Solar® Turbines

A Caterpillar Company

Date: August 10, 2004

To: UTE

From: Don Murphy - Buenos Aries
Red Hart - Mabank

Subject: **Generator Set Condition Summary**

The following site survey report, conducted on the 10th and 11th of August 2004, covers the condition of the UTE owned Generator set, (SN TG 93585), currently installed for standby duty in Rivera, Uruguay.

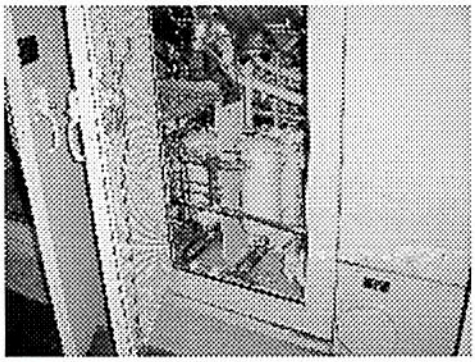
Condition of Existing Equipment

Although the unit is 10 years old and has not been upgraded since installation, it is has been well taken care of. The unit has been well maintained and is in good working order. The unit has 239 hours and has been started 173 times. There were no visible signs of deterioration. Although the controls system is of an outdated design, it is functional. The overall appearance of the unit is excellent.

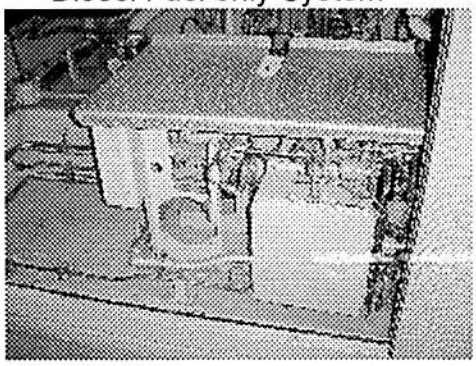
Equipment Configuration

The fuel system, (below right), is diesel fuel only and the fuel filters, (below left), are located on the skid. The low-pressure fuel pump is AC powered, (bottom right of door opening in the lower left picture).

On-skid fuel filters

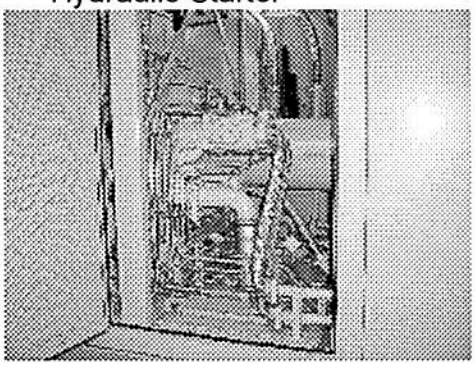


Diesel Fuel only System

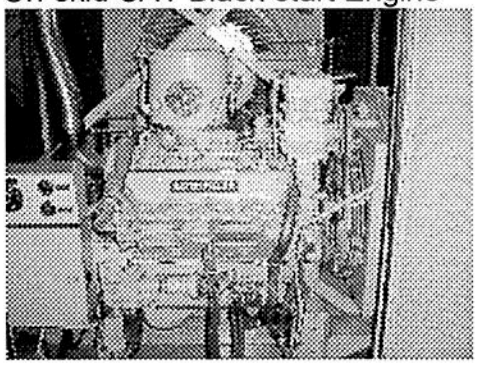


The starter, (below left), is hydraulic and driven by an on-skid caterpillar diesel engine, (below right).

Hydraulic Starter

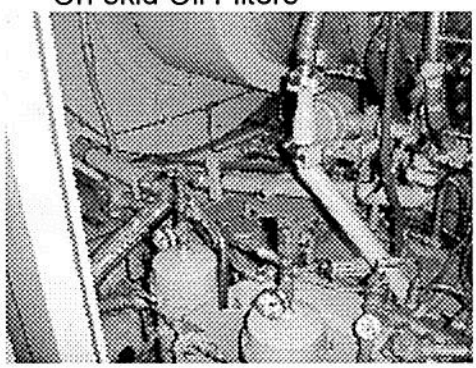


On-skid CAT Black-start Engine



The unit has two on-skid oil filters, (below left), and an AC Pre-post Lube Oil pump, (below right).

On-skid Oil Filters



Pre-post Lube Motor

Vibration Survey Taurus 60

Customer: UTE Uruguay. Location: UTE, Rivera, Uruguay.

