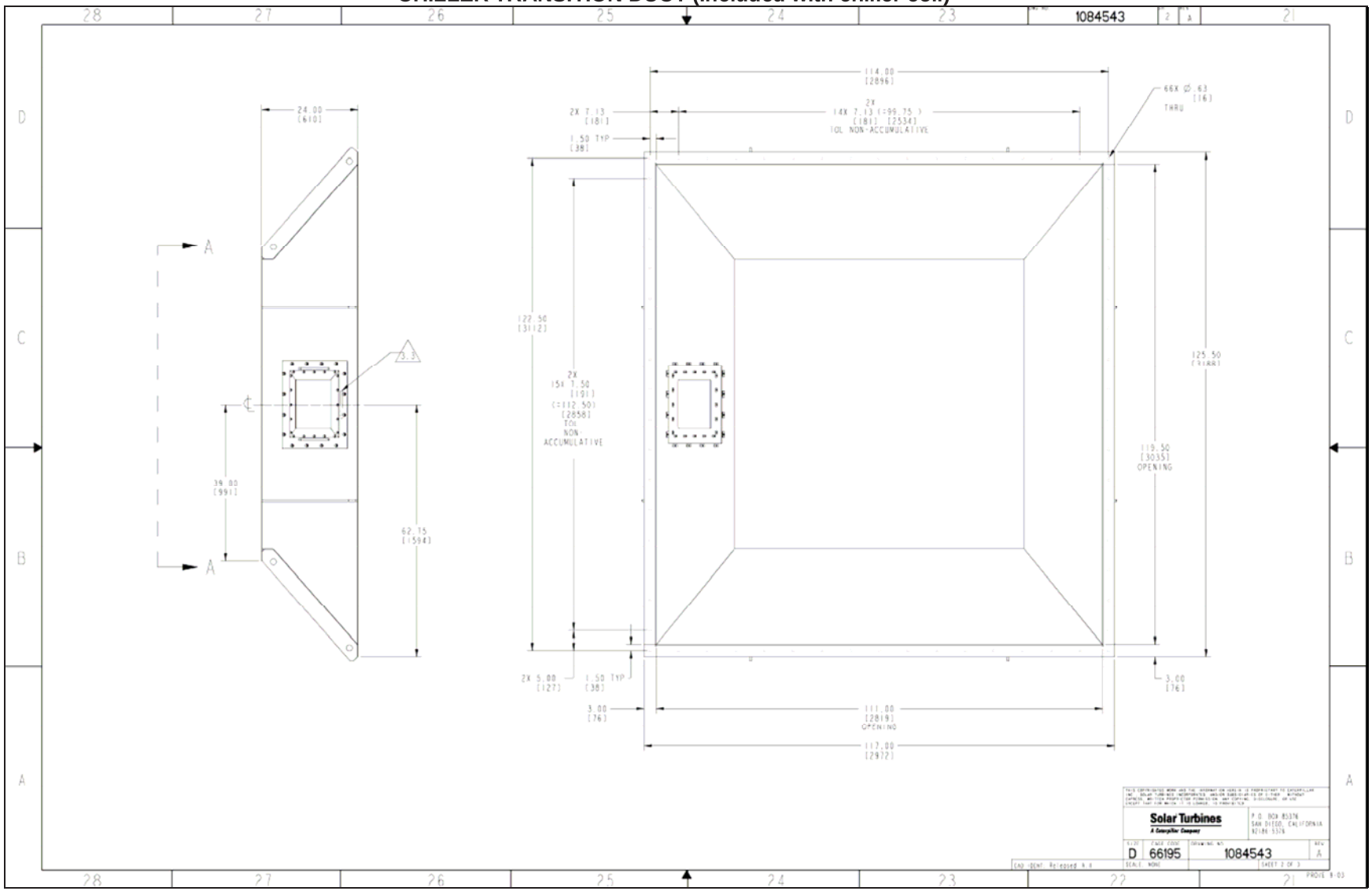
X-FLOW BARRIER FILTER WITH SIDE ACCESS



TURBINE AIR INLET CHILLER COIL



CHILLER TRANSITION DUCT (Included with chiller coil)



Section 7.0

Pricing and Commercial Considerations

PRICING

Base Price: for one (1) *Taurus 70* generator sets as described in Section 1.0: Base Bid Scope of Supply – Turbomachinery as based on Solar proposal NY07-02011 dated 25 September, 2009.

Pricing excludes taxes, duties, customs fees, etc. See Article 3.1 of Solar's Terms and Conditions for additional information and clarification.

Options:

Options to the Base Price:

- Redundant Control Net Supervisory Interface
- Delete TAI gas detector
- Delete Exhaust Bellows
- CO_2 Pressure Test
- Back-up Battery Charger
- 24 Hour Battery Capability (per NFPA 72)
- Back-up Water/Oil Lube Oil Cooler
- #8 AWG CT wiring
- 2/3 Winding Pitch
- Self-Cleaning, X-Flow Barrier Filter with Side Access
- D-salt Filter Elements (Recommended)
- Dynamic Generator Set Acceptance Testing
- Inlet Chilling Coil
- Lightning Arrestors & Surge Capcitors
- TAI Ducting, 3' Sections (Qty. 5)
- TAI Ducting, 90 degree Elbow
- TAI Ducting, 3' Section with access panel (Qty. 1)
- TAI Ducting, Flex, 1' Section (Qty. 1)

Field Activities:

- Field Performance Verification Testing
- Site Installation and Commissioning Assistance (45days)

Parts & Training:

- Start-up/Commissioning Consumable Spares
- *Taurus 70* Operation and Maintenance Training

Freight:

- Freight to Site (FOB Atlantic City)

TOTAL PURCHASE ORDER VALUE

Pricing excludes taxes, duties, customs fees, etc. See Article 3.1 of Solar's Terms and Conditions for additional information and clarification.

Validity: This proposal is valid for 30 calendar days after the issue date. Upon expiration, a price escalation of 0.3% per month will apply for up to three (3) months after which, this proposal is invalid.

Payment Schedule:

% of the purchase order amount invoiced on April 15, 2011 and payable on April 30, 2011.

% of the purchase order amount invoiced upon sumission of pruduct mechanicla intallation drawings.

% of the purchase order amount invoiced upon completion of engine assembly.

% due upon readiness for shipment paid by wire transfer prior to shipment or against a Commercial Letter of Credit to be opened by Buyer at least 30 days prior to the shipment date. Open account, subject to credit approval by a Treasury representative. Late payment fee of 1.5% per month prorated daily or the maximum amount permitted by law, whichever is less.

Solar will in return issue a standby letter of credit (SBLC) to the value of 10% of the contract value valid 6 month from the date of shipment

Payment terms for the second, third and fourth installments are Net 30 days.

All payments except the first payment shall be due net 30 days from the date of a valid invoice. Any amount not paid when due shall be subject to a late payment charge equal to one and one-half percent (1.5%) of the delinquent amount per month, pro-rated on a daily basis for each day that such amount remains unpaid. See Terms and Conditions for additional information and clarification.

Cancellation Schedule: Upon receipt of Purchase Order, or document evidencing financial commitment, cancellation charges in accordance with the following cancellation schedule will apply.

TERMINATION/CANCELLATION SCHEDULE

CALENDAR DAYS		CANCELLATION CHARGE
FROM	TO	(STRAIGHT LINE % OF ORDER PRICE)
Order	15 ARO	0
16 ARO	30 ARO	5-10
31 ARO	90 ARO	10-20
91 ARO	121 before RTS	20-80
120 before RTS	on or after RTS	80-90

Please reference Article 9 of Solar's Terms and Conditions for additional information and clarification regarding Cancellation/Termination.
For short lead times where ARO and RTS conflict, the larger % of the two applies.

Performance: See Section 3.0: Gas Turbine Performance and Emissions for performance summary.

Delivery: With a Purchase Order, or document evidencing financial commitment within the validity period stated above, the unit will be available for delivery Ex Works Seller's Designated Facility (or Facilities) (Incoterms 2000) not later than December 31st, 2011.

To the extent that shipments arrive from multiple shipping points, Solar will make reasonable efforts to coordinate deliveries with the Buyer, but cannot commit to all deliveries arriving at the same time.

Terms: Terms and Conditions as previously agreed upon between Energy and Solar Turbines Incorporated apply.

Warranty Period: Twelve (12) months after the unit commences operation at the project site, or eighteen (18) months after readiness of the unit(s) for shipment (whichever occurs first), provided the equipment is installed and operated in accordance with Solar guidelines.

Please reference Article 6 of Solar's Terms and Conditions for additional information and clarification regarding Warranty.

DRAWING SCHEDULE

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 are submitted in English, and in Adobe Portable Document Format (.pdf).

