TECH DEVELOPMENT INC.

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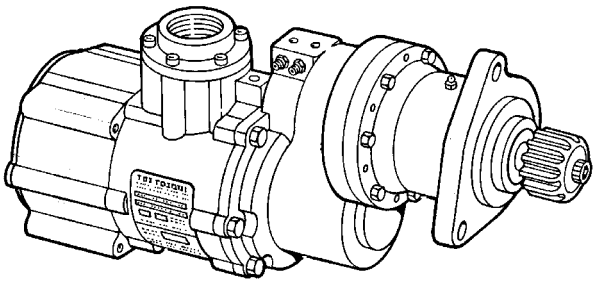
INSTALLATION AND OPERATING MANUAL



MODEL: T100-V

*TURBO**TWIN*** Engine Air Starters

AN 98-440

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1.0 GENERAL INFORMATION

This manual provides instructions for the installation and operation of the TDI *T100-V TURBOTWIN* Air Starters. If there are questions not answered in this manual, please contact your TDI *TURBOTWIN* distributor or dealer for assistance.

The T100-V starters are turbine driven starters with a pre-engaged starter drive. The *T100-V* starters have applications ranging from 1800 CID (30 Liters) on diesel engines and up to 18000 CID (300 Liters) on gas engines. The *T100-V* models are suited to operate within a wide range of inlet pressures and ambient temperatures. The engine size and parasitic loading will determine the exact minimum pressure that will assure reliable cranking.

The *T100-V* starters are designed for operation with compressed air or natural gas; materials used are compatible with "sour" natural gas and marine environments. Small amounts of foreign matter or liquid in the air supply will not adversely affect *T100-V* starters. As with all TDI starters, no lubrication is required in the air supply.

Please review the rest of this manual before installing the *T100-V* air starter.

WARNINGS, CAUTIONS, AND NOTES

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

WARNING - used where injury to personnel or damage to the equipment is possible.

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

NOTE - used to point out special interest information.

NOTE

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

1.1 DESCRIPTION

The T100-V features three basic subassemblies: a unique two stage turbine motor section, an offset/spur gear assembly and a pre-engage drive assembly.

The two stage motor section features greater stall torque than a single stage turbine plus aerodynamic speed control. This aerodynamic speed control helps protect the *T100-V* starter from damage caused by starter motor over speed. In addition, a specially designed motor housing module and low-mass rotors provide fail-safe operation.

The *T100-V* employs 9.25:1 ratio spur gearbox. This low gear ratio allows the turbine motor to spin at low speeds for long bearing life. At a typical 3000 rpm pinion speed, the turbine is rotating at a low 27750 rpm.

A reliable pre-engaged drive delivers the torque to the pinion. The pinion is translated out to engage the engine's ring gear via the starter's engagement piston.

Compressed air or natural gas is used to power the *T100-V* through the inlet port. The air or gas is expanded through the first nozzle or stators. The high velocity gas impinges on the first stage rotor to yield torque to the gearbox through momentum exchange. The gas is further directed through the second stage stators which impart additional torque to the second stage rotor.

1.2 PRODUCT IDENTIFICATION

The starter nameplate which is attached to the turbine housing contains the following information: model number, serial number, part number, direction of rotation and the maximum rated operating pressure.

The directions of rotation are either right hand or left hand rotation as shown in Figure 1. Right Hand rotation is defined as clockwise rotation as viewed from the pinion end of the starter, and Left Hand rotation is counter clockwise rotation viewed from the pinion end of the starter.

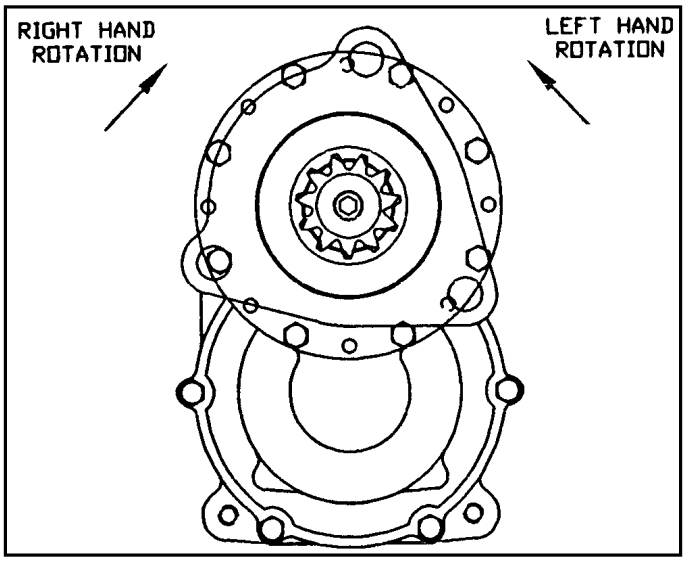


Figure 1. Direction of Rotation viewed from Pinion End.