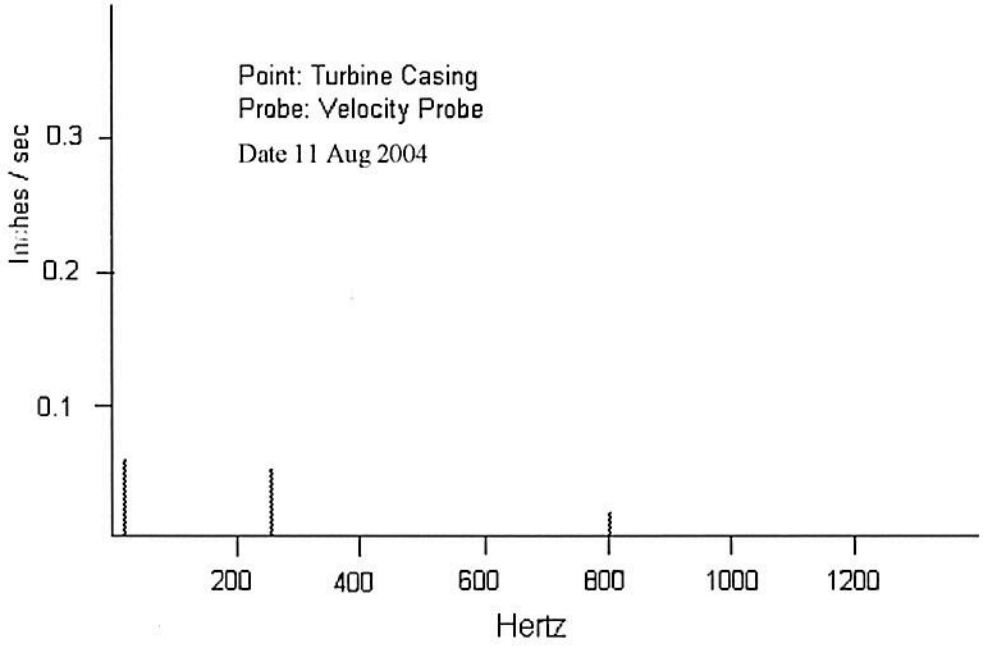
Date: 11 August 2004.

Equipment: CSI 2110 Analyzer.

Turbine Casing:

This data was taken using the velocity probe that is mounted on the turbine casing. The load on the generator was 3.8 mW at the time of the reading. Vibration level was steady throughout the test. While this information is not full load, no appreciable increase in vibration was noted while at full load. The overall reading on the control panel was 0.11 in / sec. This is a very low level of vibration for the turbine casing.

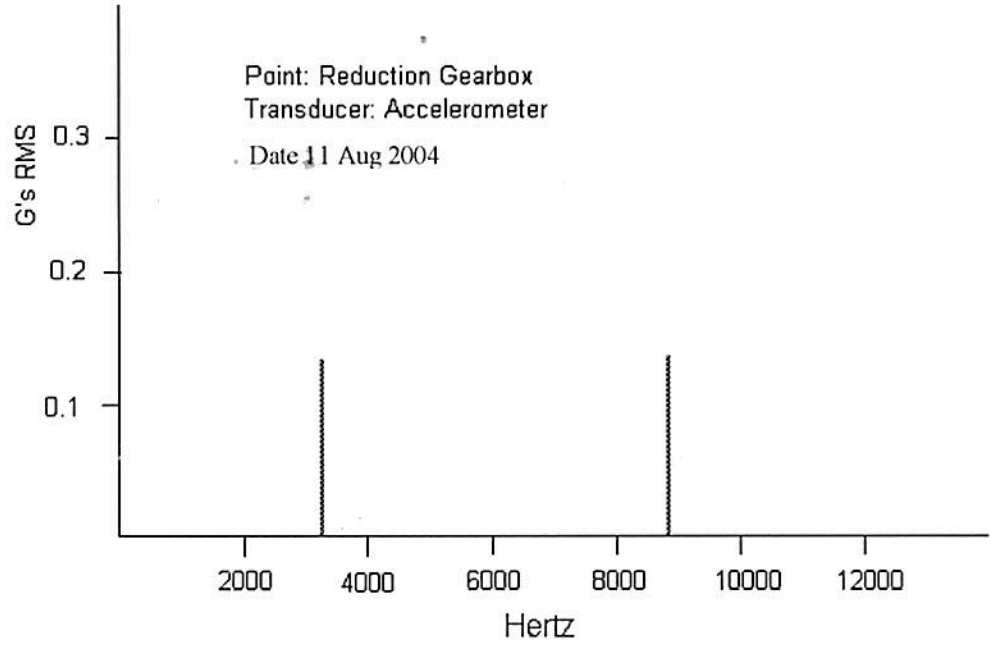
Freq in Hz	Amp in in / sec
20.18	0.06
248.9	0.05
807.1	0.03
Overall value	0.11 in / sec



