DNV·GL

Certificate No:
TAM00000R8

TYPE APPROVAL CERTIFICATE

This is to certify:

That the Gas Turbine

with type designation(s)
Centaur 40 & Centaur 50

Issued to
Solar Turbines Incorporated
San Diego CA, United States

is found to comply with
DNV GL rules for classification – Ships
DNV GL rules for classification – High speed and light craft
DNVGL-OS-E201 – Oil and gas processing systems, Edition July 2015
DNVGL-OS-D101 – Marine and machinery systems and equipment, Edition July 2015

Application :

Product(s) approved by this certificate is/are accepted for installation on all vessels classed by DNV GL.

Issued at **Houston** on **2018-02-21**
This Certificate is valid until **2023-02-20**.
DNV GL local station: **Long Beach**

Approval Engineer: **Srujanbabu Sridharala**

for **DNV GL**

Meindert van Mierlo
Head of Section

This Certificate is subject to terms and conditions overleaf. Any significant change in design or construction may render this Certificate invalid.
The validity date relates to the Type Approval Certificate and not to the approval of equipment/systems installed.

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Product description

Centaur 40- Single shaft with Conventional combustor	40-4701
Centaur 40- Single shaft with SoLoNox combustor	40-4701S
Centaur 40- Dual shaft with Conventional combustor	40-4702
Centaur 40- Dual shaft with SoLoNox combustor	40-4702S
Centaur 50- Single shaft with Conventional combustor	50-6201
Centaur 50- Single shaft with SoLoNox combustor	50-6201S
Centaur 50- Dual shaft with Conventional combustor	50-6102, 50-6202
Centaur 50- Dual shaft with SoLoNox combustor	50-6102S, 50-6202S

Application/Limitation

The Gas Turbine is Approved for the following nominal continuous rating (at ISO reference conditions1), no losses):

	Centaur 40		Centaur 50		
Natural Gas	**4702/4702S**	**4701/4701S**	**6102/6102S**	**6202/6202S**	**6201/6201S**
Gas Producer Speed(rpm)	14,964	14,950	14970	14967	14951
Power Turbine Speed max(rpm)	15,500	N/A	16500	N/A	N/A
Output Shaft Power(GS)(kWe*)	-	3515	-	-	4771
Output Shaft Power(CS/MD)(kW)	3490	-	4569	4680	-
Mass flow(kg/sec)	18.9	19.0	18.82	18.58	19.08
Compressor discharge pressure(bar)	9.2	9.1	9.58	9.53	9.60
T-5 Temperature (°C)	616	619	755	721	680

	Centaur 40		Centaur 50		
Diesel Fuel	**4702/4702S**	**4701/4701S**	**6102/6102S**	**6202/6202S**	**6201/6201S**
Gas Producer Speed(rpm)	14,808	14,950	14812	14793	14951
Power Turbine Speed max(rpm)	15,500	N/A	16500	N/A	N/A
Output Shaft Power(GS)(kWe*)	-	3438	-	-	4690
Output Shaft Power(CS/MD)(kW)	3383	-	4412	4514	-
Mass flow(kg/sec)	18.7	19.0	18.63	18.39	19.11
Compressor discharge pressure(bar)	9.1	9.1	9.4	9.35	9.58
T-5 Temperature (°C)	616	619	754	721	680

* output at generator terminals. Gear box efficiency 96%, Generator efficiency 96%

1) Ambient reference conditions corresponding to ISO standards are:
Ambient Pressure = 1.013 BAR Ambient Temperature = 15 Deg. C Relative Humidity = 60%

Application Constraints :Centaur 40(single and dual shaft)

Application Max. allowable	Conventional						SoLoNOx					
	List	Forward Trim	Aft Trim	Pitch forward	Pitch Aft	Roll	List	Forward Trim	Aft Trim	Pitch forward	Pitch Aft	Roll
with bearing scavenging	NA	NA	NA	NA	NA	NA	22.5°	13°	5°	13°	4°	30°
without bearing scavenging	22.5°	14°	4°	14°	4°	30°	22.5°	13°	4°	13°	4°	30°
Max. allowable acceleration loads	Axial		Vertical		Lateral		Axial		Vertical		Lateral	
	10g		6g		3g		10g		6g		3g	

Application Constraints :Centaur 50(single and dual shaft)

Application Max. allowable	Conventional						SoLoNOx					
	List	Forward Trim	Aft Trim	Pitch forward	Pitch Aft	Roll	List	Forward Trim	Aft Trim	Pitch forward	Pitch Aft	Roll
with bearing scavenging	22.5°	13°	5°	13°	7.5°	30°	22.5°	13°	5°	13°	7.5°	30°
without bearing scavenging	22.5°	13°	4°	13°	4°	30°	22.5°	13°	4°	13°	4°	30°
Max. allowable acceleration loads	Axial		Vertical		Lateral		Axial		Vertical		Lateral	
	10g		6g		3g		10g		6g		3g	

The above angular limits are valid for a gas turbine mounted in the direction of the vessel's longitudinal axis with no inclination relative to the vessel's horizontal plane.

*) Forward trim is defined as a static downward inclination of engine's air inlet end, and aft trim is defined as a static downward inclination of the engine's exhaust end.

**) Bearing scavenging is not available with conventional combustion Centaur 40 engines.

Fuel type designation
Gaseous or Liquid fuel per Solar specification ES9-98

Max allowable salt content in inlet air(wppm)
The total sodium plus potassium level must be less than 0.01 ppmw Fuel Equivalent Concentration (FEC) per Solar Fuel, Air and Water specification ES9-98.

Type Approval documentation

Clause for certification

1. Gas turbines using gas as fuel should be fitted in gas-tight enclosures which are arranged in accordance with the requirements for ESD(emergency shut down) protected machinery spaces as per DNVGL rules for ships Part 6 Chapter 2 Section 5:10.2.21.
2. Gas turbines requiring a gas supply with pressures above 10bar, gas piping shall be protected with a secondary enclosure in accordance with the requirements in 5.1.5 of DNVGL rules for ships Part 6 Chapter2 Section 5:10.2.2.2.
3. All changes of components in the Gas flow path are to be forwarded to DNVGL for evaluation and approval prior to use in certified turbines
4. Operational hours submitted by SOLAR were acknowledged.
5. Only the gas turbine core engine is covered by this Type Approval. All other components delivered as part of the normal package are specifically excluded.
6. Gas turbine skin temperature is not to exceed 74°C for offshore applications and 220°C for Ship rules application. Where the application of insulation is not practical an enclosure is to be fitted.
7. This Type Approval replaces the Offshore Type Approval Certificate number TAM0000044(Centaur 40) and M-12462(Centaur 50).

The following is not covered by this Type Approval and compliance with relevant standard/rules must be documented for each application:

1. The control and monitoring system (software and hardware)
2. Gas turbine installation & arrangement (fire and safety system, mounting, ducting, ventilation and insulation)

Marking of product

The product is to be marked with manufacturer's name and trade mark and type number identification

Certificate Retention Survey

For retention of the Type Approval, a DNV GL surveyor shall perform an assessment after 2 years and after 3.5 years, both referring to the issue date of the Type Approval Certificate to verify that the conditions of the Type Approval are complied with. A renewal assessment will be performed at renewal of the certificate.

In cases where the Type Approved product is manufactured at other companies, the Periodical Assessment shall verify that the Type Approval applicant has a quality control system for consistent production at their licensees/subcontractors. Furthermore, periodical Assessment shall be carried out randomly at these companies.

END OF CERTIFICATE