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

Drawings	INITIAL RELEASE Weeks (i.)	AS SHIPPED Weeks (ii.)	AS INSTALLED Weeks (iii.)
Mechanical Installation (iv.)	10	4	12
Fuel System Schematic (vi.)	10	4	12
Lube Oil System Schematic (vi.)	10	4	12
Air Drain System Schematic (vi.)	10	4	12
Start System Schematic (vi.)	10	4	12
Electrical Schematic (vii.)	10	4	12
Electrical Interconnect Diagram (vii.)	10	4	12
Electrical Wiring Diagram (vii.)	10	4	12
Software Documentation (v.)	--	4	12

Notes:

(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.) The Mechanical Installation drawing is made up of two sections – a "Turbomachinery General Arrangement" generator set package section, and an "Auxiliary Equipment General Arrangement" section including inlet and exhaust systems, lube oil cooler, battery system, etc.
(v.) A CD-ROM of the complete Software Documentation is provided for both the "As-Shipped", and "As-Installed" releases.
(vi.) Drawing formats may vary by product due to changes in the drawing creation program. For some products, the system schematics are combined into one drawing, and include additional device information.
(vii.) Drawing formats may vary by product due to changes in the drawing creation program. For some products, the Electrical Schematic, Electrical Interconnect Diagram, and Electrical Wiring Diagram are replaced with an Electrical Loop Schematic and Wire List report.

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

Please reference *Product Information Letter (PIL) 012* in the Appendix for additional information describing Solar's Customer Drawing schedule and format.

Drawing Definitions

Mechanical Installation. The Mechanical Installation drawing, also known as the Turbomachinery General Arrangement and Auxiliary General Arrangement drawings, is a graphical and systematic representation of all interface connections and includes the following systems and information:

- Installation notes
- Enclosure information
- Customer interface points
- Heat rejection information
- Loose-ship items
- Foundation layout (overall envelope)
- Alignment information
- Weights and center of gravity
- Driven equipment information
- Clearance information
- Fire system
- Inlet and exhaust (vent ducting)
- Pad loads
- Generator terminal layout

Contract loose-ship items are shown for standard options only. A tabulation of these loose-ship items, showing approximate weights, quantities, and envelope sizes, is included in the Mechanical Installation drawings.

Fuel System Schematic. The Fuel System schematic is a graphic representation of the functional relationships of the hydro-mechanical components comprising the fuel system. This includes the main fuel delivery system, the gas pilot actuating system, the torch ignition system, and the liquid fuel purge system (when applicable). It contains relevant component information such as function, set-point values, scaled ranges, etc.

Lube Oil System Schematic. The Lube Oil System schematic is a graphic representation of the functional relationships of the hydro-mechanical components comprising the lube oil system for the turbine and the generator. This includes the lube system, the pre/post lube system, and the backup lube system. It contains relevant component information such as function, set-point values, scaled ranges, etc.

Air/Drain System Schematic. The Air / Drain System schematic is a graphic representation of the functional relationships of the hydro-mechanical components comprising the turbine air and drainage systems. This includes (where applicable): the air-assist system for liquid fuel startup, pneumatic pilot actuation system, flameout detection system, bleed valve, guide vane actuator, water wash systems, and drain lines from the combustor, inlet, and exhaust ducts. It contains relevant component information such as function, set-point values, scaled ranges, etc.

Start System Schematic. The Start System schematic shows the functional relationship between the AC start motor, the variable frequency drive, and the line reactor(s). It contains relevant component information such as function, voltage, and power.

Electrical System Schematic. The Electrical System schematic is a graphical representation of all electrically controlled devices for the turbine, driven equipment and peripherals, including transmitters, switches, generator and motors. This only shows point-to-point connection information and is not intended for wiring purposes. Electrical Sys-tem schematic standard for all packages is loop format.

Electrical Interconnect Diagram. The Electrical Interconnect diagram is a graphical and systematic representation of all interface connections between the turbine generator set and its peripheral devices, including switchgear and motors. This drawing shows the wires, cables, gauges and colors for each customer connection run.

Electrical Wiring Diagram. The Electrical Wiring diagram is a graphical representation of all electrical wiring connections made for the turbine generator set. The purpose of this drawing is to show every connection made on the turbine, the generator and its peripheral devices. This drawing will indicate the type of wire, gauge and color, as well as point-to-point connection information.

Customer Approval

Solar's design and manufacturing cycles are not conducive to customer's prior and/or contingent approval of project drawings. In those cases where customer approval is absolutely necessary, the following conditions will apply:

- Drawings are not issued for the purpose of a design review. Solar's design requirements are firmly established at the time of sales order release and the drawings should reflect this requirement. Manufacturing processes will proceed based on sales/project definition.
- The drawing format is not subject to change.
- Any changes made to the design as a result of drawing review will normally have an impact on price and could affect drawing and equipment shipment schedules.
- Reasonable drawing changes for clarification purposes, or to correct errors, will be considered as normal to the review process.

TERMS AND CONDITIONS

PURCHASE ORDER
GENERAL TERMS AND CONDITIONS

1. DEFINITIONS. The following definitions shall apply to the PO:
   (a) Buyer: DCO Energy, LLC, its successors and assigns

   (b) Seller: The person or entity to provide Goods and/or Services (as defined below) under the PO.

   (c) PO: The attached purchase order, issued by Buyer to Seller, and these General Terms and Conditions, which are hereby incorporated into the PO by reference.

   (d) Goods: All apparatus, products, supplies, documentation, and other items to be provided by the Seller under the PO.

   (e) Services: All labor and other services to be provided by the Seller under the PO.

   (f) Freight Routing Guide: The shipment methods and freight carriers designated by Buyer for use when Buyer is responsible for delivery costs under the PO.

2. INTERPRETATION. The PO, including these General Terms and Conditions, constitutes the entire agreement between the parties, and supersedes all prior proposals, agreements and understandings, whether oral or written, relating to the subject matter of the PO. In the event of any express conflict or inconsistency between the provisions of the attached purchase order and the provisions of these General Terms and Conditions, the attached purchase order shall control; provided that the provisions of the purchase order will be so construed to give effect to the applicable provisions of these General Terms and Conditions to the fullest extent possible. The PO shall be controlling over additional or different terms of any other document, including any confirmations, invoices or similar documents delivered to Buyer by Seller, even if accepted in writing by Buyer.

3. NON-WAIVER. No waiver by Buyer of any provision of the PO shall be effective unless expressly contained in writing signed by Buyer. Failure by Buyer to enforce any provision of the PO, or to exercise any right arising out of the PO, shall not be deemed a waiver of that provision or right, or of any other provision or right, and no waiver by Buyer of any breach shall be construed to be a waiver of any prior or succeeding breach.

4. SEVERABILITY. If any term or condition of the PO shall be deemed to be unlawful or unenforceable by a Federal or state court or agency of competent jurisdiction, such determination shall have no effect on the validity and enforceability of the other terms and conditions of the PO, and the challenged term or condition shall be deemed deleted or modified to the extent necessary for such term or condition to be effective to the fullest extent permitted by law.

5. CHOICE OF LAW AND VENUE. The PO is to be interpreted and enforced under New Jersey law (without regard to the choice of law provisions thereof), and any dispute involving the PO shall be heard in a court of competent jurisdiction in New Jersey.

6. CHANGES. Requests by Buyer for any modifications or changes to the Order, including but not limited to, changes in specifications, quantities, delivery obligations and terms of payment, must be made in advance and must be in writing. These changes must be mutually agreed to and any price or delivery adjustments will be determined by the parties. Seller's agreement to the changes will not be unreasonably withheld, conditioned or delayed.

7. DELIVERY. Unless otherwise expressly set forth in the PO, all Goods shall be delivered, at Seller's sole cost, in a single lot F.O.B.. Should the PO indicate that Buyer shall pay for delivery, such delivery shall be in accordance with Buyers Freight Routing Guide and other instructions. **Seller shall use its best efforts and diligence with respect to meeting the schedule obligations set forth in the PO**. Seller shall immediately notify Buyer once it

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expects a delivery to occur earlier or later than as specified in the PO. Notwithstanding the foregoing, Buyer may, at its sole option, accept or return any deliveries, which vary, from the delivery date(s) or quantities specified in the PO. Furthermore, Seller shall be responsible for paying costs of delivery and return for Goods returned under the forgoing sentence or Goods otherwise rejected by Buyer under the PO.

8. PRICES. Prices are those stated in the purchase order and any subsequent modifications.

9. PAYMENT. Amounts due seller under the PO shall be paid no later than 30 days after Buyer receives an acceptable invoice from Seller. All invoices must show the applicable PO number or numbers. Payment shall not forfeit Buyer's right to inspect the Goods prior to delivery.

10. TAXES. **Buyer** shall be responsible for all taxes and duties applicable to the Goods and/or Services provided under the PO. **Buyer shall either pay any and all such taxes and duties, or Buyer shall provide Seller with acceptable tax exemption certificates. If Buyer fails to provide such certificates at least 60 days prior to the ready to ship date, Seller shall provide Buyer proof that such taxes and duties were paid, and it shall be Buyer's duty to recover such taxes and duties.**

11. RISK OF LOSS. Title and Risk of Loss shall transfer from Seller to Buyer upon delivery in accordance with the applicable delivery term. Claims for damages or shortages attributable to Seller must be in writing and received by Seller within thirty (30) days after receipt of goods or notice of loss, whichever shall occur first, and must be accompanied by Seller's packing slip and full particulars of any such claim. Seller shall be responsible for storage of Goods prior to receipt by Buyer, and for ensuring safe delivery of the Goods to Buyer's jobsite.

