
Addendum # 5

NEW STANDARD FOR MOBILE GAS TURBINE POWER PACKAGES

Introduction

There has been an increased need for large-scale transportable power to meet emergency, outage and climate driven requirements around the world. To address this need, engineers at Pratt & Whitney Power Systems created an environmentally compliant 25MW Mobile Power Plant readily transportable by air, sea, or land, and easily set up within a small footprint in potentially challenging environments.

Design

The primary design goal was to provide a transportable power plant that required minimum setup time and high reliability. A total of four trailers are required to transport all of the equipment needed to set up a MOBILEPAC plant. One of two operational trailers contains the FT8 gas turbine engine pre-coupled and aligned to the generator. In addition to the gas turbine and generator, this power trailer includes the inlet plenum, exhaust collector/diffuser, and the engine and generator lube oil systems. Figure 1 is a 3D model of the structure and assembly used for design and structural analysis. The second operational trailer contains the generator circuit breaker, MCCs, and all control/monitoring equipment. Two additional trailers carry the remainder of the package including filters, silencers, piping, and quick disconnect cables.

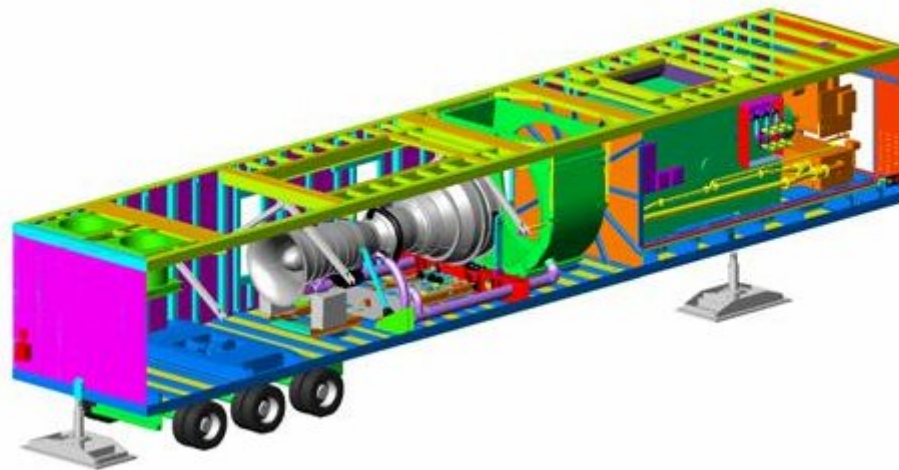


Figure 1: 3D Model of the Mobile PAC

In order to keep weight to a minimum, PWPS engineers designed a riveted aluminum monocoque structure for the power trailer. The structure is similar in construction to an aircraft in which aluminum skin is riveted to stringers to form a strong yet lightweight container which reacts much like a reinforced cylinder to resist torsional, buckling and deflection loads. Basically, the skin of the trailer supports all of the static and dynamic loading of the gas turbine generator installation as opposed to reinforcing a conventional trailer with heavy channel and beam structures for strength.

The trailer utilizes a 3-point support commonly used when installing gas turbine generator packages on offshore platforms and aboard ships. One outboard jacking/leveling plate is located towards the rear of the trailer and two are centered under the generator. In the field each of these leveling plates sits on engineered fill compacted to 4000 lbs per square foot or concrete pads at the option of the owner-operator. The 3-point support allows the monocoque structure of the trailer to act as a solid plane transferring its weight to the plates. Should one leveling plate sink, everything remains in plane so the generator and turbine coupling alignment is not affected. Thanks to a lower weight shell, the trailer could be acoustically treated to attenuate noise from the engine and generator without exceeding axle-loading limits.

Figure 2 shows a power trailer under construction. The picture is taken through the inlet with the plenum not installed. A few items of note in this figure: Interior walls are perforated aluminum sheet covering acoustic insulation; Quick disconnect cable connectors can be seen on both walls of the trailer; Roof openings for engine removal, exhaust and generator exhaust; Piping in foreground is engine lubrication oil.

