Publication: T1-685
Issued: July 28, 2015

INSTALLATION AND OPERATING MANUAL

P/N: T106-60006-MSR-1-40

MODEL: T100-MS
*TURBO**TWIN*** Gas Turbine Engine
Air Starter

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1.0 GENERAL INFORMATION

Instructions for installation, operation and maintenance of TDI ***TURBOTWIN***™ **Model T100-MS *Air Starter.*** These are suitable for use on a variety of Solar Turbine Engine applications including the Centaur & Taurus. T100-MS starter motor assemblies are used only in *single starter applications*.

Review this manual before installing or operating T100MS Model Air Starters. Questions? Contact your Authorized TDI Distributor, OEM or TDI directly.

WARNINGS, CAUTIONS AND NOTES

Certain types of information are highlighted in this manual for your attention:

WARNINGS: - used where NON-COMPLIANCE will likely result in injury to personnel or damage to the equipment.

CAUTIONS: - used where there is possibility of damage to the equipment.

NOTES/IMPORTANT: - used to point out special interest information or "optimum" use scenarios.

1.1 DESCRIPTION & NEW FEATURES

T100-MS air starters are extensively upgraded versions of previous T100M model. The **"S"** character (within in the new model nomenclature) designates the incorporation of many modifications and new product features including:

- Wet-sump (***S****plash*) Oil Lubrication of planetary gear set & drive end bearings.
- Sealed (Vent-less) Gearbox w/Sight Glass for easy oil level maintenance.
- Higher (ABEC) Spec Turbine Bearings.
- Higher Spec Double-lip Shaft Seals.
- Nitride Treated planetary ring gear.
- Higher precision Dynamically Balanced Rotors.
- New Labyrinth-Type Primary Seal.
- Proprietary Gearbox Venting System
- Balanced Pressure Venting of aft seal/bearing

NOTE

THIS STARTER IS TO BE SERVICED ONLY BY AUTHORIZED TDI TURBOTWIN™ DISTRIBUTORS, DEALERS, AND REPAIR STATIONS. DO NOT OPERATE THIS STARTER UNLESS IT IS PROPERLY ATTACHED TO AN ENGINE.

NOTE

External dimensions of new T100-MS starter motors are near identical to previous T100-M starter. **However, previous TDI starter models cannot be economically upgraded** to incorporate the many additional features found in the newer models

- ***TURBOTWIN*** Upgrades can be easily installed, generally without inlet/exhaust piping changes.
- All ***TURBOTWIN*** motors are designed for operation on either compressed air or on natural
- ***TURBOTWIN*** materials are compatible with "sour" natural gas and marine environments.
- ***TURBOTWIN*** T100MS starters are ATEX certified.
- As with all ***TURBOTWIN*** turbine motors*, mist or injection type lubrication of the air/gas supply* is NOT required. (remove external lubricators).

NOTE

Throughout this manual, the term "air" is used to designate the motor drive medium. Unless other wise stated, "air" means either compressed air or natural gas.

1.2 BASIC OPERATION

TURBOTWIN **T100-MS** air starters is a simple turbine driven, *gear reduced* air motors, with the following key differences vs. other types of motors commonly used in related applications:

- *Unlike* electric motors, power output and operating speeds correspond (and vary widely) depending on the dynamic operating pressures supplied to the motor inlet and the load imposed. (see performance data).
- *Unlike* vane-type or rotary screw-type (positive displacement) motors, *turbine type* air motors, if unloaded/under loaded will operate at much higher free-speeds.
- Turbine type motors must be properly *selected* and *regulated t*o operate efficiently, at a required loaded speed, rather than over a wide range of inlet supply pressures.

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The basic operation of the motor is as follows: Pressurized air or natural gas is admitted to the motor via the inlet port. The air expands through the two-stage turbine, which produces shaft rotation and motor output.