The maximum operating pressure identified on the nameplate is measured at the check port on the starter inlet with the starter in operation.

CAUTION

Exceeding the maximum pressure shown on the nameplate may result in drive failure, damage to the starter, or damage to the engine.

The housing proof pressure is 600 psig and is also shown on the nameplate. This means that the turbine housing will not burst when subjected to a static pressure of 600 psig.

1.3 PHYSICAL CHARACTERISTICS

Figure 2 shows the standard configuration for the T100-V with exhaust screen. This model weighs approximately 54 lbs. and is 16.8 inches in length. The turbine housing diameter is 6.8 inches, which is common to all T100 *TURBOTWIN* air starters.

1.4 PERFORMANCE

The performance curve for the T100-V illustrates the pinion torque versus pinion speed (rpm) at a constant drive air pressure, and horsepower versus pinion speed at a constant drive air pressure. The pinion speed is shown on the horizontal axis while the pinion torque is shown on the left edge of the vertical axis. Air consumption rates are given for the various drive pressures. The drive gas used for the performance curve is air.

2.0 ORIENTATION OF THE STARTER

If the factory orientation of the starter turbine housing assembly does not fit your engine installation, this component can be re-oriented.

Determine the required orientation of the turbine housing assembly and gearbox housing assembly. The turbine housing assembly can be rotated to six different positions relative to the gearbox housing assembly. The drive assembly can be rotated to twenty four positions relative to the inlet port.

Orientation of the starter should be accomplished prior to installing the starter on the engine.

CAUTION

All screw threads are treated at the factory with a fastener retention compound. Every screw and tapped hole must be clean and have a drop of Loctite 242 applied to the threads before being installed.

3.0 INSTALLING THE STARTER

A turbine air starter does not require lubrication in the supply air. Therefore, if a vane type starter motor is being replaced, TDI recommends that all lubrication devices and lines be removed to minimize flow restrictions.

WARNING

If a fuel (pulse) lubricator has previously been installed in the system, disconnect and plug the line to eliminate spraying diesel fuel on the engine.

The starter should be installed with the inlet valve in a position between horizontal and straight down. Any condensation will be restricted to the air lines and not in the starter.

WARNING

Do not operate this starter unless it is properly connected to an engine.

3.1 SUPPLY LINE INSTALLATION

WARNING

Be sure to either bleed the pressurized air reservoir and/or safety the system such as closing all valves prior to installing any starter supply line.

T100-V starters come standard with a 2" NPT female pipe thread for the inlet connection port**.** The supply line consists of the line from the air source, a pressure regulator (when necessary), a manual or relay valve, and the connection to the starter inlet. Hard piping may be used, but a section of flexible tubing should be installed at the starter to prevent leaks due to engine vibration.

Care must be taken to ensure that all inlet supply line piping is no less than 1.5" and that all components used are capable of passing the required air flow.

NOTE

Valves with a Cv of 40 or higher are recommended.

If the supply line must be longer than 20 feet, the inlet supply line piping should be increased to 2" in diameter to ensure proper performance by your *TURBOTWIN*.

Because turbine starters such as the *T100-V* are sensitive to flow restrictions, care must be taken to use uniform hose or tubing and fittings for connection of the supply line. Tees, elbows and line length must be kept to a minimum. TDI recommends that hose or flex couplings be installed to eliminate possible leakage caused by strain on the supply line.

Normally, an air strainer is not required. In dirty environments, use of a #40 mesh Y-strainer is recommended. The ***T100-V*** is highly tolerant of dirt in the air line, however, starter life can be increased with the use of an air strainer.

A pressure regulator is required when the air supply pressure is great enough to exceed the starter operating pressure (at the inlet port) and/or the maximum torque.

A manual ball valve may be used to admit drive air/gas to the starter. The manual valve should be located in a safe position away from the engine.

A preferred valve is pilot-operated, which can be pneumatically or electrically actuated. The valve should be located close to or even on the starter inlet for best performance. Pneumatic or electrical control lines may be routed virtually anywhere for the customer's preferred operating station. This type of valve actuates from a fully closed to a fully open position very rapidly. TDI offers a variety of relay valves such as P/N RLVA-25683-001-2-01, which is a 1-1/2" port, pneumatically actuated valve.