The control trailer is built on a custom fabricated trailer. This trailer includes: 15-kV generator circuit breaker, engine and station control and monitoring system, protective relays and synch panel, batteries and charger, motor control center, package auxiliary transformer, hydraulic engine starter, and CO2 fire suppression system. To maintain a benign environment for the electronics, the control enclosure is heated and air-conditioned.

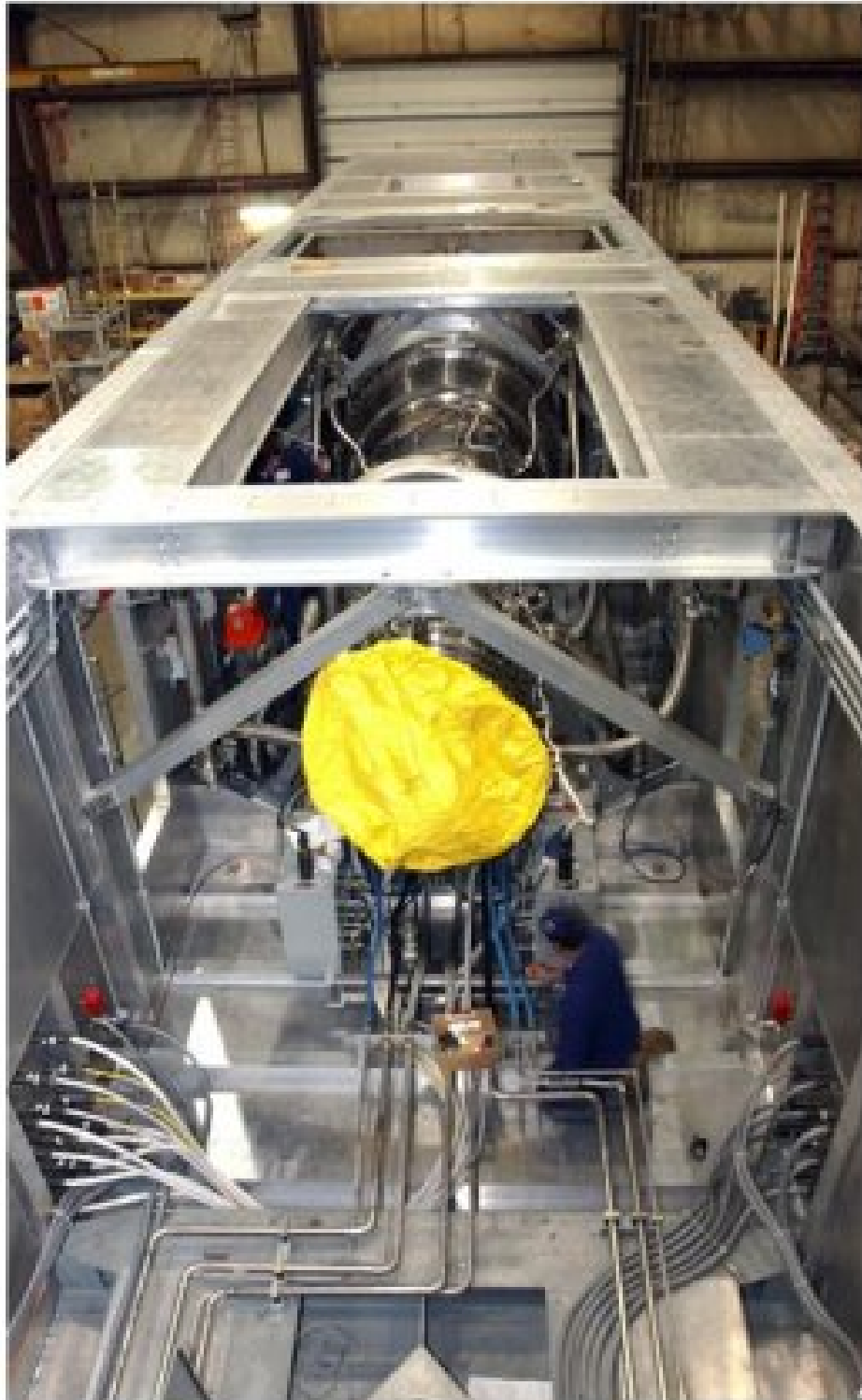


Figure 2: MOBILEPAC Power Trailer under construction

Transportation

The power trailer is transported to its site by a jeep and wheeled tractor that fits to a pivot pin under the front of the trailer. In addition, a hydraulically steered bogey located towards the aft end of the power trailer increases maneuverability on tight roads and simplifies positioning the trailer upon arrival at site. The power trailer suspension is equipped with an air ride system to absorb road shock and pneumatic jacking capability to adjust for road clearance. This trailer is approximately 65 ft long by 12 ft wide and 13.5 ft high. Significant clearance was design on the underside of the trailer to accommodate highly crowned or undulating roads.



Figure 3: MOBILEPAC Power Trailer in transit on the Interstate.

The control trailer is approximately 50 feet long by 11.5 feet wide and 13.5 feet high.



Figure 4: MOBILEPAC Control Trailer on the Interstate

Two standard flatbed trailers about 48 ft long by 11.8 ft wide by 13.5 ft high are required to deliver accessory equipment. The inlet air filter, inlet silencer, and turbine exhaust stack sections are carried on one trailer. A second trailer carries additional turbine exhaust silencers, a generator exhaust silencer, and field piping and electrical equipment.

MOBILEPAC Installation

Depending upon site preference, the control trailer can be set either in-line with the power trailer or parallel to it. In either case, the switchgear end of the control trailer is positioned near the generator. Little is required in the way of advanced site preparation to support the power and control trailers. There are no pilings or concrete pads required. Basics required are a mobile crane, site electrical power, a relatively flat surface and, for the power trailer, compacted soil areas for supports.



Figure 5: Assembly of Power Trailer

Upon arrival, air suspension at the front and rear of the power trailer are inflated to take up the load and lift the trailer, the jeep is unhitched and removed, and the trailer leveled using the jack plates. After the jacks are set and locked, the air bags are deflated.