Upon a successful engine start (or cycle), turn the air off to the motor immediately. Minimizing the time the motor is operating, especially unloaded, will maximize motor life

IMPORTANT

To attain maximum product life, it is important to properly match the motor inlet supply pressure, output and motor speed to required load.

- Attain (regulate) starter to the lowest possible supply pressure required to start the engine. Minimizing starter back pressure will extend the life of air motor. Back pressure should not exceed 15 psig.

1.3 PRODUCT IDENTIFICATION

The identification nameplate(s) attached to motor housing should indicate the following information:

- Model designation
- P/Ns(OEM &/or aftermarket p/ns may be present)
- Serial Number (date of manufacture)
- Maximum Operating (Inlet) Supply Pressure
- Direction of Rotation

NOTE

Direction of Rotation is either left hand (LH) rotation (CCW) or right hand (RH) rotation (CW) viewed looking into the output (shaft) end of the motor.

CAUTION

Exceeding the *Maximum Operating Pressure* rating shown on starter nameplate may result in damage to the motor or damage to the driven equipment.

NOTE

Maximum Operating Pressure is indicated on the nameplate. This can (should) be measured at the pressure check port below starter inlet port, and *dynamically* (while the motor is in operation).

IMPORTANT

Optimum (correct) *Maximum Operating Pressure* is not necessarily the dynamic motor supply pressure recommended for *your* application. Starter supply pressure regulation, by application, has been proven to maximize the service life and reliability of the starter(s) in most all applications. (See section 1.2)