The supply line 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.

CAUTION

In cold weather climates, care should be taken while designing your installation to prevent condensation from developing in the starter system. In systems with a regulator valve or relay valve, there is the possibility of freeze-ups.

A tee connection with a quick disconnect can be added to the inlet. This will allow an external air source to be used to accomplish a "blow start" if the system freezes. Once the engine has been started, the other system components may be thawed.

CAUTION

On new installations, it is strongly recommended to blow out the supply line with air to remove possible dirt and welding slag prior to final connection to the *TURBOTWIN* starter. Be sure to secure the free end of the supply line prior to blowing out the line.

3.2 INLET PRESSURE PORT

A 1/4" NPT port is located on the air inlet. This port may be used to check the supply pressure at the starter when the starter is operating. Remove the 1/4" NPT pipe plug and save for later use. Install 1/4" minimum size tubing to the port. Route the tubing away from the starter to a safe location away from the engine. Install a pressure gauge on the tubing. This pressure monitoring line/gauge may be permanently installed. Use Loctite Pipe Thread Sealant or equivalent. 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.

This pressure port is invaluable in diagnosing air starter and/or installation problems.

3.3 EXHAUST PIPING

The turbine exhaust may be plumbed away from the starter area. All starters using natural gas must be piped according to industry codes and local regulations.

The performance of a turbine starter will be decreased because of back pressure when smaller than recommended exhaust piping is installed. If back pressure hampers starter performance, compensation

can be made by increasing the supply pressure. Consult your TDI distributor for advice.

Exhaust piping should be routed downward to help prevent any accumulation of condensation in the starter motor.

If the overhung section of the starter is not otherwise supported, TDI recommends that the exhaust piping be supported with a suitable bracket(s).

3.4 SOFT START VALVE & FILTER FITTING

The ***"soft start"* fitting (P/N: 2-28243)**, by providing a slower opening of the starter relay valve, eliminates excessive starter pinion gear loading. The soft start fitting is identified by the mark "EL-SOFT START" found on its body. This fitting **MUST** be installed at the starter relay valve as shown in figure 4. It is screwed into the applied pressure ("IN" or "APP") port on the starter relay valve. There are currently no approved substitutions for this fitting.

The **filter fitting (P/N: 2-28270)** provides contamination protection to the starter's pre-engagement mechanism and the soft start fitting installed downstream. The filter fitting is to be installed on the "IN" port of the starter as shown in figure 4. It appears similar to the soft start fitting, however, there are no identifying marks on the filter fitting.

For multiple starter applications, a soft start fitting must be installed on **EACH** relay valve and a filter fitting must be installed on **EACH** starter as shown in figure 5.

CAUTION

For maximum pinion life and full warranty coverage, the soft start valve (P/N: 2-28243) MUST be installed in the applied pressure port (APP) of the relay valve.

3.5 NATURAL GAS INSTALLATION

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

Proper control of natural gas is a major consideration when used in the starter system. All starters using natural gas must pipe the exhaust according to industry codes and local regulations.

There is a natural gas vent port in the turbine housing that is plugged for compressed air use. This vent is used to remove any natural gas that could leak past the primary turbine shaft seal. Remove this 3/8"NPT plug and install a line to carry gas away from the starter area.

WARNING

Do not connect the turbine housing vent line to the turbine exhaust line. Exhaust gas can pressurize the turbine housing.

3.6 PIPING SYSTEM

Only type approved metallic hose assemblies are approved in permanently pressurized compressed air lines of starters. Non-metallic hose assemblies are allowed only in case the piping system will be emptied after the starting procedure.

Pipe unions must be type approved by GL. Downstream of the pressure regulator a pressure relief valve is to be provided.

4.0 STARTER OPERATION

Prior to operation, check that all connections are tight and free from leaks. Check the 1/4" NPT pipe plug or a pressure gauge/transducer that may be connected to the pressure port on the starter inlet.

WARNING

Do not operate the TDI *TURBOTWIN* starter with air pressure greater than the pressure rating on the nameplate. This pressure is measured at the starter inlet while the starter is running.

The maximum operating pressure limit is the inlet pressure measured at the starter's inlet pressure check port. In order to check the starter, a 1/4"NPT pipe tap connection is provided in the inlet housing to attach a pressure gauge/transducer). The maximum pressure assumes an open exhaust (the standard turbine exhaust guard). The standard exhaust guard causes no back pressure.