Epicyclical Gearbox:

This data was taken using the accelerometer transducer that is mounted on the gearbox casing. The load on the generator was 3.8 mW at the time of the reading. Vibration level was steady throughout the test. The overall reading on the control panel was 0.2 g RMS. This is a very low level of vibration for the gearbox. The two frequencies that you would expect to see are listed below.

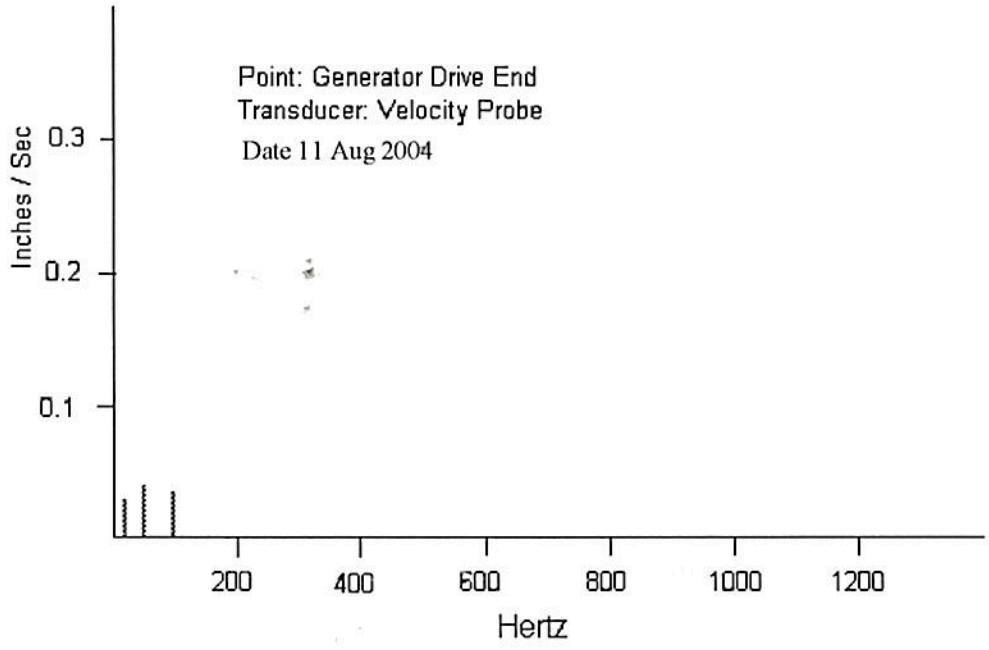
Freq in Hz	Amp in g RMS	
3124	0.06	Second stage reduction gear mesh frequency.
8710	0.05	First stage gear mesh frequence.
Overall value	0.2 g RMS	



Generator Drive End:

This data was taken using the velocity transducer that is mounted on the generator drive end bearing cap. The load on the generator was 3.8 mW at the time of the reading. Vibration level was steady throughout the test. The overall reading on the control panel was 0.05 in / sec. This is a very low level of vibration for the generator.