12. SAFETY. Seller (and all persons working at the direction of Seller) shall at a minimum comply with Federal Occupational Safety and Health Act (OSHA) and with all other applicable laws, ordinances, rules, regulations, and orders of Federal, state and local regulatory bodies who may have jurisdiction over the Services, as well as the safety and security rules and requirements of Buyer. Seller is solely responsible for protecting the health and safety of its employees, agents and contractors. Seller (and all persons working at the direction of Seller) shall at all times conduct all Services in a manner to avoid the risk of bodily harm to persons or risk of damage to any property, including utilizing practices and procedures within Sellers expertise which are not inconsistent with Buyers safety rules and requirements.

13. WARRANTIES.
Seller represents and warrants that all Goods shall consist of new material, not used , reconditioned, repaired, reworked or surplus goods or materials, shall be free from defects in materials and workmanship during the Warranty Period (as defined below) and shall be furnished in accordance with the plans and specifications. The "Warranty Period" commences upon delivery of the goods, on a unit by unit basis, in accordance with the applicable delivery/trade term, and expires on the earlier of (i) the date which is eighteen (18) months after delivery in accordance with the applicable delivery/trade term; or (ii) the date which is twelve (12) months after the unit commences operation at the project site; or (iii) if commencement of actual operation is delayed due to any cause beyond the reasonable control of Seller, the date which is twelve (12) months after the unit would have otherwise been capable of commencing operation at the project site (if not for the cause(s) of delay beyond the reasonable control of Seller). The foregoing warranty coverage shall be subject to the following conditions, qualifications, remedies and exclusions:

a. A warranty claim is submitted to Seller in writing promptly upon discovery of the purported defect.
b. The goods are installed, operated, and maintained in accordance with Seller's recommended procedures and specifications (including, without limitation, the applicable operation and maintenance manual(s) for the unit(s) and any applicable fuel, air, water, packaging and/or preservation specifications or recommendations communicated or otherwise made available to Buyer in writing).
c. Upon written notification by Buyer, any defective part or parts of the goods shall be promptly removed by Seller and repaired or replaced at the sole expense of Seller.

d. Examination of such part or parts by Seller confirms the existence of such a defect.
e. Seller's obligations under this warranty are limited to repair or replacement of such defective part or parts (as Seller elects), free of charge, and Seller shall bear the cost of removal and replacement. All replacement parts and repaired parts are warranted through, but not beyond, the original Warranty Period. Seller's sole liability and responsibility, and Buyer's sole and exclusive remedy, with respect to this warranty shall be limited to the remedies set forth above.
f. This warranty shall not apply to or include: (i) Normal maintenance services or adjustments; or (ii) any goods which have been repaired or altered, other than by Seller, in any way so as to adversely affect their operation or reliability; or (iii) the effects of normal corrosion, erosion, degradation, wear and tear, or failure occasioned by operation or condition of service more severe than specified or otherwise not in accordance with Seller's written recommendations.
g. Construction works, fabrications, major off-package accessories, and driven equipment not of Seller's manufacture are warranted in accordance with this Paragraph 13.

g. Acceptance tests and inspection by Buyer shall not be construed to limit in any way the warranty obligations of Seller.

14. ACCEPTANCE OF GOODS AND/OR SERVICES.
Seller's normal tests and inspection of the goods and tests specifically stated in the Order may be witnessed by Buyer at times scheduled for Seller's convenience and subject to Seller's standard security procedures. Special tests and inspections may be arranged at Buyer's written request, upon acknowledgement from Seller and adjustment of the price. Buyer may inspect the goods and any unit and review all test results and documentation prior to shipment and, unless good cause for rejection is shown, the goods and any unit thereof shall be deemed accepted upon satisfactory completion of such tests and readiness for shipment. If Buyer rejects the Goods because they do not meet the requirements of the PO, Seller shall promptly correct or replace such rejected Goods at Seller's sole expense.

15. TERMINATION/ CANCELLATION.
In the event of termination or cancellation of the Order by Buyer, Buyer shall pay Seller termination charges in accordance with the Termination/Cancelation Schedule approved by the Parties and attached to the PO.

16. FORCE MAJEURE.
(a) Force Majeure shall mean any cause beyond the control of the party affected, including failure of facilities due to drought, flood, earthquake, storm, fire, lightning, war, riot, civil disturbance, sabotage, strike or labor difficulty, accident or curtailment of supply, unavailability of construction materials or replacement equipment beyond the affected parties control, inability to obtain and maintain rights-of-way, permits, licenses, and other required authorizations from any local, state or Federal agency or person for any of the facilities or equipment necessary to provide service hereunder, restraint by a court, acts of God or public enemy, and acts of the United States or any state or political subdivision thereof. Neither party shall be required to prevent or settle a strike against its will. Delays caused by infringement actions shall not be considered Force Majeure.

(b) If either parties ability to perform its obligations under the PO is affected by an event of Force Majeure, such party shall promptly, upon learning of such event and ascertaining that it will affect its performance under the PO, give notice to the other party stating the nature of the event, its anticipated duration, and any action being taken to avoid or minimize its effect. Such notice shall be given no later than ten (10) days after the affected party ascertains that its performance will be affected. Failure to give such notice within the time specified shall be deemed a waiver of the relief for Force Majeure provided below in Sections 16 (c) and (d).

(c) The party claiming Force Majeure may extend the time for its performance for a period, agreeable to both parties that would be necessary to compensate for the effect of such Force Majeure event.

(d) In the event the performance by either party or a portion thereof is rendered impossible by a Force Majeure event, that portion of performance so affected shall be deemed terminated and any adjustment price is to be negotiated between the parties.

17. INDEMNITY.

a. Seller shall protect, defend, indemnify and hold harmless Buyer, Buyer's Affiliates, and their respective owners, officers, directors, employees and agents from and against all claims, demands, costs, expenses (including reasonable attorneys fees) and causes of action of every kind and character asserted by any person (including but not limited to employees of Seller and Buyer) that arise out of or are related to the Work under this Agreement and to the extent such claims, demands, costs , expenses and causes of action are caused by or arise out of Seller's negligence or willful misconduct .

b. Buyer shall protect, defend, indemnify and hold harmless Seller and its officers, directors and employees from and against all claims, demands, costs, expenses (including reasonable attorney fees) and causes of action of every kind and character asserted by any person (including but not limited to employees of Seller and Buyer) that arise out of or are related to the Work under this Agreement and to the extent such claims, demands, costs , expenses and causes of action are caused by or arise out of Buyer's negligence or willful misconduct..

c. If a claim or cause of action of the nature described in Subparagraphs a. or b. above arises out of the joint or concurrent negligence or willful misconduct of Seller and Buyer, it is the express intent of the parties that each of them shall protect, defend, indemnify and hold harmless the other to the extent of the indemnifying party's negligence or willful misconduct.

d. If Buyer or Seller is held strictly liable under law, the other party's respective duty to protect, defend, indemnify and hold harmless the first party shall be in the same proportion that such other party's negligence or willful misconduct contributed to the personal injury, illness, death or loss of or damage to property for which the first party is held strictly liable.

e. The indemnification obligations under this Paragraph 17 shall survive the termination of the PO.

18. INSURANCE. Seller shall maintain workers compensation insurance covering its personnel engaged in such performance in accordance with all Federal, state, and local requirements and in amounts not less than required by law in the applicable location. Without limiting the foregoing, during the provision of any Goods and/or Services under the PO, Seller shall effect and maintain at its own expense primary insurance of the following types with minimum limits not less than those amounts set forth below:

(a) Employers Liability: $1,000,000 per occurrence;

(b) Automobile Liability (covering owned, non-owned and leased vehicles): $1,000,000 per occurrence:

(c) Commercial General Liability (including products/completed operations, blanket contractual liability, broad from property damage and personal injury) $1,000,000 per occurrence; and

(d) Professional Liability: $1,000,000

(e) Under paragraphs (c) and (d) **coverage will be provided under a combined program of insurance and the Seller's self-insurance.**

Seller shall keep in force whatever insurance is necessary (extended reporting, tail or retroactive coverage) to provide Professional Liability insurance for the incidents occurring both during the provision of Goods and/or

Services under the PO and during the period three (3) years thereafter. Upon acceptance of the PO, Seller shall provide to Buyer certificates of insurance in compliance with the requirements herein with respect to the above insurance requirements, and with respect to (b) and (c) above, naming Buyer, its officers, employees and agents as an additional insured **to the extent of the liabilities assumed herein.** Such certificates and the insurance coverage required by this Section 18 shall contain a provision that no coverage afforded under the policies will be canceled, materially changed or allowed to expire until at least thirty (30) days prior written notice has been given to Buyer.