The static non-flowing supply pressure will always be higher than the operating (dynamic) pressure. The maximum pressure limit (proof pressure) that the *T100-V* starter housings may be subjected to is 600 PSIG (42 BAR). System pressure that exceeds the maximum operating limit must use a pressure reducing device to ensure that the operating pressure limit to the *T100-V* starter is maintained.

System static pressure that exceeds the 600 PSIG (42 BAR) limit must, in addition to pressure reducer devices,

incorporate a pressure relief valve set below 600 PSIG (42 BAR) in the supply air line.

NOTE

For maximum life of the starter pinion and for the protection of the engine ring gear, limit the operating pressure to that necessary to start the engine at its most difficult starting conditions.

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

Consult your TDI distributor if you have exhaust plumbing that creates back pressure and reduces starter performance. You may be able to increase the supply pressure to restore the lost power.

Follow the engine manufacturer's instructions for starting the engine.

4.1 BASIC OPERATION

The basic operation of the starter follows:

Pressurized air or natural gas is admitted to the starter's engagement piston chamber via the "in" control port by opening the manual or solenoid valve. The air then translates the starter's piston forward allowing the pinion to engage the engine's ring gear.

The forward movement of the piston causes the starter's "out" control port to open. Air is then transmitted to the automatic pilot port (APP) on the relay valve causing the relay valve to open.

Pressurized air or natural gas is admitted to the starter's turbine assembly by the opening of the relay valve. The air expands through the turbine which produces shaft rotation and torque. The starter motor torque causes the engine to accelerate. The fuel and ignition systems now fire the engine. Closing the relay valve stops the starter.

The operator may decrease starter life by the continual operation of the starter after the engine has started. Upon a successful engine start, turn the air off to the starter immediately. Minimizing the time the starter is operating unloaded (i.e. the engine is running) will maximize starter life. If a start is aborted, a restart may be attempted after the engine and the starter has come to rest.

CAUTION

Do not engage the starter while the engine is running.

The drive air pressure is the primary starter control parameter**.** It is important, especially on new installations, to measure this pressure during several engine starts. The secondary parameter is the starter pinion speed. This speed is usually measured by knowledge of the engine starting speed and the starter cranking ratio. The cranking ratio is the number of ring gear teeth divided by the number of pinion teeth. The starter pinion speed is then found by multiplying the engine speed by the cranking ratio. The pinion speed is usually 2000-3500 rpm at typical engine starting speed.

4.2 AUTOMATED START PANEL

The starter drive pressure measured at the starter inlet will need to be set. As noted above, for maximum life of the starter pinion and for the protection of the engine ring gear, limit the operating pressure to that necessary to start the engine at its most difficult starting conditions.

The speed control parameter will then need to be set. Engine starting speed along with the cranking ratio number can be used to determine starter pinion speed. The pinion speed is usually 2000-3500 rpm for a typical engine starting speed. Once the start sequence has begun, the air is admitted to the starter. The starter begins to accelerate the engine. Once the firing speed of the engine is reached, the automated start panel may deliver fuel to the engine. The engine will begin to accelerate under its own power. The starter should be dropped out of the sequence at a rpm higher than the firing speed, but less than the engine idle speed.

The automated start panel should monitor engine speed to determine air on and air off. Do not simply use time as a control parameter. Avoiding excessive operation of the starter after the engine is firing will maximize the starter life.

5.0 WARRANTY

TDI *TURBOTWIN* ENGINE STARTER WARRANTY

Tech Development Inc. (TDI) warrants to the original user of the TDI *TURBOTWIN*™ Model T100-V Series air starters to be free from defects in material and workmanship for a period of one year from the date of installation. The warranty period shall not extend beyond two years 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 Inc. 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 Inc. 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 Inc. 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.