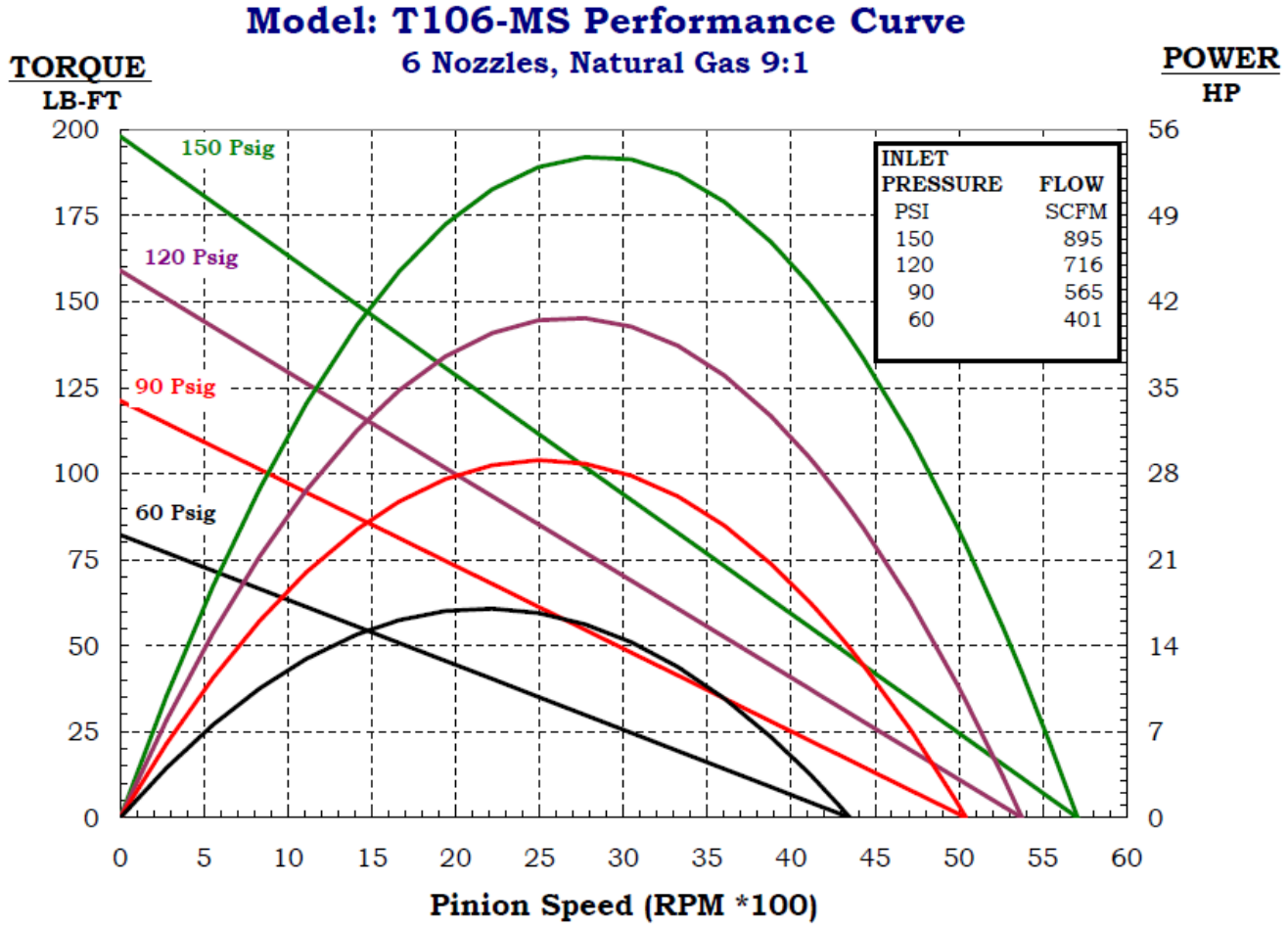
NOTE

Proof Pressure, if shown on the nameplate, indicates the maximum static pressure rating at which starter turbine motor housing(s) will not burst in operation.

1.4 STARTER MOTOR OUTPUT AND PERFORMANCE

Please refer to specific Performance Graphs of the model being applied which illustrate:

- *Starter Output* (shaft HP/Torque) over range of *dynamic* supply pressures, 0 RPM (stall) to maximum free speed.
- *Air Consumption Rates* over range of *dynamic* supply pressures (consumption is constant at *dynamic* inlet pressures indicated on performance charts).
- Starter output & operating speed vary considerably on DIFFERENT drive mediums (e.g. air vs. methane gas).
- On methane gas, starter produces significantly more HP, at higher speeds, so inlet supply pressures may need to be reduced (regulated) to prevent excessive engine cranking speeds (flame out).
- In all cases, indicated performance assumes exhaust routed to a safe location, through system & piping that **minimizes back pressure not to exceed 15 psig.**



2.0 INSTALLING THE MOTOR

- TDI T100-MS starters feature a turbine type air motor that does not require lubrication in the supply air. ***This is a separate consideration from the lubrication of the starter motor gearbox,*** **a discrete oil sump which requires oil maintenance (oil fill, checks & changes).**