Such insurance shall provide waiver of subrogation in favor of Buyer, state that coverage is primary to the extent of the liability assumed by Seller in this contract to any other valid insurance available to Buyer (to the extent permitted by applicable insurance policy), and allow cross liabilities and coverage. Seller shall maintain adequate insurance coverage for Seller's independent contractors, and in the event any subcontractor provides any Goods and/or Services for Seller, Seller shall require such subcontractor (s) to maintain insurance in accordance with the requirements of this section 18.

19. COMPLIANCE WITH LAWS. By accepting the PO or any agreement resulting therefrom, Seller represents and warrants that the Services covered by the PO shall, upon provision to Buyer, be in compliance with the standards required by all applicable Federal, state and local laws and all rules and regulations of any government authority in effect as of the date of the PO and during performance under the PO, including the Federal Occupational Safety and Health Act (P.L. 91-956), Executive Order 11246 (41 CFR 60-1 and 60-2), relating to equal employment opportunity and nonsegregated facilities; Executive orders 11458 and 11625 (41 CFR 1-1.13) and P.L. 95-507, relating to the utilization of minority owned, small and small disadvantaged business enterprises; the Vietnam Era Readjustment Assistance Act of 1974, and Executive Order 11701 (41 CFR 60-250), relating to the employment of discrimination based on age; and all amendments thereto and all rules, regulations , and orders issued thereunder. Any provisions required to be included in the PO by any law, rule, or regulation shall be deemed to be included in the PO.

20. ASSIGNMENT. Neither party may assign or subcontract the PO or any of its rights or obligations under the PO without the prior written consent of both parties.

21. BUYERS EMPLOYEES. Without the express prior written permission of Buyer, Seller shall not (directly or indirectly) solicit, hire or otherwise retain as an employee, supplier, consultant or contract any person who is or was an employee of Buyer, other than any such person who was terminated for any reason by Buyer, or who has otherwise ceased to be an employee of Buyer and has not been in the employ of Buyer for a period of at least one year prior to such solicitation, hiring and retention.

22. THIRD PARTY BENEFICIARIES. Buyer's affiliates are third party beneficiaries under the PO, fully-entitled, either alone or with Buyer, or any other affiliate of Buyer, to enforce and take the benefit of any and all rights **and be responsible for any obligations** of Buyer under the **warranties as specified in Article 13 herein.**

23. CONFIDENTIALITY. As part of the process whereby Buyer requests or seeks goods or services from Seller, Buyer may provide to Seller specific project related or company related information, specifications, design details, financial information or any other information that is not known or available to the public and which Buyer deems confidential. Any such information provided to Seller by Buyer as part of this transaction shall be considered "Confidential Information" and shall be treated as such by Seller. Seller agrees that it will treat all information supplied by Buyer as confidential and Seller shall not use, disclose, duplicate or distribute such Confidential Information to any person or entity without the written consent of Buyer. The Seller shall use the same degree of care to keep the Confidential Information confidential as it employs with its own confidential information of like kind, but in all events the Seller shall use at least a reasonable degree of care.

24. LIMITATION OF LIABILITY. Neither Buyer nor Seller or their affiliates, subcontractors, agents and/or employees shall be liable for any incidental or consequential damages, including but not limited to, loss of product, loss of profit (except any profit of Seller from the Order), loss of use, losses resulting from or related to downtime of

the goods or the cost of replacement power or compression, howsoever caused, and whether based on warranty, contract, tort (including negligence) strict liability or otherwise. The total liability of Seller, its affiliates, subcontractors, agents and employees arising out of the performance or nonperformance of the Order or its obligations in connection with the design, manufacture, sale, delivery, storage, erection or use of goods or the rendition of any work or services in connection therewith, whether based on warranty, contract, tort (including negligence), strict liability or otherwise, shall not exceed in the aggregate a sum equal to the Order price or on a unit by unit basis, whichever is less. The limitations of liability set forth in this Article shall prevail over any conflicting or inconsistent provisions contained in any documents comprising the Order.

25. SUSPENSION. Buyer's request for suspension of the Order or a delay in shipment must be delivered in writing to Seller, and is not effective until acknowledged in writing by Seller. Such suspensions or delays may result in adjustments to prices, payments and delivery schedules. The time required for subsequent completion of the Order may exceed the number of days of suspension or delay due to Seller's scheduling constraints. If a suspension is more than sixty (60) days in duration, Buyer will pay Seller pro rata for the portion of the Order completed. In the event that production-fabrication has proceeded to the point that Seller deems it cannot reasonably reschedule completion or the request for suspension is received less than sixty (60) days prior to scheduled shipment, the Order shall be completed, invoiced, and the goods placed in storage at Buyer's expense. Ownership of the goods shall transfer to Buyer and Seller shall retain a security interest therein until payment of the total Order price is received. In the event Seller is otherwise unable to deliver the goods when ready due to the action or inaction of Buyer, Seller shall so notify Buyer. Such inability to deliver shall also be subject to the above provisions.

The Acceptance Copy of the PO shall be returned to Buyers representative identified on the attached purchase order.

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January 29, 2010

("DCO"), and confirms that we have entered DCO's requirements into our provisioning and production schedules, and the work is in progress.

This action is being taken to protect DCO's requested delivery date during our technical and commercial review of the PO, which we have completed. Up until now, Solar has proceeded with this PO on the basis of its referenced Proposal. Now that our review of the PO has been completed, our acceptance of the PO will be acknowledged based on the clarifications stated below, and DCO's written acknowledgment and acceptance of such items.

We have found that the following items in the PO require immediate resolution by the parties:

PO, Pages 1&2, Seller. The correct legal name of Seller is: "Solar Turbines Incorporated".

PO, General Terms & Conditions, Page 1, Art. 7, Delivery. Solar takes exception to "time is of the essence" language and requests that alternative language be used. Therefore, in lines 3-4, please delete: "Time is of the essence with respect to Seller's performance under the PO" and replace with: "Seller shall use its best efforts and diligence with respect to meeting the schedule obligations set forth in the PO."

PO, General Terms & Conditions, Page 2, Art. 10, Taxes. Taxes and duties are not included in the PO price. Therefore, in line 1, please replace the word "Seller" with: "Buyer". Insert the following as a new sentence: "Buyer shall either pay any and all such taxes and duties, or Buyer shall provide Seller with acceptable tax exemption certificates. If Buyer fails to provide such certificates at least 60 days prior to the ready to ship date, Seller shall provide Buyer proof that such taxes and duties were paid, and it shall be Buyer's duty to recover such taxes and duties."

PO, General Terms & Conditions, Page 4, Art. 18, Insurance. Solar's insurance program has been updated to include a combined program of insurance and self-insurance. Therefore, please modify 18(e) in paragraph one as follows: "(e) Under paragraphs (c) and (d), coverage will be provided under a combined program of insurance and Seller's self-insurance." In paragraph 2, line 6, after: "an additional insured" please insert: "to the extent of the liabilities assumed herein."

PO, General Terms & Conditions, Page 5, Art. 19, Compliance with Laws. The Goods will comply with the specifications as agreed in the PO documents. In line 2, please delete the words: "Goods and/or".

PO, General Terms & Conditions, Page 5, Art. 22, Third Party Beneficiaries. Buyer's affiliates, as third party beneficiaries, shall only have the right to enforce and take benefit of Buyer's rights under the warranty provision, and not the entire PO. Therefore, please modify this section to read: "Buyer's affiliates are third party beneficiaries under the PO, fully entitled, either alone or with Buyer, or any other affiliate of Buyer, to enforce and take benefit of any and all rights and be responsible for any obligations of Buyer under the warranties as specified in Article 13 herein."

Please confirm that DCO agrees with the above clarifications to the PO by having an authorized representative sign below and returning a copy of this letter to me by fax, e-mail or overnight mail.

Thank you for your order.

Termination/Cancellation Schedule

Turbomachinery

In the event of termination or cancellation of the Order by Buyer (other than due to a material breach by Seller), or termination by Seller due to a material breach by Buyer, Buyer shall pay Seller cancellation charges in accordance with the following cancellation schedule.

TERMINATION/CANCELLATION SCHEDULE

CALENDAR DAYS		CANCELLATION CHARGE (STRAIGHT LINE % OF ORDER PRICE)
FROM	TO	
Order	15 ARO	0
16 ARO	30 ARO	5-10
31 ARO	90 ARO	10-20
91 ARO	121 before RTS	20-80
120 before RTS	on or after RTS	80-90

ARO: after receipt of Order or other authorization to proceed with manufacturing (e.g., letter of commitment)
RTS: scheduled ready to ship date

All construction works, fabrications, major off-package accessories, and ancillary equipment to be supplied, and engineering, installation and construction work to be performed by Seller, as separately priced in the Order, shall be subject to termination charges of twenty-five percent (20%) over and above Seller's total costs, including costs associated with termination of subcontracts and purchase orders, and for any disposition of such goods/work.