6.0 OPERATOR'S TROUBLESHOOTING GUIDE

TROUBLE	PROBABLE CAUSE	SOLUTION
1. Air always flow through exhaust	A. Relay valve improperly installed.	A. Check typical installation diagram and correct.
	B. Relay valve not sealing properly.	B. Check for damaged sealing ring, replace relay valve or damaged parts.
	C. Solenoid is not sealing, pressure remains in APP port of relay valve.	C. Check solenoid potential at the lead to ground should be 0. If not, fix ignition switch problem.
2. Starter engages but does not run,	A. Bad relay valve	A. Replace relay valve.
3. Starter does not run, small air flow from turbine exhaust or drive housing.	A. Nozzle blockage.	A. Remove blockage or obstruction from nozzles.
4. Starter does not run. Normal air flow from exhaust.	A. Excessive bends in the supply line.	A. Shorten length or straighten supply air line.
5. Pinion does not engage	A. Air pressure is too low	A. Increase air pressure to 40 - 150 psig.
	B. Control lines to starter ports reversed.	B. Check installation diagram and correct.
	C. Solenoid valve not operating or plugged.	C. Check wiring and solenoid operation. Correct wiring, remove blockage, or replace solenoid valve as needed.
	D. Damaged pinion teeth.	D. Replace pinion or starter drive as necessary.
6. Starter runs but engine cranks slowly or not at all.	A. Air pressure too low	A. Increase air pressure to 40 – 150 psig.
	B. Excessive back pressure.	B. Check Exhaust Closure Plate.
	C. Nozzle blocked or damaged.	C. Remove blockage or replace damaged parts.
7. Starter continues to operate after start button is released.	A. Solenoid valve is not sealing correctly.	A. See 1C above
	B. Relay valve is not sealing correctly.	B. See 1B above
8. Air tank pressure decays after extended shut down.	A. Air connections are not tight.	A. Tighten loose fittings. Repair or replace damaged fittings.
	B. Damaged air lines: crushed, frayed, and kinked.	B. Replace damaged lines.
	C. Relay valve is not sealing correctly.	C. See 1B above
	D. Solenoid valve is stuck open.	D. A. See 1C above