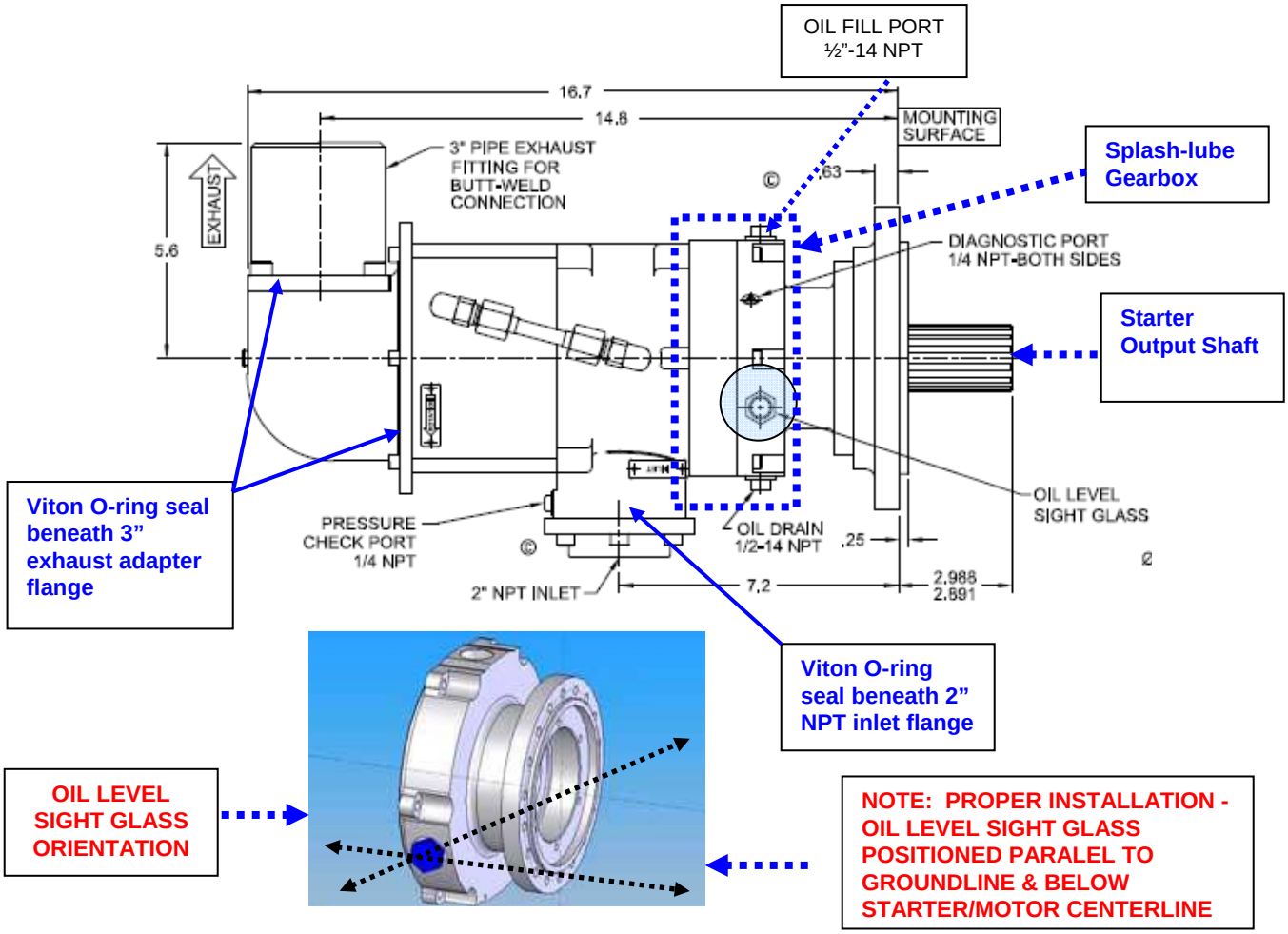
- If a vane-type starter motor is being replaced by a TDI turbine type starter, TDI recommends removal of in-line/mist type lubricators to minimize their inherent flow restriction to the starter and eliminate this maintenance item.

CAUTION

All T100-MS/CS motors should be installed with the inlet either straight down (6 o'clock or 180 degrees) or straight up (0 degrees or 12 o'clock). **In all cases, orientation of gearbox sight glass must be just below the motor/starter centerline,** to insure proper indication/maintenance of gearbox oil level (**see section 2.1**).

2.1 PROPER INSTALLATION, ORIENTATION & OIL LEVEL MAINTNENACE

Motor/Starter Gearbox must be filled w/ (150ML) of Approved Oil Type & Level Maintained**



**** Oil Type Recommended: Spec MIL-L-7808H, MIL-L-23699 (or equivalent synthetic grade turbine oil)**

NOTE
TDI recommends synthetic grade oil (turbine oil) is used in the starter gearbox sump. Use of either improper synthetic or mineral based oils may compromise unit service life, manufacturer's warranty, and will increase the frequency of maintenance intervals required.