In no event shall the cancellation charge exceed the Order price, and any payments made by Buyer up to the date of termination shall be credited against the applicable cancellation charge. The parties agree that the cancellation charges identified above are a fair and reasonable estimation of the damages to be incurred by Seller as a result of any such cancellation/termination, and are not intended to be compensation or consideration for any goods. Accordingly, upon any such cancellation or termination, Seller shall retain all goods, in whatever stage of completion.

Section 8.0

Optional Service Products and Agreements

SERVICE PARTS

Service Parts

Solar's Service Parts organization offers a wide range of parts and tooling to help ensure that your turbomachinery achieves the highest availability and lowest life-cycle cost. As a supplementary addition to this proposal, the following Budgetary Summary is included to provide budgetary pricing estimates for recommended service parts that Solar has available to support the proposed equipment.

Recommended Spare Parts Lists, or RSPLs are broken down into five (5) categories,

- Start-up/Commissioning Consumable Parts
- Operational Consumable Parts (1yr, 2yr, and 3yr options)
- Critical Insurance Parts
- Non-Critical Insurance Parts, and
- Repair Kits/Components

Collectively, these categories of service parts make up Solar's RSPL. Service tooling quoted separately. By breaking the RSPL down into more meaningful categories, you can determine the level of parts support based upon your unique maintenance requirements, and downtime sensitivity.

Start-up/Commissioning Consumable Parts. Startup/commissioning parts are recommended to be available on site for immediate use during commissioning. Startup/commissioning parts include the following:

- spare fitting kit,
- one (1) set of lube oil and fuel filtration elements,
- gaskets, o-rings, and other sealing media, and
- a selection of electrical components with historical usage during normal equipment startup and commissioning.

Start-up/Commissioning Consumable Parts (Budget Price) ..... included

Long Lead Critical Insurance Parts. Critical items are generally of a proprietary design and are recommended to maximize equipment availability. Critical items typically include:

- actuators,
- fuel control valves,
- pumps,
- probes,
- sensors,
- fuel injectors (Qty. 2)
- power supplies,
- control system I/O modules, etc.

Critical Insurance Parts (Budget Price) ..... US$

TECHNICAL TRAINING

Solar Turbines provides a complete suite of training solutions designed to meet all your operational and maintenance training needs. Improved performance and reliability, lower maintenance costs, and enhanced process operations are just some of the benefits you can achieve when your personnel are trained by Solar.

Our highly qualified Technical Training instructors are dedicated to providing the highest quality standards. Comprehensive training programs are available at Solar's training facilities or at customer sites. Solar offers a variety of training solutions including:

- Solar Factory Training
- Multi-Customer Training
- On-Site Training
- Hands-On Training
- Computer-Based Training

Solar Factory Training

Solar factory training classes are available at locations worldwide including Solar facilities in San Diego, California; and Mabank, Texas. Technical Training instructors customize the training courses to match your specific equipment to ensure the courses are best suited to meet your operational requirements. All personnel benefit by receiving the same instruction at the same time. Other benefits of this type of training include enhancing team building, increasing one-on-one interaction with the instructor, factory tours and focused question and answer sessions. Solar factory training courses are the same duration as the multi-customer training courses (normally five days) and class size is limited to maintain an effective learning environment.

On-Site Training

On-site training classes are available at locations worldwide. Solar's Technical Training instructors bring the training courses to your chosen location on a time schedule best suited to your operational requirements. On-site training is designed to maximize your training budget and reduce your travel costs. All personnel benefit by receiving the same instruction at the same time. Other benefits of on-site training include lowering overall training expenses, enhancing team building, decreasing out of office time, increasing one-on-one interaction with the instructor, focusing question and answer sessions. In house training courses are the same duration as the multi-customer training courses (normally five days). Class size is limited to maintain an effective learning environment.

Foundational Training Courses

Foundational training courses are available either at the San Diego training facility as a multi-customer, other Solar facilities worldwide, or at customer-designated locations as an on-site course. Onsite training courses allow the customer to have a group of employees trained at the same time at the customers chosen location. These courses provide detailed insight into the characteristics of Solar's equipment from both an operational and a maintenance perspective. The learning experience enriches the course participants with a high level of product understanding that can be applied to many real-life situations in their daily work environment. Most courses provide five days of instruction.

Operation & Routine Maintenance Course (O&M)
Developed as an introduction and orientation course. Each course begins with the fundamentals of operation and maintenance of the turbine package and progresses through a functional description of each system and its components. Topics covered include package description, turbine engine, start system, air system, lube system, fuel system, driven equipment, control system, operating procedures, condition analysis, and safety. This course is available for each of Solar's gas turbine package models. *(Optimum enrollment is 15 students)*

2011 Budget Price:
> At designated Solar Facility (per student) .....
> Onsite (per course) .....

General Terms and Conditions - Training:

Onsite Courses:

- Pricing excludes instructor travel and expenses. Mobilization/Demobilization and per diem expenses will be invoiced additionally at actual cost.
- Exclusions from *Turbotronic* 4 pricing:
  - Airfreight charges associated with shipment of the *Turbotronic* 4 control system simulator to and from Solar's facility and the course site.
  - Local, corporate, personal, sales, or any other taxes/fees that may be applicable
  - Insurance coverage for the *Turbotronic* simulator during use for the course.

  (Any of the exclusions listed above will be invoiced additionally at actual cost)

General Considerations:

- Course fees include workbooks and classroom materials.
- Course prices exclude any taxes, duties, or fees of any kind.
- Students that are unable to attend training at their scheduled time are encouraged to contact Solar's Technical Training department to reschedule the course as soon as possible. Substitute students are allowed.
- For on-site and customized courses, Solar will make every attempt to reschedule the course to a mutually agreeable time; however, availability of certain dates may be limited.

Intellectual Property Rights:

It is Solar's policy to offer a range of Technical Training for customer employees, and under certain circumstances outlined in the policy document, a limited range of training to customer sub-contractor employees.

Solar does not offer Technical Training directly to third party personnel. Training in overhaul techniques is not provided to customers, except in the special circumstances. Under no circumstances is training in overhaul techniques offered to customer sub-contractors or third parties. Training is offered subject to Solar's standard Terms and Conditions for the provision of Technical Training. Solar may, in the course of its performance pursuant to this Agreement, disclose training information, technical documents, computer programs and/or computer data files (information) of a proprietary nature. All such information is "Confidential" or "Proprietary Information" and is disclosed to Company for Company's agreed-upon use, subject to the following terms and conditions:

a. Company agrees to hold in confidence the Information, including any changes thereto, which Solar may at its discretion provide to Company. Company further agrees not to disclose the Information to third parties or to use it for any purpose other than the purpose for which it is provided.

b. Company agrees not to copy the Information. Company may purchase additional copies of materials from Solar if additional copies are desired. Company further agrees not to film, video tape or audio tape the course or any part of the course.

c. Company agrees to establish and maintain appropriate security measures to protect the information from unauthorized access, use and disclosure.

d. Company understands and agrees that upon termination of this Agreement, or upon breach of the Agreement by Company, Solar may terminate Company's right to use the Information and require the destruction of, or secure the return of the Information and other materials (including translations) embodying the Information in any tangible form, and any copies thereof.

General Terms and Conditions: (cont'd)

Rights to Drawings and Data:

a. All drawings, designs, data and specifications ("Data") relating to the Agreement are the property solely of Solar and shall not be disclosed to third parties or reused by Company without the prior written consent of Solar. This consent may be withheld in Solar's sole and absolute discretion.

b. Solar's courses are intended for the sole use of Company and other recognized end-users of Solar manufactured equipment. Enrollment in courses and purchase of materials is restricted to authorized agencies or personnel officially representing end users. The contents of the training manuals contain proprietary Data and Information of Solar Turbines Incorporated, a subsidiary of Caterpillar Inc. As such, it is protected under U.S. copyright law. All reproduction is prohibited without written approval of Solar.

Please reference *Product Information Letter (PIL) 212* in the Appendix for additional information describing Solar's position on Customer Training practices.

Rights to Drawings and Data:

- All *Multi-Customer* courses and course materials, with the exception of Mexico and South America, are provided in English.
- *Onsite* and custom classes may be conducted in several languages, such as English, French, German, Portuguese or Spanish. In general, there is a nominal charge for providing training workbooks and materials in languages other than English. Specific language needs are discussed during the formal needs assessment.

Certificates:

- Solar's Technical Training awards a Certificate of Completion to all participants who successfully complete each course.

Registration and Scheduling:

- *Multi-Customer*, and *Onsite* courses should be arranged by contacting the Solar Turbines Technical Training Registrar.
- *Multi-Customer* registrations will be acknowledged upon receipt, and then confirmed by the Registrar thirty (30) days prior to course date. The size of each class is limited, so register early.
- *Onsite* courses are scheduled at the convenience of both parties; a minimum of ninety (90) days lead-time should be allowed for booking and a further thirty (30) days lead-time for translations. The scheduling can be arranged by Solar's Technical Training Registrar, Solar's Project Manager, or Solar's local Customer Services office.