Electrical preparations include plugging in quick disconnect cables to mate with the already checked out turbine and plant electrical and control systems. Mechanical preparation includes removing shipping closures, connecting the cold air buffer, fuel and hydraulic start piping and hoses. Given a true emergency, the MOBILEPAC can be operated without installing filtration or silencing equipment. In this situation full power output could be supplied to the grid in as little as 12 hours. A normal timetable allows for installation of the turbine inlet silencer and filter (using crane supplied by operator-owner), turbine exhaust transition and silencers, and a generator exhaust silencer – all of which bolt to the top of the power trailer. Both accessory trailers remains on site just long enough to deliver (or pick up) the accessory equipment. Using an experienced crew, a typical installation requires and additional 12 hours for completion of mechanical and electrical preparations plus pre-operational system checkout by a 4-man crew working two 8-hr shifts.

All that remains for the plant to become operational is a fuel supply and connection to the power grid.



Figure 6: Trailers are designed for Air Shipment

First Site

The first installation of and FT8 MOBILEPAC was in the Canary Islands on the island of La Palma. The airport in La Palma was not capable of accepting such a large transport so the package was flown to an adjacent island and ferried to its final destination. The customer made the entire plant transportable by supplying a mobile sub-station and mobile high-side transformer. The only available site for this package was a terraced lot located on the side of a hill. A temporary access road was constructed to this lot and the trailers had to be located only a meter from the stone terrace wall to make everything fit. The flexibility and relatively small size of the MOBILEPAC made using this site possible.

Maintenance

There is plenty of room around the gas turbine engine to carry out routine inspection and maintenance procedures. Access and working room inside the power trailer is the same as inside a stationary FT8 enclosure. For instance, there is full access around the combustors to inspect and replace fuel nozzles, cans and transition pieces (as required) without first having to remove

other hardware that might be in the way. If necessary, the gas turbine and power turbines can be easily hoisted out of the removable power trailer roof. If it is ever necessary to remove the generator, the generator end wall of the trailer is also easily removable. Maintenance access to both the turbine and generator lube systems is also excellent thanks to a total of 10 full size access doors provided on the power trailer.



