DNV·GL

Certificate No:
TAM00000MD

TYPE APPROVAL CERTIFICATE

This is to certify:

That the Gas Turbine

with type designation(s)
Taurus 60 & Taurus 70

Issued to
Solar Turbines Incorporated
San Diego CA, USA

is found to comply with
DNV GL rules for classification – Ships
DNV GL rules for classification – High speed and light craft
DNV's Offshore Standard DNV-OS-D101 "Marine and Machinery Systems and Equipment"
DNV-OS-E201 "Oil and Gas Processing Systems" October 2010

Application :

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

Issued at **Houston** on **2018-03-02**
This Certificate is valid until **2023-03-01**.
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: **262.1-025093-1**
Certificate No: **TAM00000MD**

Product description

Taurus 60 - Single shaft with Conventional combustor	60-7801, 60-7901
Taurus 60 - Single shaft with Solonox combustor	60-7801, 60-7901
Taurus 60 - Dual shaft with Conventional combustor	60M-7302, 60-7802, 60-7902
Taurus 60 - Dual shaft with Solonox combustor	60-7802, 60-7902
Taurus 70 - Single shaft turbine (Cold End Drive) with Conventional combustor	70-10801
Taurus 70 - Single shaft turbine (Cold End Drive) with Solonox combustor	70-10801S
Taurus 70 - Dual shaft turbine (Hot End Drive) with Conventional combustor	70-10802
Taurus 70 - Dual shaft turbine (Hot End Drive) with Solonox combustor	70-10802S

Application/Limitation

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

	Taurus 60
	- 7302
Diesel Fuel	
Gas Producer Speed	14857rpm
Power Turbine Speed max	12986rpm
Mass flow	21.0 kg/sec
Compressor discharge press.	10.87 bar
T-5 Temperature	709°C

	Taurus 60	**Taurus 60**	
	Dual Shaft	**Single Shaft**	
	7802/7802S	**7801/7801S**	**7901/7901S**
Natural Gas			
Gas Producer Speed	15000rpm	14951 rpm	14951 rpm
Power Turbine Speed max	13947rpm	N/A	N/A
Output Shaft Power	5740 kW	5500 kWe*	5670 kWe*
Mass flow	21.4 kg/sec	21.6 kg/sec	21.5 kg/sec
Compressor discharge press.	11.27 bar	11.43 bar	11.2 bar
T-5 Temperature	741°C	706°C	710°C

	Taurus 60	**Taurus 60**	
	Dual Shaft	**Single Shaft**	
	7802/7802S	**7801/7801S**	**7901/7901S**
Diesel Fuel			
Gas Producer Speed	14886rpm	14951 rpm	14951 rpm
Power Turbine Speed max	13860rpm	N/A	N/A
Output Shaft Power	5570 kW	5368 kWe*	5513 kWe*
Mass flow	21.1 kg/sec	21.6 kg/sec	21.5 kg/sec
Compressor discharge press.	11.11 bar	11.37 bar	11.3 bar
T-5 Temperature	741°C	706°C	710°C

	Taurus 70		**Taurus 70**				
	Dual Shaft		**Single Shaft**				
	- 10802	**- 10802S**		**- 10801**		**- 10801S**	
Natural Gas			**Exhaust**	**Axial**	**Radial**	**Axial**	**Radial**
Gas Producer Speed	15200rpm	15200rpm	60Hz	15158rp	15158rpm	15158 rpm	15158 rpm

				m			
Power Turbine Speed max	11030rpm	11690rpm		N/A	N/A	N/A	N/A
Output Shaft Power	7844 kW	8100 kW		7770 kWe*	7540kWe*	7965 kWe*	7726 kWe*
Mass flow	27.0 kg/sec	27.1 kg/sec		27.1 kg/sec	27.1kg/sec	26.9kg/sec	26.9kg/sec
Compressor discharge press.	16.0 bar	16.5 bar		16.7 bar	16.7 bar	16.7 bar	16.7 bar
TRIT	1149°C	1177°C		1149°C	1149°C	1177°C	1177°C
T-5 Temperature	758 °C	769 °C		718°C	718°C	737°C	737°C

	Taurus 70				
	Single Shaft				
		- 10801		**- 10801S**	
Diesel Fuel	**Exhaust**	**Axial**	**Radial**	**Axial**	**Radial**
Gas Producer Speed	60Hz	15158rpm	15158 rpm	15158 rpm	15158 rpm
Power Turbine Speed max		N/A	N/A	N/A	N/A
Output Shaft Power		7560kWe*	7330 kWe*	7410 kWe*	7190 kWe*
Mass flow		27.15 kg/sec	27.15 kg/sec	26.9kg/sec	26.9 kg/sec
Compressor discharge press.		16.6 bar	16.6 bar	16.4 bar	16.4 bar
TRIT		1149°C	1149°C	1177°C	1177°C
T-5 Temperature		718°C	718°C	718°C	718°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 :Taurus 60

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°	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	

Application Constraints :Taurus 70

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°	15°	22.5°	22.5°	22.5°	22.5°	22.5°	15°	22.5°	22.5°	22.5°	22.5°
without bearing scavenging	5°	4°	5°	6°	6°	4°	5°	4°	5°	6°	6°	4°
Max. allowable acceleratio n 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.

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 TAM00000DD(Taurus 60 ship rules), TAM0000045(Taurus 60 offshore rules) and TAM0000046(Taurus 70 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