Accommodations:

- Travel, lodging and meal expenses are the responsibility of the student, or the sponsoring company.
- For *Multi-Customer* courses, Solar can reserve a block of single rooms at a conveniently situated hotel; however, students should confirm registrations directly with our travel department at (+1) 858-694-6560.

Section 9.0

Solar Experience

SOLAR TURBINES COMPANY OVERVIEW

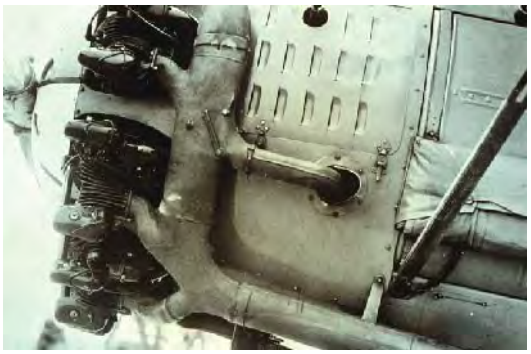
Solar Turbines Incorporated is a San Diego, CA based company whose business is the design, manufacture, installation and servicing of proven lines of gas turbine-driven generator sets, mechanical-drive packages and centrifugal natural gas compressor sets. Since 1981, Solar has been a wholly owned subsidiary of Caterpillar Incorporated. Caterpillar Inc., primarily known as the world's largest manufacturer of construction and mining equipment, diesel and natural gas engines, and industrial gas turbines, was actively engaged in gas turbine development 25 years prior to Solar's acquisition. Both Caterpillar and Solar are committed to providing turbomachinery products designed as the industry standard.

Solar's current axial-flow industrial gas turbine product line consists of:

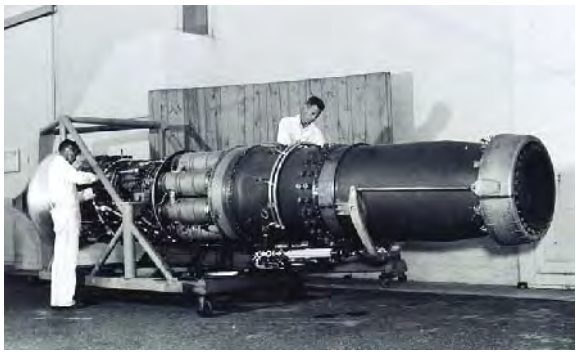
Family and Model	Generator Set (kWe)
Saturn 20	1 210
Centaur 40	3 515
Centaur 50	4 600
Mercury 50	4 600
Taurus 60	5 670
Taurus 65	6 300
Taurus 70	7 520
Mars 90	9 450
Mars 100	10 690
Titan 130	15 000
Titan 250	21 745

COMPANY HISTORY

Solar was founded in 1927 as a manufacturer of all-metal airplanes. In the 1930's, the company entered the aircraft components business and manufactured the first stainless steel manifolds for aircraft engines. Shortly thereafter, the company became a major supplier of manifolds, exhaust stacks and heat exchangers for military and commercial aircraft. This early background in the manufacture of aircraft engine components, combined with achievements in high temperature metallurgy, resulted in Solar's participation in the first U.S. jet engine programs beginning in 1944. The first successful jet engine afterburner was designed and built by Solar.



Stainless Steel Manifold



Jet Engine Afterburner

COMPANY HISTORY (cont'd)

This experience led to the development of turbine engines and gas compressors for industrial applications, which became the mainstay of the power systems presently designed, manufactured, packaged, modularized and serviced for our customers worldwide. In less than two decades, Solar Turbines Incorporated became the world's leading manufacturer of industrial gas turbines and power packages.

Solar's first radial gas turbine (the original Mars gas turbine), introduced in 1948, was a 60-hp engine used as an auxiliary power unit for aircraft and to power portable fire pumps primarily for the United States Navy. Since then, Solar has built more than 12,800 units, including the Spartan gas turbine used in a 225-kW generator set, the original Titan engine used for many different applications, including a start engine for the Centaur 40 gas turbine, and the Gemini engine originally developed as a portable 10-kW generator set for the U.S. Army.

The evolution in Solar's product line led to the introduction of axial-flow gas turbines in 1948.

1948 The ***Jupiter****, Solar*'s first axial-flow turbine.

1957 The *Saturn, Solar*'s first industrial turbine engine. Originally designed for naval shipboard power generation and propulsion applications, the *Saturn* turbine engine was applied as an industrial prime mover for electrical power generation, as well as in gas compression, pumping, and other mechanical-drive applications.

1969

The ***Centaur* 40** industrial gas turbine features rugged construction, conservative firing temperatures and long-life sleeve bearings.

1976 The ***Mars*** turbine, a development from *Centaur* turbine experience, is a rugged, heavy-duty engine designed for continuous-duty industrial service under the most severe conditions, is the most efficient industrial gas turbine in its power class.

1985

The ***Centaur* 50** turbine was the next step in a planned series of uprates and has achieved its current rating by capitalizing on the *Centaur* 40 experience and the conservative use of technology and hardware developed with the *Mars* turbine.

1989 The ***Taurus* 60** gas turbine evolved from the *Centaur* gas turbine. *Taurus* 60 achieves an approximate 20% power advantage over the *Centaur* 50 gas turbine by using an additional "zero" stage in the engine compressor, while operating at the same turbine inlet temperature as the *Centaur* 50 gas turbine.

A distinct advantage of the *Centaur* 40, *Centaur* 50 and *Taurus* 60 gas turbine products is the interchangeability of engines on a common "universal" turbomachinery package. The three engines are all packaged on essentially the same skid and the skid-mounted components are sized to accommodate all three engines. This feature facilitates the ability to replace the engine with a higher power unit should additional power be required in the future, assuming the driven equipment can be replaced or modified to use the additional power.

COMPANY HISTORY (cont'd)

1995 

The ***Taurus* 70** gas turbine evolved from the Centaur product and achieves an additional 39% power advantage over the *Taurus* 60 gas turbine by using an additional "zero-zero" stage in the engine compressor and operating at the same turbine inlet temperature as the *Mars* 100 gas turbine.

1997 The ***Titan* 130** gas turbine design consists of a linear scale-up of the proven *Taurus* 70 gas turbine and also allows for the use of many components common to the *Mars* gas turbine product line. The *Titan* 130 engine is, thus, designed to be durable and reliable for demanding industrial applications, while offering the highest efficiencies in its class.

2004 

The ***Mercury* 50** represented a technological breakthrough in recuperative gas turbine technology, with a host of environmental, operational, economic and siting advantages. It is a product of *Solar's* commitment to the US DOE's Advanced Turbine Systems (ATS) program. Features include the highest electrical efficiency for a gas turbine in its size range and an ultra-low emissions profile.

2009 The ***Titan* 250** is the latest gas turbine to be introduced to Solar's product line. It leverages the technologies developed for the Taurus 65, Mercury 50, and Titan 130 products; delivering the highest reliability, durability and availability of any gas turbine in it's class.

PRIMARY FACILITIES

Solar's industrial gas turbine engine and centrifugal compressor manufacturing and turbomachinery packaging facilities are the largest and most modern in the industry. More than 101,350 square meters (1,000,000 square feet) of floor space are dedicated to manufacturing and packaging gas turbines.

The San Diego, Harbor Drive facility accommodates general offices, engineering, development test facilities, research, field support organizations, and parts and components manufacturing. The Harbor Drive Development Testing facility began in 1945 when the company designed and constructed its first test cell specifically for testing industrial turbines. The present array of test beds and instrumentation, therefore, is based on more than 50 years of experience in this field.

Solar's Headquarters – Harbor Drive Plant

PRIMARY FACILITIES (cont'd)

Solar's modern manufacturing assembly plant is located in the Kearny Mesa area of San Diego. All assembly and production testing of the Centaur, Taurus, Mercury, Mars and Titan gas turbines, centrifugal boost compressors and turbomachinery packages is conducted at the Kearny Mesa plant facility.

Plant features include an engine assembly lines, centrifugal compressor assembly area, pre-test area, computerized production test cells consisting of enclosed cells and outside test pads, an advanced retrieval parts stacking and storage system, and dedicated space for the production of generator set, mechanical-drive package, and compressor set systems and control consoles. All turbomachinery packages are assembled on easily movable dollies and transported throughout assembly, pretest, production testing, final painting, and package finishing. The plant also includes facilities for final product crating, preparation for shipment and loading onto transport vehicles.

Solar's Manufacturing and Test Facilities - Kearny Mesa Plant

The Saturn product is manufactured, assembled and tested at Solar's Mabank facility located southeast of Dallas, Texas.

WORLD LEADER IN INDUSTRIAL GAS TURBINES

Solar Turbines Incorporated is a world leading producer of industrial gas turbines and turbomachinery packages in the 1.2 – 21.7 MW (1,600 – 30,000 hp) range. Solar gas turbine units are operating in 93 different countries and under varying conditions, including arctic, desert, coastal/tropical and offshore. Even in the harshest environments, Solar gas turbines continue to provide safe and reliable power.