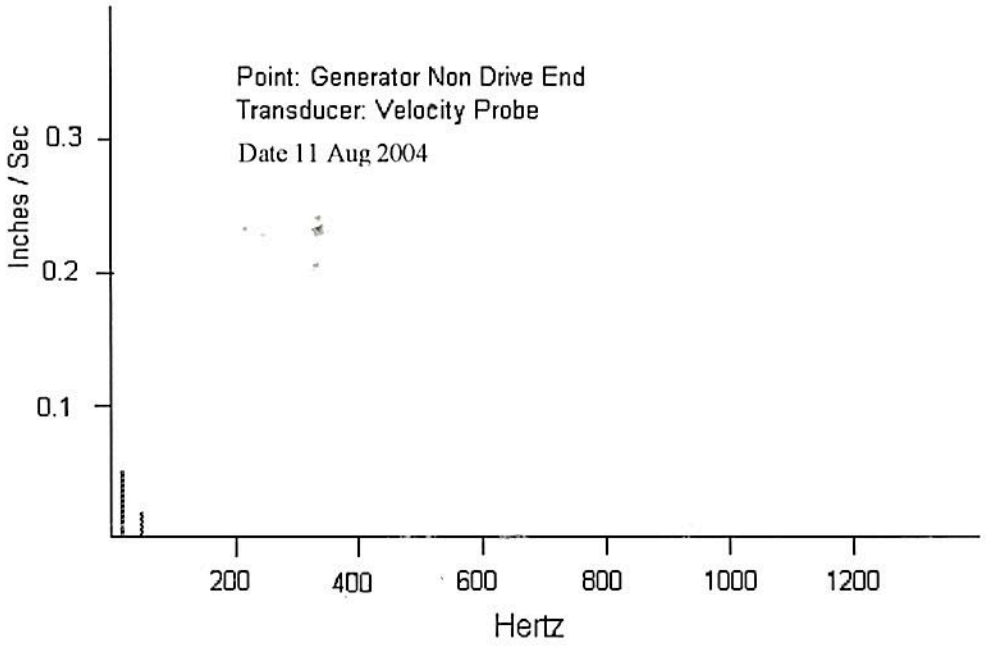
Freq in Hz	Amp in In / Sec	
25.02	0.03	Running speed of generator
50.01	0.04	
100	0.03	
Overall value 0.05 in / sec		



Generator Non Drive End:

This data was taken using the velocity transducer that is mounted on the generator drive end bearing cap. The load on the generator was 3.8 mW at the time of the reading. Vibration level was steady throughout the test. The overall reading on the control panel was 0.06 in / sec. This is a very low level of vibration for the generator.

Freq in Hz	Amp in In / Sec	
25	0.05	Running speed of generator
50.01	0.02	
Overall value 0.05 in / sec		



Turbine Performance

SOLAR TURBINES INCORPORATED
ENGINE PERFORMANCE CODE REV. 3.26
JOB ID:

DATE RUN: 17-Aug-04
RUN BY: Donald Murphy

TAURUS 60-6500
GSC
STANDARD
LIQUID
TT8-1 REV. 0.0
ES-2098

DATA FOR MINIMUM PERFORMANCE

Fuel Type		DIESEL 2-D
Specific Gravity of Fuel		0.850
Elevation	metres	200
Inlet Loss	mm H20	101.6
Exhaust Loss	mm H20	15.2
Engine Inlet Temp.	deg C	24.3
Relative Humidity	%	60.0
Elevation Loss	kW	93
Inlet Loss	kW	70
Exhaust Loss	kW	5
Specified Load*	kW	3827
Net Output Power*	kW	3827
Fuel Flow	kcal/sec IT	3426.37
Heat Rate*	kcal/kW-hr	3223
Therm Eff*	%	26.68
Inlet Air Flow	kg/hr	67460
Engine Exhaust Flow	kg/hr	69028
PCD	barG	9.2
Compensated PTIT	deg C	674
Exhaust Temperature	deg C	493

*NOTE: ELECTRIC POWER MEASURED AT THE GENERATOR TERMINALS

The intension of this test was to see if there was any major discrepancy in the performance of the turbine. The package instruments were used to measure the turbine parameters, so there has to be a certain amount of uncertainty as to the accuracy of the test. With this said the T5 temperature was within 1% of predicted and the PCD was with 1.5% of predicted. T7 was not available for the test. In general it can be said that the turbine's performance was as expected with the low number of running hours of this unit.

Product Support

Control System:

The table below shows the various control system architecture Solar have used over the years. The control system that is fitted to your unit is Turbotronic 2 1st generation. Solar has been able to provide service support using our stock of components, repairing or remanufacturing of hardware, and custom engineering, but the cost and risk of continuing this support model is no longer feasible. What this means is that Solar recommends that you should upgrade your control system to ensure that you will continue to be able to purchase parts, get support from engineering, be able to upgrade or up-rate your turbine.

System	Architecture	Production Span
Relay	Relay Based	Pre 1990
Turbotronic 1	Proprietary Systems	1985 –1988
Turbotronic 1.5	Proprietary + PLC 5	1986 –1990
Turbotronic 2 1st Generation	PLC 5/15 + 1771 I/O	1990 –1993
Turbotronic 2 2nd Generation	PLC 5/20, 30, 40 enhanced + 1771 I/O	1993 –1995
Turbotronic 3	PLC 5 CNet 1.25 + 1771 I/O	1995 –1996
Turbotronic 3 MX	PLC 5 CNet 1.25 + Flex I/O	1996 –2003
Turbotronic 4	Control Logix Processor and I/O	2003 - present

Vibration Protection:

The system you are using is the Bently Nevada 3300 system. This is a stand alone system, which does not communicate with the PLC. Solar have been informed recently by Bently Nevada that they are going to phase out the 3300 probe system. As time goes on it will become more and more difficult to purchase parts for this system.