WARNING
Do not operate this starter unless gearbox has been filled to the proper oil level and maintained at this level.

WARNING
Do not operate this starter unless it is properly connected to an engine or load (see below).

2.2 SUPPLY LINE & EXHAUST LINE INSTALLATION

WARNING
Be sure to either bleed the pressurized air reservoir and/or safety the system such as closing all air/gas supply valves, prior to installing motor or a new supply line.

T100 TURBOTWIN T100-MS starter motors come standard with a 2" NPT female pipe thread adapter for the inlet connection port & various 3" exhaust adapters. Various flange or thread adapters may be utilized at these joints. Supplied adapters are sealed to the motor housing with Viton O-rings (see section 2.1). Hard piping may be used on supply/exhaust lines. A section of flexible tubing may also be use/installed at the starter inlet/outlet, to prevent leaks or wobble out due to vibration.

The supply line consists of the line from the air/gas supply source (via a pressure regulator when necessary) through filters, manual and/or automatic relay valves, to the starter inlet.

The exhaust line consists of the line from the motor exhaust to a "safe" location. Turbine exhaust (air) is typically plumbed away from the engine area.

Both supply & exhaust lines and components should be dry-fitted for proper alignment /location, prior to final assembly.

All pipe threaded joints should be sealed with Loctite Pipe Thread Sealant (TDI P/N 9-94085) or equivalent, for leak tight joints prior to final assembly. Be sure to tighten all joints to proper torque after final assembly.

The installation of the motor using natural gas is similar to the air installation except all fittings, piping, valves and regulators must be compatible with natural gas.

WARNING
When using natural (or combustible) supply gas (e.g. methane gas) must be piped to a safe location, routed and terminated according to industry codes and local regulations.

NOTE
If the supply line is longer than 40 feet, the line piping size may need to be increased to 2" diameter, to minimize dynamic flow losses through piping and ensure specified output. Similarly, if exhaust piping is longer than 40 ft. in length, it may be necessary to increase its diameter from 3" to 4" to minimize motor exhaust back pressure and insure specified output.

On T115-MS applications, valves or regulators on the supply side, having a **Cv of 40** or higher, are recommended for starter having 15 nozzles (T115-MS) Care must be taken to insure all inlet supply line piping & components are capable of passing the required air flow needed to produce specified power levels (motor output).

- See motor performance chart for specific flow rates.

WARNING
Be sure that any/all piping &/or tubing used, meets applicable requirements and that no leaks are present following line installation or thereafter.

CAUTION
Although the light weight of these motors is easily supported by their mounting flange designs, TDI recommends properly bracing all rigid piping attached to the motors… to eliminate axial strain on motor & motor mounting flanges. High axial loads ("over-hung bending") will greatly reduce motor life.

CAUTION
There is often weld slag, grindings, thread shavings, hardened compounds and other heavy debris in new package piping & at new site installations. Therefore, at commissioning (before running motors), TDI recommends a "blow-down" procedure to purge motor supply lines of all hard debris that may otherwise damage the motor severely. While ***T100 TURBOTWIN*** motors are highly tolerant of contamination in the air/gas supply, motor life can be greatly increased by using a coarse mesh strainer. At sites where dirty supply air/gas is present, use & maintenance of a #40 mesh Y-strainer, upstream of the motors, is highly recommended.

NOTE
Expensive moisture abatement (air/gas drying) is not required, as this has no effect on the motors.

2.3 MOTOR CONTROLS

A preferred motor supply control valve is typically a pilot-operated type, which can be pneumatically or electrically actuated. The valve should be located relatively close to the motor inlet, to prevent motor over-running at the end of the cycle (especially on starter applications).