Solar Industrial Gas Turbine Operating Experience Summary

Experience by Package	Units Sold	Estimated Hours
Compressor Sets	3,960	659,300,000
Mechanical Drives	2,570	404,900,000
Generator Sets	7,360	627,900,000
Total	**13,890**	**1,692,100,000**

NOTE: Total includes >1,200 Spartan generator sets
Effective: 12/31/10, © Solar Turbines Incorporated

Taurus 70 Industrial Gas Turbine Operating Experience Summary

Experience by Package	Units Sold	Estimated Hours
Compressor Sets	190	6,100,000
Mechanical Drives	90	3,700,000
Generator Sets	320	14,100,000
Total	**600**	**23,900,000**

Effective: 12/31/10, © Solar Turbines Incorporated

SoLoNOx Industrial Gas Turbine Operating Experience Summary

Generator Sets Packages	Units Sold	Estimated Hours
Titan 130	160	3,600,000
Mars	90	8,000,000
Taurus 70	230	9,500,000
Taurus 65	20	300,000
Taurus 60	460	19,900,000
Mercury 50	60	1,000,000
Centaur 50	100	4,400,000
Centaur 40	50	3,100,000
Total	**2,300**	**94,700,000**

Effective: 12/31/10, © Solar Turbines Incorporated

Cogeneration Experience Summary

Market Segment	Centaur 40	Centaur 50	Mercury 50	Taurus 60	Taurus 65	Taurus 70	Mars 90	Mars 100	Titan 130	Total
Brewery/Distillery	1	4		6		1	1	1		14
Chemicals and Allied Products	10	29		43		19	3	8	10	122
Communications/IT Facilities		5	2							7
District Heating Power Plant	1	1	1	3		2		5	6	19
Educational Services	6	12	4	24		14		2	13	75
Electric Power Plant	8	35	4	52		22	3	17	17	158
Financial Services			1	1						2
Food Processing	3	27	2	74	4	15	6	14	7	152
Forest Products	11	45		94	7	40	3	11	10	221
Health Care Facilities	8	15	3	6		2				34
Hotels, Resorts and Casinos			3	2		1				6
Metals									1	1
Mining	1			22		3		5	1	32
Other - Commercial	1	3		7		3				14
Other - Gov/Inst.	7	1		2		1				11
Other - Industrial	16	25	2	50		12	7	7	3	122
Pharmaceutical	7	8		19		2	3	1	1	41
Refinery	1	1	1	3		1			4	11
Research and Development Facilities	1	1	3	2			1		1	9
Solid Waste Management Facilities	6			2				3		11
Stone, Clay, Glass, and Concrete Products (incl. Ceramics)		24	2	26	1	6			2	61
Textiles	5	5	2	39		9	1	5	1	67
Tires and Rubber		4		7	1	10	1	2		25
Transportation Facilities		3		3		1		2		9
Water/Sewage Treatment Plant	2	6	1	11	1		3			24
Grand Total	95	254	31	498	14	164	32	83	77	1,248

Appendix

See attached CD-ROM for the Referenced Documentation

ATTACHMENTS

Sales Literature.

SPTT-PG Turbotronic 4 Control System
Provides an illustrated overview of the *Turbotronic 4* control system organized the following topics:
> Standard Hardware
> Optional Control and Display Features
> App A: Hardware
> App B: Technical Supplement
> App C: Control System Information

Product Information Letters (PIL).

PIL 012 Customer Drawings
This Product Information Letter (PIL) specifies the standard drawings that are supplied to the customer with all Power Generation gas turbine packages, and the respective lead times involved in the production and delivery of these drawings.

PIL 058 Package Sound Levels
This Product Information Letter (PIL) provides guidance on sound levels for Solar's turbomachinery packages. It describes how levels are defined and measured, and the factors that should be considered when reviewing project requirements. It discusses available guarantees and their limitations.

PIL 097 Guidelines for Package Preservation and Preparation for Shipment
Solar turbomachinery packages are shipped with protection against environmental conditions. Either "short term" or "long term" package preservation is available depending on the destination, and the length of time between shipment and installation. This Product Information Letter provides an overview of the typical types of packing used and the factors that should be considered regarding longer term storage of the equipment.

PIL 149 Direct AC Start System
This Product Information Letter (PIL) describes the application and installation of the direct-drive AC start systems available for Solar® gas turbines using Rockwell Automation's PowerFlex Variable Frequency Drive (VFD). Depending on the package power requirements either the 700 or 700H model is applicable.

PIL 150 Fire and Gas Detection and Control System
This Product Information Letter (PIL) provides an overview of the fire and gas monitoring and detection system used in Solar's enclosed turbomachinery packages.

PIL 162 Recommendations and Requirements for the Sourcing, Handling, Storage and Treatment of Fuels for Solar Gas Turbines
Fuel quality directly affects the performance and operating life of gas turbines. Solar's specification ES 9-98 defines the requirements for fuels. This PIL provides additional information related to ES 9-98 and emphasizes the importance of providing and maintaining proper fuel quality to ensure optimal performance of the turbomachinery. Issues and symptoms related to contaminants in the gas and liquid supply are discussed, along with specific recommendations and requirements for protecting gas and liquid fuel systems against these contaminants.

PIL 170 Start-up Emissions
This Product Information Letter (PIL) is to provide emission estimates for start-up and shutdown events for Solar® gas turbines with *SoLoNOx* dry low emissions combustion systems. The commissioning process is also discussed.

PIL 171 Particulate Matter Emissions Estimates
This document summarizes Solar's recommended PM10/2.5 emission levels for our line of gas turbines. The recommended levels are based on an analysis of emissions tests collected from customer sites.

PIL 212 Customer Training Practice
Clarifies Solar's position relative to providing training to Customers and Parties that may be competitors of Solar.

PIL 221 Water Treatment System Guidelines
This Product Information Letter (PIL) is intended to assist customers in acquiring a Water Treat-ment System capable of conditioning site water to meet the requirements of Solar Turbines' specification ES 9-98, defining the limits for contaminants in the water for fuel system purge, on-crank engine cleaning and on-line engine cleaning. Various supply water sources may be used, including distilled, potable, and untreated fresh water. The treatment system is intended to be mounted on a structural skid or baseplate, suitable for an indoor or an outdoor environment, with an analyzer and control panel to monitor all functions and ensure that treated water is meeting the required quality.

PIL 222 XM Vibration System
The XM vibration system is based on the Rockwell Automation XM-120 product line. Its primary purpose is to protect the equipment from damage due to excessive vibration levels. Additionally, with the proper equipment, the system provides information that can be used to evaluate vibration problems and enable the user to trace the root cause before equipment availability is affected.

The primary advantage of the XM vibration system results from the seamless integration with Solar's existing ControlNet-based Flex I/O control system. By integrating the vibration system, the diagnostic information is readily obtained through the existing network configuration, and allows more complete condition monitoring of the turbine.

Engineering Specifications (ES).

ES 1923 Alternating Current Integral Horsepower Motors NEMA Frames, inclusive of the following Sections:

1.0 Scope
2.0 Standards, Codes, and References
3.0 General
4.0 Mechanical
5.0 Electrical
6.0 Noise
7.0 Efficiency
8.0 Inverter Duty Motor
9.0 Approved Suppliers

ES 2201 Auxiliary Service Air, inclusive of the following Sections:

1.0 References
2.0 Purpose
3.0 Scope
4.0 Definitions
5.0 Requirements
6.0 Standards

ES 2220 Package Test Requirements for Industrial Power Generation Packages

ES 2252 Standard Alternating Current Generators for Use with Solar PG Single-Shaft Turbines, inclusive of the following Sections:

1.0 Purpose
2.0 Applicable Documents
3.0 Requirements
4.0 Quality Assurance Provisions
5.0 Preservation
6.0 Proposals

Attachment 1: Specification Data Sheet (completed by Solar)
Attachment 2: Generator Data Sheet (completed by Generator supplier)
Attachment 3: Supplier Drawing and Data Requirements

ES 2416 Battery Supply Systems, inclusive of the following Sections:

1.0 Scope
2.0 Applicable Documents
3.0 Requirements
4.0 Requirements Verification

ES 9-62 Ingestive Cleaning Solar Turbine Engines, inclusive of the following Sections:

1.0 Scope
2.0 Definitions
3.0 Applicable Documents
4.0 General Requirements
5.0 Cleaning Product

ES 9-97 Gas Turbine Emissions Test Specification, inclusive of the following Sections:

1.0 Scope
2.0 Applicable Documents
3.0 Requirements
4.0 Definitions
5.0 Principle of Emissions Measurement
6.0 Essential System Components
7.0 Pre-Test Procedures
8.0 Periodic Calibration Checks
9.0 Sampling
10.0 Purpose

Appendix A: P517, The Subroutine

ES 9-98 Solar Fuel, Air, Water (or Steam) & Compressor Cleaning Fluids for Solar Gas Turbine Engines, inclusive of the following Sections:

1.0 Scope
2.0 Applicable Documents
3.0 General Requirements
4.0 Air
5.0 Injected Water (or Steam)
6.0 Evaporative Cooler Water
7.0 Compressor Cleaning Fluids
8.0 Fuel
9.0 Handling and Storage of Distillate Fuels
10.0 Notes

Appendix A: Total Site Contamination Worksheet
Appendix B: Derivation of Total Fuel Equipment Concentration Equation for Undesirable Contaminants
Appendix C: Liquid Fuel Handling and Storage Requirements **See Note a**
Appendix D: Liquid Fuel Suitabilty form

Notes:

(a) Appendix C provides generalized recommendations with regard to liquid fuel storage and handling requirements. In practice, each site carries with it, its own set of constraints and customized requirements. Solar acknowledges the unique characteristics of each installation, and has created a tool to aid with specific end-use recommendations. A copy of the *Liquid Fuel System Assessment* form is attached. When completed, Solar will provide you with a recommended configuration for Liquid Fuel Storage and Handling, consistent with the requirements of this specification.