Figure 7: Mobile Site in the Canary Islands

Other Features

A MOBILEPAC can generate passive revenue by qualifying as “spinning reserve” or when operated as a synchronous condenser when not needed for emergency back-up or peaking. It does not require a clutch to operate as a synchronous condenser due to its free power turbine design. When in synchronous condenser operation, the plant can switch over to generate a full 25 MW power output within 1 minute. Under normal startup conditions base load power can be reached in less than 10 minutes.

The FT8 Mobile Pac is not taxed as a permanent structure.

Summary

The new Pratt & Whitney MOBILEPAC incorporates several new design concepts resulting in the most flexible and highest performing mobile power plant on the market. Improved design concepts for trailer design, equipment alignment, and leveling technology, create a package that lowers costs to the customer and allows installation in as few as 8 hours at a wider range of sites.

Scope of Supply and Purchaser's Responsibilities

FT8-3 MOBILEPAC W/ POWER ISLAND
BRUSH GENERATOR
DUAL FUEL WATER INJECTION



Pratt & Whitney
A United Technologies Company

Qty:H

Pratt & Whitney Power Systems

Line No.	Item	Description	Quantity	Design	Supply	Erection	Notes
2	I.	POWER TRAILER					
4							
6	1	GAS TURBINE PACKAGE		P	P	C	
8		Gas Generator (GG8 Core Engine)					
14		Power Turbine					
18		Diffuser					
20		Collector Box					
22		Exhaust transition					
24		Fabricated gas turbine base and mount assembly					
26		Coupling connecting power turbine and generator					
28		Hydraulic starting motor					
30		Ignition system					
32		Off-line compressor internal water wash system.					Pipe, nozzle, valve internal to Power Trailer included.. One (1) Water wash skid included for the project. Water Wash heating system is not included.
44		Lube oil system					Combined GG & PT
46		* Single oil-to-air cooler					
48		* Motor driven pumps					One AC; One DC
50		* Stainless Steel Piping					
54		Fuel supply system					
56		* Fuel gas strainer					
58		* Gas fuel fire valve					
60		* Liquid fuel fire valve					
62		* Fuel Gas/Liquid Fuel flowmeter/totalizer					
64		* Last Chance Filter					
65		Liquid Fuel forwarding skid					
66		Buffered air system					
68		* Single air-to-air cooler					
70		* Instrumentation for temperature control					
71		* One AC motor driven pump					
72		Water injection NOx control system					
74		* One AC motor driven pump					
76		* Single air-to-air cooler					
78		Gas Turbine Enclosure					
79		* Secondary cooling air system with louvers					
81		* Secondary cooling air inlet silencer					
82		* Vents and drains					Customer to provide waste drain tank at each site for each unit.
84		* Interior AC/DC lighting					
86		* CO ₂ Fire Suppression System					CO ₂ Bottles supplied by PWPS. CO ₂ and Nitrogen precharge supplied by Customer at jobsite. Bottle rack is external to power trailer. System is compliant with GOST/ATEX Standards.
88		* Sound attenuation to meet 95 dB(A) Average					Average at 3 feet (one meter)
90		* Three point jacking and leveling system					Customer to provide level and compacted site with soil of at least 191,521 Pa. (4000 lbs) per square foot compressive strength.
92		Two-stage inlet air filter with weather protection					1st stage prefilter, 2nd stage high-efficiency media. Prime painted.
100		Inlet silencing					One 1.2 m (4 ft.) inlet section included. Prime Painted
106		Exhaust Stack					Top of exhaust stack 10.36 m (30ft) above grade; transition and two exhaust silencing sections included.
108		* Quick Disconnect Electrical Interface					
110							
114							
116	2	GENERATOR PACKAGE		P	P	C	