CAUTION
Proper supply pressure "matching" and over-speed control is highly recommended on all installations of Models T100MS (See section 2.5)

Do not use supply pressure indications only as a method to properly set the motors' supply pressure. A pressure regulator is required, where dynamic air/gas motor supply pressure is great enough to exceed the motor operating pressure (at the inlet port) **and/or where a "default" supply pressure would produce motor output speeds beyond what is specified for the application. (Result is over-speed, not necessarily an indicated over-pressure). Both over-pressure & over-speed will reduce life of the motor & wastes supply air/gas (increases operating costs).**

2.4 INLET PRESSURE CHECK PORT (checking dynamic operating pressures)

A 1/4" NPT port is located on the motor housing, under the air inlet. This port can be used to check the supply pressure at the motor when the motor is operating. To check dynamic pressure, remove the 1/4" NPT pipe plug and save for later use. Install a pressure gauge to read at this port. Using Loctite Pipe Thread Sealant or equivalent, replace ¼" NPT pipe plug when done. This pressure monitoring line/gauge may also be permanently installed. Alternately, a pressure transducer may be installed at the pressure check port and electrical lines routed to a digital display at the operator's station.

2.5 MATCHING MOTOR OUTPUT (SPEED) TO LOAD

A hand held tachometer should be used to double-check motor output speeds. Motor supply pressure should be set at the *minimum pressure required* to insure the motor runs the speed/load required by the application.

It is recommended that all starters be installed with a discrete supply pressure regulator. Do not use supply pressure only, (such as the default fuel gas pressure on the package) as indicators of motor speed & output, which typically **do not** account for:

- Varying fuel gas pressures (on various turbine engine models)
- Varying compressor loads during start-up
- Varying site conditions (temperatures, etc…)
- Varying turbine engine ramp-up speeds (& time) required.

NOTE
Starter motor over pressure (even where starter supply pressure minimally exceeds that needed for proper ramp-up speeds/times) may result in engine turning too fast, too quickly… a.k.a. "flame-out**."** ***In these cases simply reducing starter supply pressure will generally correct this.***

3.0 MOTOR OPERATION

WARNING
Do not operate the TDI *TURBOTWIN* starter at dynamic supply pressures greater than the pressure rating on the nameplate. This dynamic pressure is measured at the motor inlet while the motor is running.

- Static (non-flowing) supply pressure will always be higher than the operating (dynamic) pressure.

- The maximum pressure limit (proof pressure) that the TDI *TURBOTWIN* motor housings may be subjected to is 600 PSIG (42 BAR).

- Where system static pressure may exceed the 600 PSIG (42 BAR) limit, in addition to pressure reducing device, it a pressure relief valve set below 600 PSIG (42 BAR) should be used.
- Where operating supply pressure exceeds motors' maximum operating pressure ratings, or produces outputs above required by the application, a pressure reducing device (regulator) must be used.

All appropriate local pressure codes and pressure limitations on other system components must be adhered to and supersede the guidelines given in this manual.

4.0 PREVENTIVE MAINTENANCE

IMPORTANT
All *TURBOTWIN* T100-MS/CS starter motors use new oil-sump lubrication of the drive end (gearbox) which must be properly maintained.

- ***Severe Service*** **** & Required Field Maintenance Procedures**, to be performed as preventative maintenance include:
    - Utilize only oil types recommended by the manufacturer (TDI), in the starter gearbox.
    - Properly orient the motors/starters as described herein, to insure proper oil levels can be easily maintained in the starter gearbox (See section 2.1)

MAINTENANCE SCHEDULE		
INTERVAL	**CHECKS**	**MAINTENANCE**
2,000 operating hours (or quarterly)	**Check Oil Level**	**Check oil condition**, *change oil if using oil other than recommended synthetic types*
4,000 operating hours (semi-annually)	**Check Oil Level**	**Check oil condition**, *change oil if using oil other than recommended synthetic types*
8,000 operating hours (annually)	**Check Oil Level**	**Change Oil** *(regardless of type being used)*

** **Severe *Service*: is where motor(s) are cycled longer than one (1) hour continuously or wherever motor(s) can/may become unloaded for periods longer than 30 seconds during cycle.**

Repair technicians or un-authorized/un-trained service organizations, without TDI ***TurboTech*** certification, should not attempt to rebuild nor repair these products.