Basler:

Many of the electronic components for the generator are manufactured by Basler. Similar to Bently Nevada as time goes on it will become more difficult to purchase parts or have parts repaired.

Turbine general:

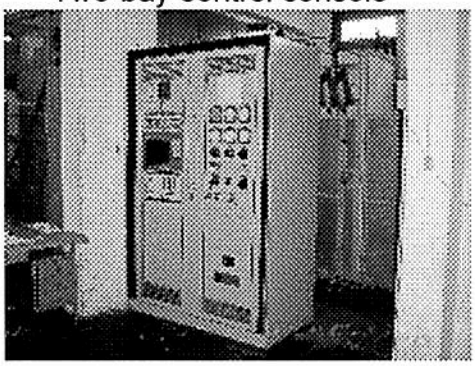
The T60 turbine is a relatively new turbine and will continue to be supported by Solar for a long time.

Supporting systems:

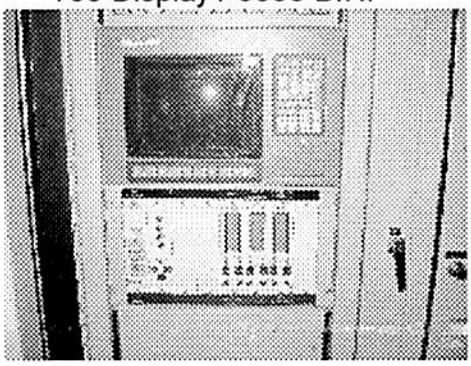
The turbine supporting systems such as the lube oil will continue to be supported. What may happen is that certain components may discontinue to be manufactured and a retrofit may be needed. An example of this is on the Saturn turbine we no longer support the hydraulic driven motor lube oil cooler. The only option for customers now is to move to an electric motor.

The control console is of a Non EP design in a two bay configuration. All components function properly. Only one of the meters is faded. The PLC 5 based controls are outdated, but function properly.

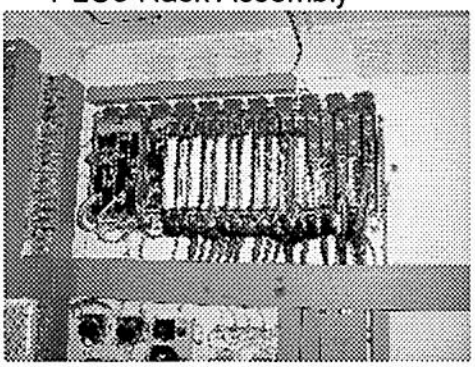
Two-bay control console



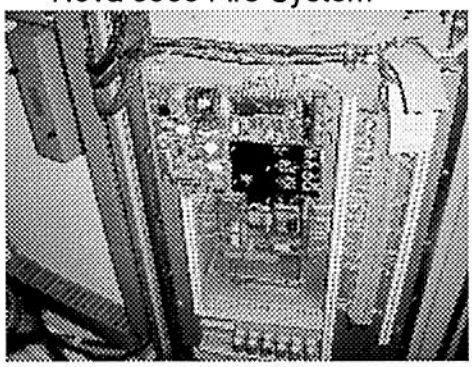
T36 Display / 3300 B.N.



PLC5 Rack Assembly

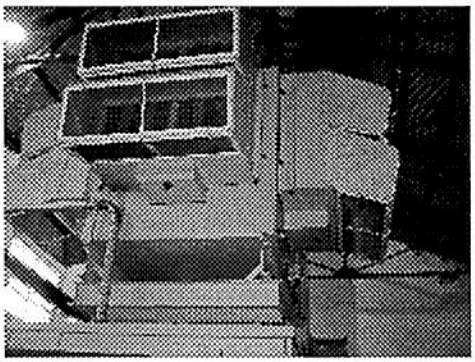


Nova 5000 Fire System

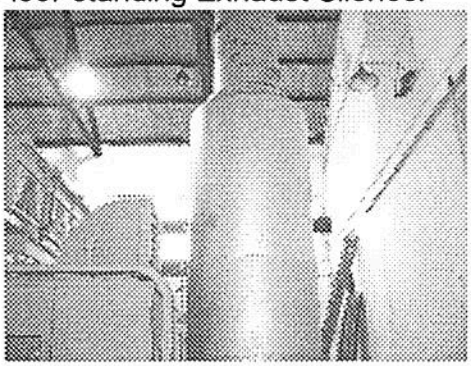


The Donaldson air inlet filter is mounted on an ancillary skid along with the atomizing air tank and the three oil coolers. The exhaust silencer is of a floor standing design and includes a heat shield around the bottom.