P = Derwick
C = Customer

Scope of Supply

Line No.	Item	Description	Quantity	Design	Supply	Erection	Notes
118		Brush Open Ventilated Air Cooled Synchronous Generator or equivalent					Brush 62-170. Generator to be installed & aligned by customer in the field.
124		Brushless Exciter Assembly					With pilot exciter
126		Stator Heaters					
128		Neutral ground transformer/resistor					
130		Current transformers					Quantity 4 per package
132		Stator RTD's					Quantity 6 with 6 spares per package
134		Vibration probes					Proximity
136		Bearing drain RTD's					One per bearing
138		Bearing metal RTD's					One per bearing
140		Hot and cold air RTD's					
142		Rotor ground detection					
144		Generator Lube oil System					Air cooled
146		* Single Stage Filter					
148		* Oil pumps					One Rotor Driven; One DC
149		* Air/Oil heat exchanger with fan					
150		* Stainless steel piping downstream of filters					
154		Enclosure					Finish Painted aluminum enclosure
158		* Inlet air filter					
160		* Inlet and exhaust silencing					
162		* Interior AC/DC lighting					
164		* Sound attenuation to 95 dB(A) Average					Average at 3 feet (one meter)
166		* Fire detection system					
170		* Quick Disconnect Electrical Interface					Installed by customer on generator junction boxes in the field.
172							
174	II.	CONTROL TRAILER	3	P	P	C	Prewired and checked
176		1. Control Enclosure					
178		* HVAC					
180		* Fluorescent lighting					
182		* DC emergency lighting					
184		* AC power outlets					
186		* Smoke detection					
190		Operator control cabinet					
192		* Starting and operating controls					Manual and automatic
194		* Speed indication					
196		* Voltmeters meters					Bus and generator
198		* Ammeter					
200		* Wattmeter					
202		* VAR meter					
206		* Synchroscope and lamps					
208		Monitoring cabinet					
210		* HMI Interface (CRT, keyboard and software for operator interface)					Citect ICE.
212		* Printer					
214		Instrument Cabinet					
216		* Micro automatic voltage regulator					Auto follower and trip to standby
218		* Digital synchronizer					
220		* Vibration monitor					Gas turbine and generator
222		* Fire protection system power supplies					
224		* Static inverter					
226		Unit control cabinet					
228		* Control system for automatic starting, running, loading, unloading and shutdown of the unit.					
230		* Timer Panel					
232		* Expansion chassis					
240		Generator protective relay panel					
242		* Generator protective relays					One Beckwith 4325A. Transformer protection by Customer.
244		* Lockout relays					
246		* Watt hour meter					
248		Motor Control Center					
250		* AC and DC distribution panels					
252		* Motor starters					
254		* Distribution transformer					
256		* Breakers as required					

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Scope of Supply

Line No.	Item	Description	Quantity	Design	Supply	Erection	Notes
258		* Manual transfer switch					
262		Master terminal cabinet					
264		* Field termination blocks					
266		* Power supplies					
268		Rack mounted sealed lead acid cell batteries					24 VDC and 125 VDC
270		Battery chargers					One 24VDC; One 125VDC
272		Switchgear module 15 kV Class					
274		* Metalclad switchgear compartment					Mounted in control enclosure
276		* Circuit breaker					2000 Amp/ 750 MVA, 15kV class Totally enclosed, 15kV class, 2000 Amp
286		* Lightning arresters and surge capacitors					
288		* Current transformers and potential transformer					
290		* CTG Auxiliary transformer					
292		Remote Control System On-Site		P	P	C	For Monitoring and Control from an On-site Location. 200ft fiber optic cable included.
303		2 HYDRAULIC STARTING PACKAGE	3	P	P	C	Trailer mounted with enclosure including fire detection (No fire suppression)
306	III.	FIELD INSTALLATION HARDWARE		P	P	C	
310		Interconnecting piping and hoses for: Hydraulic Start, CO2, Fuel		P	P	C	Between PWPS supplied aux skids, Power Trailer, and Control Trailer
318		Interconnecting Quick Disconnect electrical cables for power and signal.		P	P		Between PWPS supplied aux skids, Power Trailer, and Control Trailer. HV cables from generator to switchgear included.
320		Access Stairs and platforms for Power Trailer and Control Trailer		P	P		Std supply provides for 3 access points per trailer which can be configured per customer requirements at site.
322		Piping interfaces		P	P		Mating flanges on all Customer piping interfaces is by others
324		Special Maintenance Tools		P	P		One set for the site
326	IV.	PWPS SUPPLIED SERVICES AND RESPONSIBILITIES					
		1 PROJECT MANAGEMENT, CONSTRUCTION AND COMMISSIONING SUPPORT			P		
328		PWPS Project Manager assigned to project to manage project execution single point contact for customer.			P		
330		Technical Representatives to advise Customer Supervisory Personnel during initial equipment erection, checkout, commissioning, and testing.			P		
332		Instruction Manuals and Plant Documentation provided: Construction Manual, Commissioning Manual & Sign-off Sheets, Picture Book, PWPS Drawing Package, Vendor Manuals & Drawings, FT8 Maintenance Manual, FT8 Illustrated Parts Catalog, FT8 Service Bulletins, MOBILEPAC Operating Instructions, Bill of Material, As Built Drawings.			P		Provided in CD or alternate electronic format for PWPS Supply. One (1) hard copy of O&M Manual in English is included.
334		PWPS training "Power Plant Operators Course"			P		Training description can be found in the PWPS Customer Training Document version 21-0802. Travel and lodging for customer's personnel not included.
		2 PERFORMANCE TESTING SUPPORT					
336		Thermal Performance Testing			P	C	Customer to provide all personnel and equipment required for emissions testing.
338							
340	V.	OWNER SUPPLIED SERVICES AND RESPONSIBILITIES					Owner is responsible for compliance with PWPS' operating, installation, and maintenance instructions. Warranty is contingent upon compliance.
344		1 PROJECT AND SITE DEVELOPMENT		C	C	C	Owner is responsible for all areas of site development and are not limited to the items listed in this document.