Proper maintenance, qualified maintenance repair of your TDI *TURBOTWIN* starters & motors will assure continued reliable and superior performance for many years.

5.0 TROUBLESHOOTING CHART

TROUBLE	PROBABLE CAUSE	SOLUTION
1. Motor does not run; small air flow from exhaust.	A. Valve not fully open.	A. Repair or replace valve.
	B. Nozzle blockage.	B. Remove blockage or obstruction from nozzles.
2. Motor does not run; normal air flow from exhaust.	A. Broken turbine rotor.	A. Replace all damaged parts.
	B. Broken gear train.	B. Repair or replace gear train.
	C. Damaged motor drive.	C. Repair or replace motor drive.
3. Reduced Motor output power.	A. Inlet air pressure too low.	A. Increase air pressure in 10 PSIG (0.6 BAR) increments; DO NOT EXCEED OPERATING LIMIT.
	B. Inlet supply piping too small.	B. Supply piping must be a minimum of 1.5" diameter.
	C. Pressure regulator orifice too small.	C. Increase orifice size or replace pressure regulator
	D. Inlet supply line valve (ball, gate, relay, plug) too small.	D. Install larger valve.
	E. In line lubricator installed in supply line.	E. Remove lubricator.
	F. Y-Strainer in supply line clogged.	F. Clean strainer.
	G. Excessive back pressure; exhaust restricted.	G. Clean exhaust piping or increase size to at least the minimum diameter recommended.
	H. Damaged turbine nozzle.	H. Replace turbine nozzle.
	J. Wrong rotation motor.	J. Replace with motor or proper rotation.
	K. Wrong size motor.	K. Check the Application Guide for the correct motor.
4. Engine cranks too fast (flameout).	A. Motor Inlet air pressure too high.	A. Decrease air pressure in 10 PSIG (0.6 BAR) increments. OR If there is a manual shut-off valve in the supply line, partially close it. OR Install a restriction orifice in the inlet supply line.
	B. Wrong size motor.	B. Check the Application Guide for the correct motor.

6.0 WARRANTY

TDI TURBOTWIN ENGINE MOTOR WARRANTY

Tech Development (TDI) warrants to the original user of the TDI *TURBOTWIN*™ air starters to be free from defects in material and workmanship for a period of one year (6 month for remanufactured units) from the date of installation. The warranty period shall not extend beyond two years (12 months for factory remanufactured units) from the date the unit was manufactured. (i.e.: a unit with a manufactured date of July 1999 (SN: 9907-101) will not be covered under warranty after July 2001). The conditions of this warranty are: **a)** TDI is notified within this period by return of such product to TDI or its authorized distributor/dealer, transportation prepaid by user; **b)** the starter has been installed according to TDI's specifications; **c)** the starter has not been misused, abused, or improperly maintained by user; **d)** the defect is not the result of normal wear and tear; **e)** the starter has been repaired with parts manufactured or authorized by TDI; and **f**) TDI installation and repair procedures as outlined in the appropriate manual were properly followed.

Tech Development will repair, or at its option, replace the unit during the warranty period at no charge to the customer, provided it is returned to TDI with the proper return procedure.

Tech Development makes no other warranty, and implied warranties including any warranty or merchantability or fitness for a particular purpose are hereby disclaimed.

This warranty constitutes the entire obligation of Tech Development relating to the sale and use of such product and TDI's maximum liability is limited to the purchase price of such product at the date of purchase. In no event shall TDI be liable for incidental, indirect, consequential, or special damages of any nature arising from the sale or use of such engine starter product.