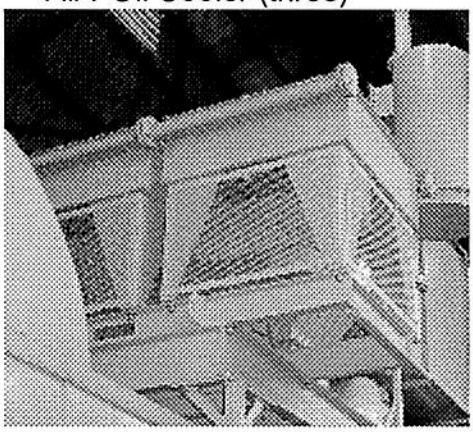
Donaldson air filter



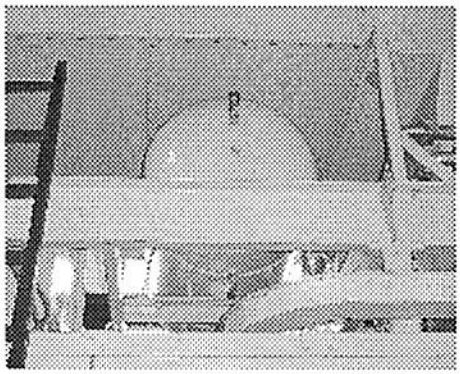
Floor-standing Exhaust Silencer



Air / Oil Cooler (three)



Fuel Atomizing Air Tank



The controls and DC lube pump are powered by a 24Vdc battery / charger system. The Diesel black-start motor uses a similar charger / battery system.

Controls / DC Lube and CAT Diesel Start Batteries and Chargers

The first stage Power Turbine blades, (above left & right), showed little wear.

The unit was run up and loaded to 3827 Kw for one hour. After one hour of operation at 3827 Kw, a vibration survey was performed. No abnormal vibration levels were observed. The unit synchronized in automatic mode with no problems.

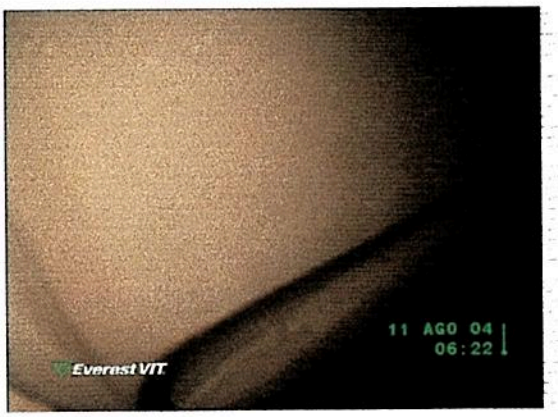
The equipment in general functions well, with all systems functioning correctly. We did have some difficulty starting the unit, as the air assist pressure was low. All the instrumentation functioned although I would say that they could do with being calibrated. There were no sign of any oil leaks although there was an air leak from under the exhaust blanket. The package is kept in a very clean condition and I would say even though it is not used very much it is looked after.

The control system is kept energized at all times, which is good as this keeps the oil temperature at pre-start temperature preventing moisture and condensation risks. It also means that the pre-post pump will occasionally circulate oil through the system keeping gears and bearings coated with lube oil. The customer stated that the lube oil is occasionally tested to ensure it has not degraded.

The enclosure and supporting structure is in immaculate condition. This is because the customer has looked after the equipment and because the turbine is in an enclosure and the enclosure is housed in a large building.

A local engineering company provided a bore-scope in order to inspect the turbine engine. See below pictures for details.

The final stage nozzles, (above left), and blades, (above right), of the Gas Producer showed virtually no signs of wear.



The diffuser looked good and the first stage Power Turbine nozzle leading edges, (above left), and, (trailing edges), showed very little signs of wear.