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Scope of Supply

Line No.	Item	Description	Quantity	Design	Supply	Erection	Notes
346		Adequate Title and Interest, Permanent Facility Permits, Construction Permits and Licensing			C		To permit the installation of such units and their operation for at least the period contemplated by the contract. Provide PWPS representatives unrestricted access at all times as may be reasonably necessary in the performance of their duties.
350		Foundations for all Equipment		C	C	C	Site prep, leveling and compaction to meet at least 191,521 Pa (4000 lbs per square foot) compressive strength.
351		Equipment Mounting		C	C	C	Customer responsible for hardware to secure PWPS supplied Stairs/Platforms & Ancillary Skids (CAB, Fuel Metering Skids, CO2 Enclosure, Cable Trays).
354		Provision of Secure Field Office adequate for 3-5 PWPS field personnel. Furnished with electricity, Heating and Air Conditioning, Drinking Water, Desks, Chairs, Parking Area, Lockers and others which are necessary for Field Works, Services & Sanitary Facilities of Office Personnel.		C	C	C	
355		SAFETY PROVISION, Provide a safe working environment that meets or exceeds all applicable local, regional, national, and international safety standards and regulations.		C	C	C	The purpose of this provision is to emphasize the importance of site safety and insure safe working conditions for all personnel. PWPS and our sub-contractors/suppliers will only be able to provide support under safe site conditions.
356		Provision of First Aid and Medical Services - OSHA Approved		C	C	C	
358		Provisions of Local Communication Facilities		C	C	C	Telephone (local and long distance) with international direct dialing and fax machine. This should be a minimum of 3 lines in the PWPS field office. A separate dedicated phone line shall be provided to each turbine control system in the control house.
360		Temporary Construction Staging & Secure Inventory Area			C		
362		Access Road(s), Interior Roads, and Parking Areas		C	C	C	All-weather and unobstructed
364		Transmission System		C	C	C	Including interconnection to PWPS supplied equipment.
366							
368	2	ENGINEERING AND CONSTRUCTION					
370		Site Engineering			C		
372		All Supervision and Craft Labor for complete off-loading, Inventory, Inventory control, Storage, Erection, Installation, Checkout, Testing, and Start-up of all non-PWPS supplied equipment and material. Services to dispose of waste generated on site.			C		Customer is responsible for scheduling all works on site and directing all craft.
374		Maintaining and Guarding all Facilities, Equipment, and Materials during construction			C		Including security fence
376		Site Organization During Construction			C		Including Resident Field Construction Manager.
378		Emissions and Acoustic Testing			C		
380		Worker's Compensation, Employer's Liability, or any other Local Insurance Required			C P		Each party will cover its personnel.
382		Consumable Material for Erection Works			C		As required
384		Construction Equipment, Tools and Aids			C		For PWPS Supplied equipment.
386		Required Tests Prior to Startup: Including but not limited to:			C		
388		* Resistance ratio and polarity tests			C		For PWPS Supplied equipment.
390		* All high voltage dielectric tests * Field check and calibration Protective Relay Calibration			C		For PWPS Supplied equipment.
392		Phasing and Synchronizing the Generator to Purchaser's system			C P		Interface between Genset & Grid.
394							
396	3	INTERFACE REQUIREMENTS AND RESPONSIBILITIES					
398		Site Facilities Motor Control Centers			C		Customer to provide power, potable water, fuel, service air.

