DNV·GL

Certificate No:
TAM00000RA

TYPE APPROVAL CERTIFICATE

This is to certify:

That the Gas Turbine

with type designation(s)
Titan 130 and Titan 250

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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Job Id: **262.1-027127-1**
Certificate No: **TAM00000RA**

Product description

Titan 130-Single shaft turbine(Cold End Drive) with Conventional combustor	130-20501	130-22401
Titan 130-Single shaft turbine(Cold End Drive) with Solonox combustor	130-20501S	130-22401S
Titan 130-Dual shaft turbine(Hot End Drive) with Conventional combustor	130-20502	130 -22402
Titan 130-Dual shaft turbine(Hot End Drive) with Solonox combustor	130-20502S	130 -22402S
Titan 250-Dual shaft turbine, Conventional combustor	-	250-30002
Titan 250-Dual shaft turbine, Solonox combustor	-	250-30002S

Application/Limitation

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

Titan 130	**Dual Shaft**		**Single Shaft**				
	- 22402	**- 20502**		**- 22401**		**- 20501**	
Natural Gas			**Exhaust**	**Axial**	**Radial**	**Axial**	**Radial**
Gas Producer Speed	11220 rpm	11220 rpm	60Hz 50Hz	11170 rpm 11197 rpm	11170 rpm 11197 rpm	11170 rpm 11197 rpm	11170 rpm 11197 rpm
Power Turbine Speed max	8856 rpm	8856 rpm		N/A	N/A	N/A	N/A
Output Shaft Power	16369 kW	15287 kW		16450 kWe*	15956.3 kWe*	15000 kWe*	15000 kWe*
Mass flow	54.79 kg/sec	49.3 kg/sec		53.88 kg/sec	53.88 kg/sec	49.1 kg/sec	49.1 kg/sec
Compressor discharge press.	18.3 bar	16.3 bar		18.2 bar	18.2 bar	16.3 bar	16.3 bar
TRIT	1182.2°C	1176.7°C		1182.8°C	1182.8°C	1176.7°C	1176.7°C
T-5 Temperature	753.7 °C	768 °C		749.8°C	749.8°C	732.7°C	732.7°C

Titan 130	**Dual Shaft**		**Single Shaft**				
	-22402	**- 20502**		**- 22401**		**- 20501**	
Diesel Fuel			**Exhaust**	**Axial**	**Radial**	**Axial**	**Radial**
Gas Producer Speed	11 009 rpm	11 008 rpm	60Hz 50Hz	11170 rpm 11197 rpm	11170 rpm 11197 rpm	11170 rpm	11170 rpm
Power Turbine Speed max	8856 rpm	8 856 rpm		N/A	N/A	N/A	N/A
Output Shaft Power	15444.6	13886 kW		15228.1 kWe*	14771.9 kWe*	13846 kWe*	13 431 kWe*
Mass flow	53.89	47.56 kg/sec		53.89 kg/sec	53.89 kg/sec	49.08 kg/sec	49.08 kg/sec
Compressor discharge press.	17.9 bar	15.4 bar		17.9 bar	17.9 bar	16.0 bar	16.0 bar
TRIT	1154.4	1148.9°C		1154.4°C	1154.4°C	1149°C	1149°C
T-5 Temperature	732.8	748.3°C		729°C	729°C	712.7°C	712.7°C

Titan 250 (Dual Shaft)	**CS/MD**	**Generator Sets**	
	-30002S	**- 30002S**	**- 30002S**
Natural Gas		**60Hz**	**50Hz**
Gas Producer Speed	10500 rpm	10500 rpm	10500 rpm
Power Turbine Speed max	7000 rpm	6993 rpm	6959 rpm
Output Shaft Power	22391kW	21745 kWe*	21745 kWe*

Mass flow	4030 kg/sec	4030 kg/sec	4030 kg/sec
Compressor discharge press.	22.7 bar	22.7 bar	22.7 bar
TRIT	1203°C	1203°C	1203°C
T-5 Temperature	764°C	764°C	764°C

* 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 :Titan 130

Application Max. allowable	Single Shaft						Dual Shaft					
	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°	22.5°	22.5°	22.5°	22.5°	22.5°	22.5°	12°	18°	12°	18°	22.5°
without bearing scavenging	22.5°	12°	6°	12°	6°	22.5°	22.5°	12°	6°	12°	6°	22.5°
Max. allowable acceleration loads	Axial		Vertical		Lateral		Axial		Vertical		Lateral	
	10g		6g		3g		10g		6g		3g	

Application Constraints :Titan 250

Application Max. allowable	Dual Shaft					
	List	Forward Trim	Aft Trim	Pitch forward	Pitch Aft	Roll
with bearing scavenging	22.5°	10°	15°	10°	15°	22.5°
without bearing scavenging	22.5°	10°	5°	10°	5°	22.5°
Max. allowable acceleration loads	Axial		Vertical		Lateral	
	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.

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 TAM00000FH(Titan 130 ship rules), M-12453(Titan 130 offshore rules) and M-12574(Titan 250 offshore rules).

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