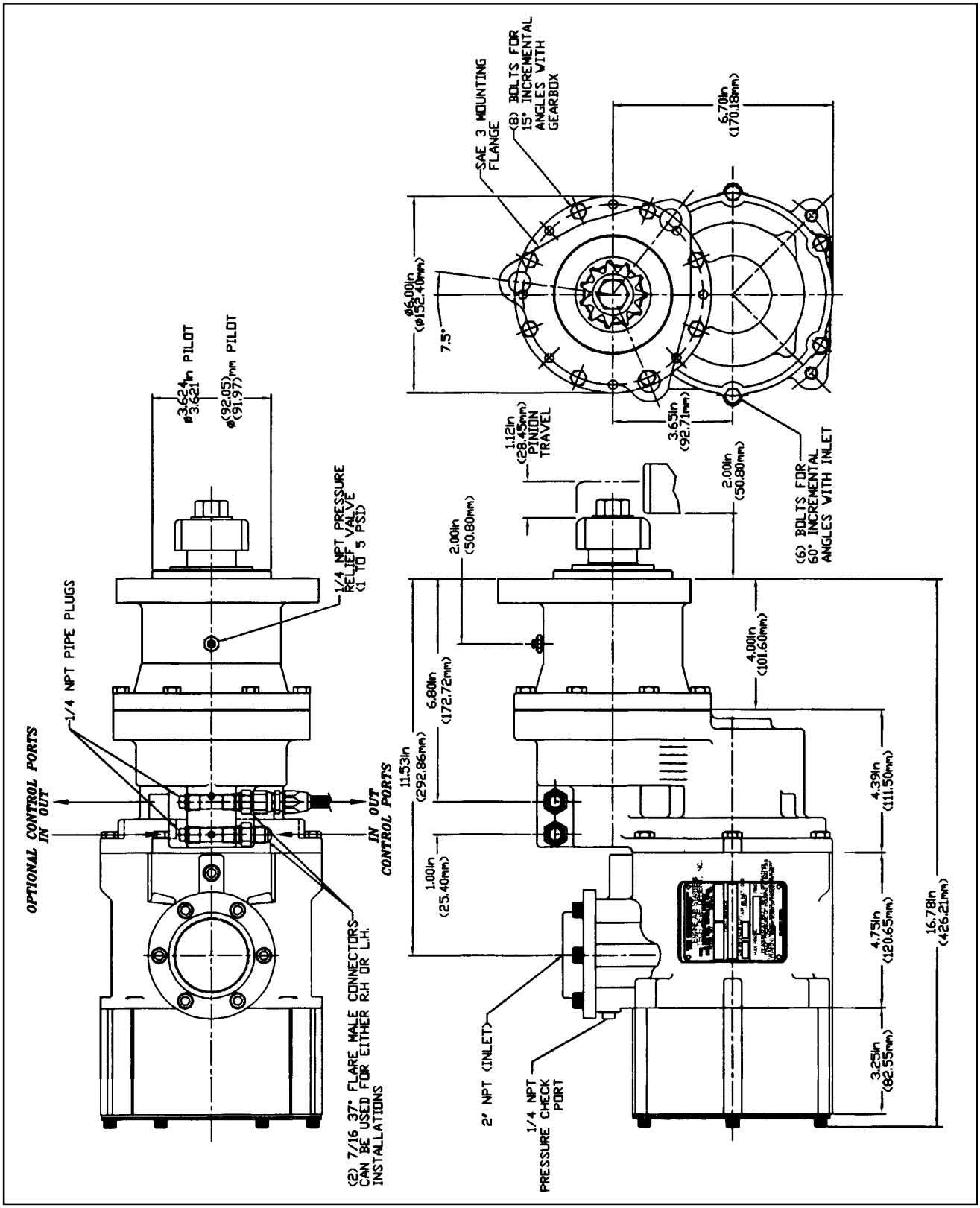
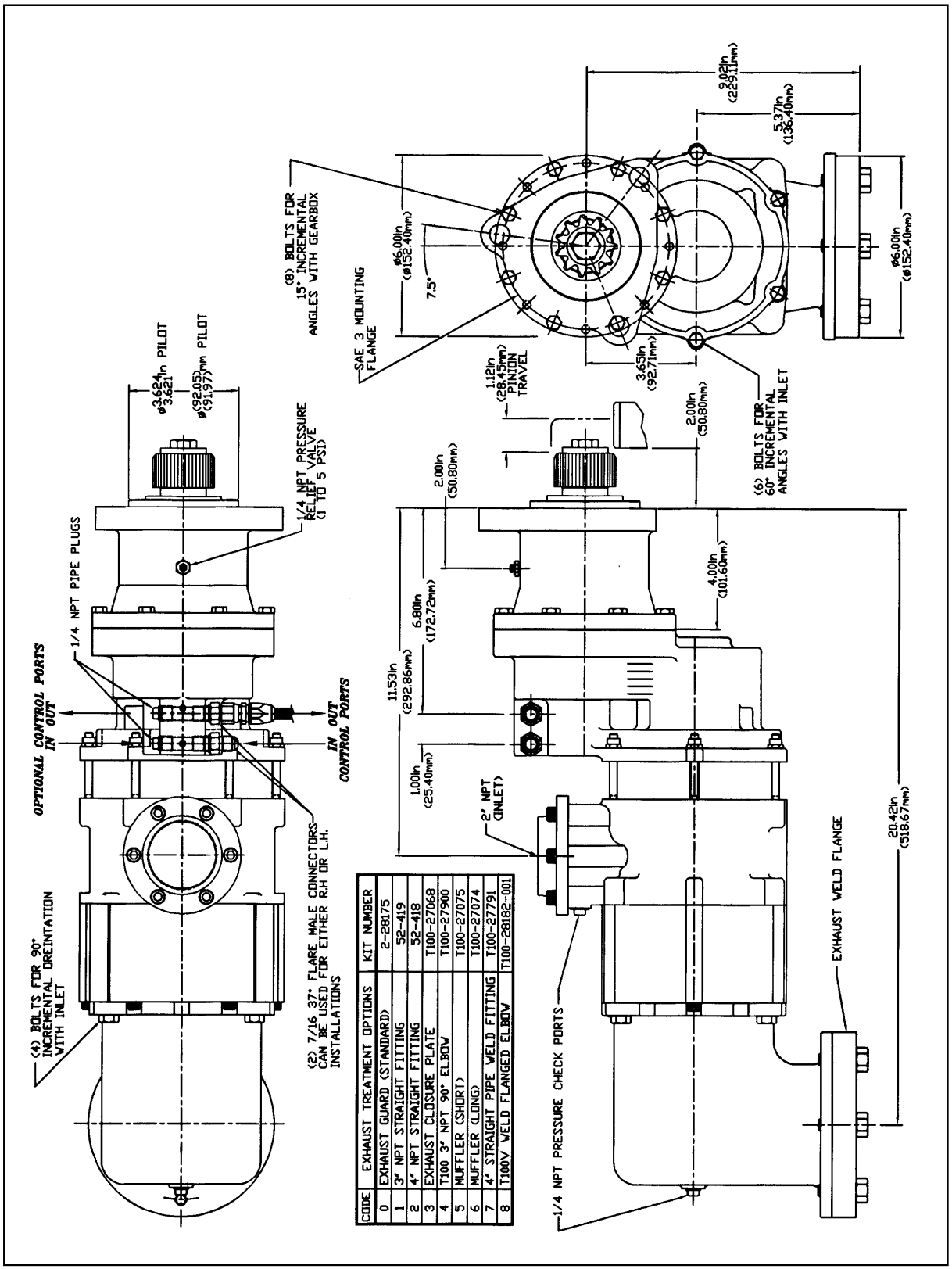