ES 9-224 Specification for Lubricating Oils for Use in Solar Gas Turbines, inclusive of the following Sections:

1.0 Scope
2.0 Applicable Documents
3.0 New Oil Requirements
4.0 Used Oil Requirements
5.0 Operating Limits
6.0 Electrical Conductivity of Lube Oils
7.0 Quality Assurrance

ATTACHMENTS

Sample Field Performance Verification Test Report

As referenced in the section on Field Performance Verification Testing, the following is typical of the Test Report that will be made available for distribution in a reasonable period of time after the site testing has been completed.

Solar Turbines Incorporated

9330 Sky Park Court
MZ SP3-x
San Diego, CA 92123-5398
Tel: (858)694-xxxx
Fax: (858)694-xxxx
pm@solarturbines.com

Solar Turbines
A Caterpillar Company

Mmm DD, YYYY

Customer Company Name
Customer Company Address

Customer Name:

Subject: Field Performance Verification Test Report

Project Name:	xxx
P.O. Reference:	xxx
Solar PD#:	xxx
Package Serial Number:	xxx
Engine Serial Number:	xxx

1.0 Introduction

A field performance verification test was conducted on <insert date> for the Solar gas turbine generator set(s) at the <insert plant name> facility located at <insert location>. The unit is described as a Solar <insert model> gas / liquid / dual <delete as applicable> fuel gas turbine generator package having serial number <insert serial number>. Testing was conducted by Solar Turbines FSR <insert name>. Also present during testing were Customer witness <insert customer names>.

2.0 Objective, Guarantee, and/or Stipulated Agreements

In general, the objective of the test was to perform a site verification that the Solar gas turbine generator set (s) meets or exceeds the declared performance values for generator gross output power and gross heat rate (both referenced to generator terminals), as previously demonstrated during factory performance testing. As the field tests were performed at site, and performance readings taken from permanently installed and customer instrumentation, the results are inherently less accurate than those obtained under factory test conditions, and allowances for test uncertainty and other factors affecting the test results need to be considered, as stipulated in the test procedure.

3.0 Test Arrangement, Procedures, and Other Considerations

The test was arranged and performed in accordance with the Solar "Site Performance Verification Test" procedure reference in the Solar proposal.

The generator set was started and fully loaded for <insert duration> hours before commencing the performance verification test in order to allow the engine to properly heat soak. The actual test had a two (2) hour duration, with data recorded every fifteen minutes, making for a total of nine data points.

The gas turbine performance was then calculated using Solar's on-line performance program "FASTE". Prints of the FASTE calculation outputs for each data point and the average are attached hereto, and following tables provide details of the recorded results and calculated performance results.

<Note, as an alternative, the performance calculations may be made using Solar's ENGPERF Performance Program, in which case the ENGPERF result sheets will be attached>

4.0 Observations and Other Considerations

The generator set had <insert operating hours> operating hours at the commencement of the test run. In accordance with the test procedure, a compressor detergent wash was performed prior to commencement of the test to reduce the performance degradation resulting from the accumulated operating hours.

The gas fuel LHV value used in the heat rate calculation is based on a gas composition provided by the Customer. The PIPELINE program was used to determine LHV and SG. The actual gas quality during the test was not known, and therefore adds to the test uncertainty.

As no barometer is installed at the power plant, atmospheric pressure and relative humidity values are based on the published data from <insert name> Airport. Prints of this published data are attached to this report.

<Insert any further observations>

5.0 Performance Summary

The following summarizes the results of the test run. The summary of the site performance test results is made on an individual generator set basis, however, the individual generator set values are essentially for information, as the overall evaluation of the test results is based on the average performance of the installed units. Performance correction calculations were made using the Solar FASTE performance software, and the results do not consider test uncertainty.

5.1 Full Load Power Evaluation. A performance comparison of the generator power output under test conditions versus declared performance at reference conditions identical to the test conditions was accomplished by measuring the gross power at the generator terminals, air inlet temperature (T1), inlet and exhaust duct losses and barometric pressure using the package and Customer supplied instrumentation. A total of nine data points were considered.

The averaged results for the nine data points indicate that the measured power output exceeded, and was therefore better than the site corrected declared performance value by <> kW. The results of each individual data point may be viewed on Table 1 attached. The above summary, and the values set forth in Table 1 do not include any allowance for test uncertainty.

5.2 Full Load Heat Rate Evaluation. A performance comparison of the heat rate under test conditions versus declared performance at reference conditions identical to the test conditions was accomplished by measuring the fuel flow with the package fuel flow meter at the same times and with the same number of data points as for the power measurement in Item 5.1 above.

The averaged results for the nine data points indicate that the measured heat rate was lower, and therefore better than the site corrected declared performance by <> Btu/kWh. The results of each individual data point can be viewed on Table 1. The above summary, and the values set forth in Table 1 do not include any allowance for test uncertainty.

6.0 Conclusion

In conclusion, the site performance verification test showed that prior to any consideration of test uncertainty, the average power output for the generator set(s) exceeded, and was therefore better than the declared performance value by <>%. The average heat rate for the generator set(s) was lower, and therefore better than the declared performance by <>%.

As detailed in the Solar proposal, the factory tests allow engine operation under steady, closely controlled conditions with special and redundant instrumentation, and as a result, Solar does not consider test uncertainty when evaluating factory test results. The factory test results already provided are therefore 'zero tolerance' values with no further correction for test uncertainty. This is not the case for the Site test results, which were obtained using package and other permanently installed instrumentation, and further influenced by other factors beyond Solar's control, such as power transformer (PT) and control transformer (CT) accuracy, cable losses,

the accuracy of Customer supplied instrumentation, accuracy of Customer supplied fuel analysis, etc. This results in a field test accuracy that is inherently lower than a factory test, and the specified 3% allowance for test uncertainty must be considered. A 3% test uncertainty means that the computed or measured value being evaluated does not deviate from the actual value by an amount greater than 3% (with 95% or greater confidence). In the case of the site performance verification test, the average values showed an improvement over the declared value, meaning higher power output, and lower heat rate, and the test is therefore considered successful.

If, after reviewing this report, you have any comments or questions regarding its content, please don't hesitate to contact me.

Respectfully Submitted,

PM Name
Project Manager
Power Generation Products
Solar Turbines Incorporated

Attachments:

Table 1: Full-Load Test Results

	Test Results									
Data Point	1	2	3	4	5	6	7	8	9	Average
Date										
Time										
Barometric Pressure (inHg)										
T1 (Deg F)										
T2 (Deg F)										
Inlet Diff Press (inH2O)										
Exhaust Diff Press (inH2O)										
Relative Humidity (%)										
PCD (psig)										
Gen Power Output (Kw)										
Voltage (kV)										
Frequency (Hz)										
Power Factor										
Fuel Flow (mmBtu/h)										
	Power Analysis (test condition)									
PASTE / ENGPERF predicted power [kW]										
Site Test Power [kW]	0	0	0	0	0	0	0	0	0	0
Test Power – Predicted Power	0	0	0	0	0	0	0	0	0	0
Percent Delta (positive is favorable)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
	Heat Rate Analysis (test condition)									
PASTE / ENGPERF predicted fuel flow [mmBtu/h]										
PASTE / ENGPERF predicted power [kW]	0	0	0	0	0	0	0	0	0	0
PASTE / ENGPERF predicted HR [Btu/kWh]										
Site Test fuel flow [mmBtu/h]	0	0	0	0	0	0	0	0	0	0
Site Test Power [kW]	0	0	0	0	0	0	0	0	0	0
Site Test HR [Btu/kWh]	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Test HR – Predicted HR	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Percent Delta (negative is favorable)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Comments / Remarks: -
<> Engine hours at start of test. Water wash performed / not performed.
No fuel LHV provided by customer, so default 18,330 Btu/lb, and SG 0.85 used.
Barometric pressure and RH reading from <> Airport used.