Line No.	Item	Description	Quantity	Design	Supply	Erection	Notes
399		Natural Gas for Start-up, Testing and Operation 475 psig (33 bar), Approximately 4700 scfm (2.2 m3/sec) per gas turbine		C	C	C	Interface Point: Flange on PWPS Power Island. Per PWPS Natural Gas Fuel Specification FR-2. Fuel to be tested by a certified lab and the results provided to PWPS prior to start-up.
400		Injection Water for NOx Control 5-50 psig (0.3 - 3.4 bar), Approximately 36 gpm per gas turbine			C		Interface Point: Flange on PWPS Power Island. Per PWPS Specification AR-1. Water to be tested by a certified lab and the results provided to PWPS prior to start-up.
401		Potable Water for Gas Turbine Off-line Water Wash 30 -105 psig (2.1-7.3 bar). Flow rate is approximately 36 gpm (136 LPM).			C		Interface Point: Flange on PWPS Power Island. Per PWPS Potable Water Quality Specification
402		Control System Interface / Grid Signals			C P		PWPS and Customer to coordinate I/O interface between PWPS supplied equipment and Customer supplied equipment.
406		Liquid Fuel for Start-up Testing, and Operation 30-75 psig (2.0-5.1 bar), Approximately 36 gpm (136 l/min) per gas turbine			C		Interface Point: Flange on fuel storage tank. Per PWPS Liquid Fuel Specification FR-1. Fuel to be tested by a certified lab and the results provided to PWPS prior to start-up.
413		Vent and Drain. Maximum flow on Oily Waste drain is 35 GPM for water wash. Total waste water per wash is 300 gal.			C		Interface Point: Flange connection+I163+I145 on drain pipe on underside of PWPS Power Trailer.
416		High Voltage Power			C		Interface Point: Switchgear terminals on the control trailers.
419		Alternate Electrical Power Supply 255 kW per Power Island, 400V, 60 Hz, 3 phase for lighting, heating and intermittent auxiliaries			C		Interface Point: Manual transfer switch on control trailer.
422		Electrical ground grid interconnections. Grounding pads are provided by PWPS on each trailer and aux skid.			C		Customer to provide adequate ground grid and cable, lug, etc. required to make interconnection. Ref. Drawing 0719-123-E300D, Grounding, Field Electrical.
423							
424		4 OTHER RESPONSIBILITIES		C	C	C	The following list of items is provided for your convenience and gives examples of the types of equipment and/or services that are outside the PWPS Scope of work, and if required, are the sole responsibility of the Owner.
426		Site Survey/Plot Plan					
428		Excavation for Foundations, Pipes, Roads, Cabling & Grounding Grid					
430		Site Leveling					
432		Backfill					
434		Finish Grading					
438		Surface Drainage to and including any Collection Pond					
440		Oily Water Separator					
442		Sanitary Waste Disposal					
444		Plant Fire Protection Systems-Hydrants Panels and Extinguishers					Including Fire Protection during construction
446		Plant Lighting					
448		Intra-communication system					
450		Site Fencing and Gates					
452		Construction Water					
454		Builder's All Risk Insurance (BAR)					
460							
465							
470		<u>Options</u>					
480	1	One (1) year additional Warranty					