Figure 2. T100-V *TURBOTWIN* Air Starter with Exhaust Guard



CODE	EXHAUST TREATMENT OPTIONS	KIT NUMBER
0	EXHAUST GUARD (STANDARD)	2-28175
1	3" NPT STRAIGHT FITTING	52-419
2	4" NPT STRAIGHT FITTING	52-418
3	EXHAUST CLOSURE PLATE	T100-27068
4	T100 3" NPT 90° ELBOW	T100-27900
5	MUFFLER (SHORT)	T100-27075
6	MUFFLER (LONG)	T100-27074
7	4" STRAIGHT PIPE WELD FITTING	T100-27791
8	T100V WELD FLANGED ELBOW	T100-28182-001

Figure 3. T100-V *TURBOTWIN* Air Starter with Flanged Exhaust Elbow

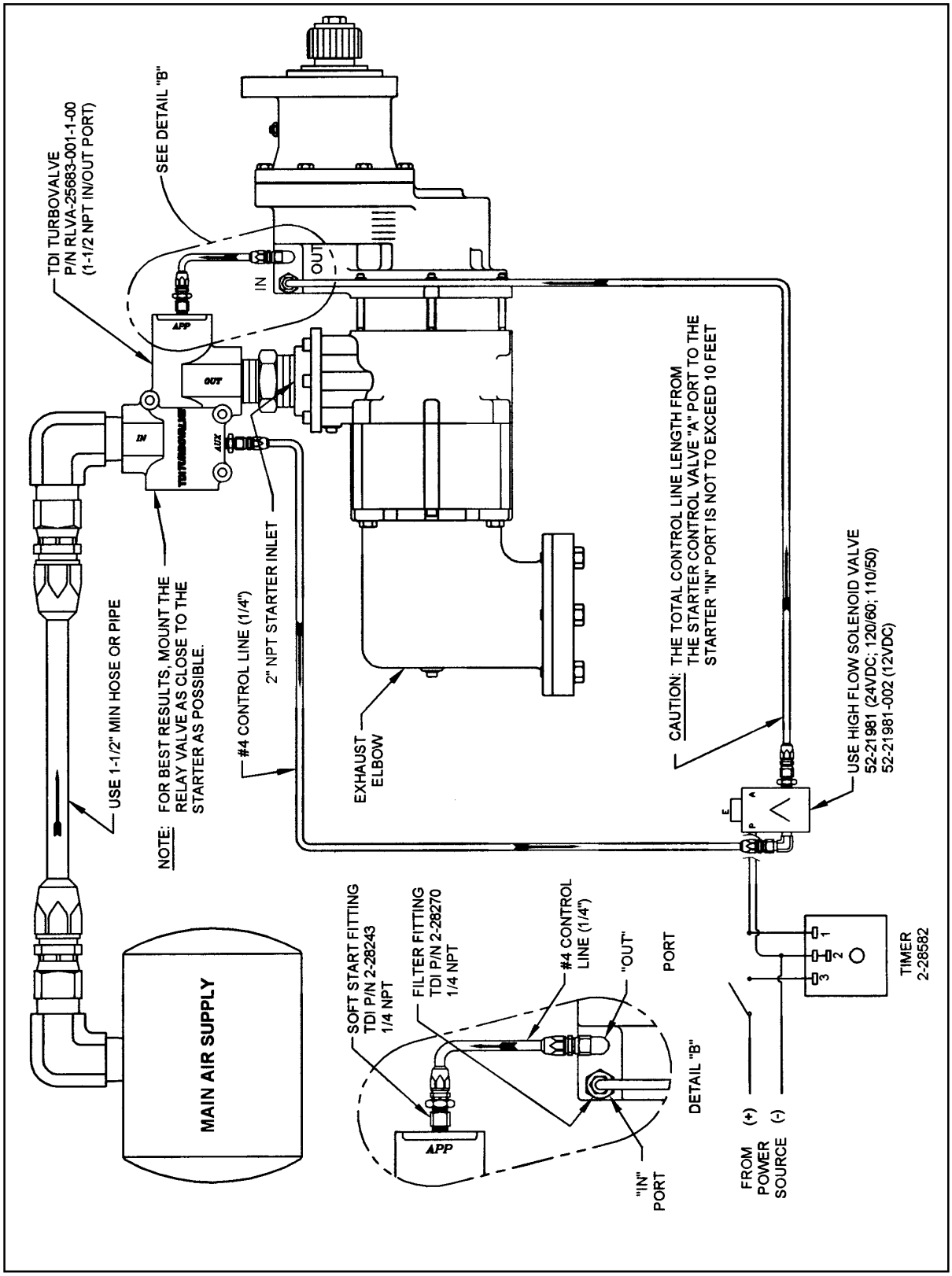
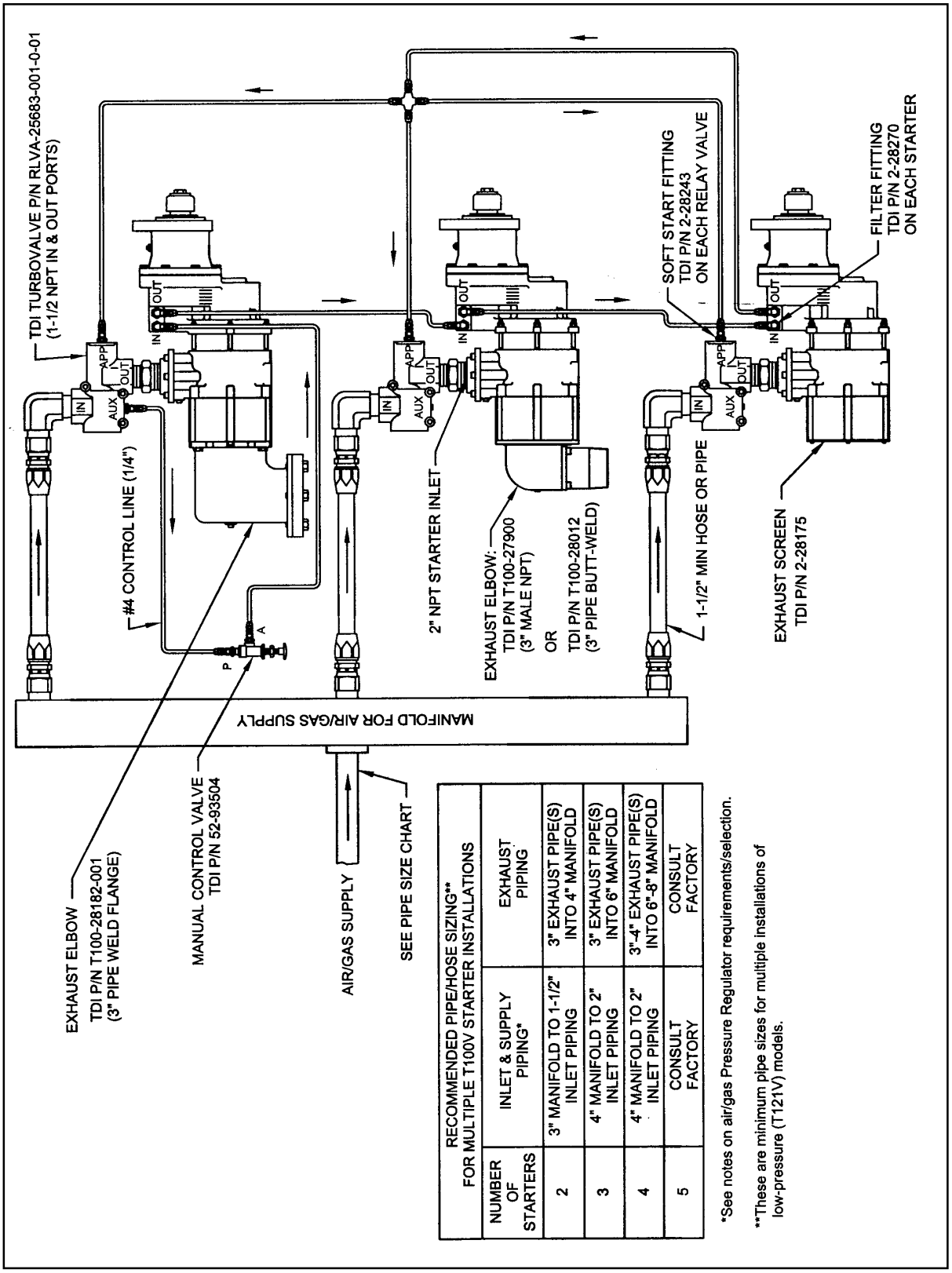


Figure 4. T100-V *TURBOTWIN* Air Starter Installation Drawing



RECOMMENDED PIPE/HOSE SIZING** FOR MULTIPLE T100V STARTER INSTALLATIONS		
NUMBER OF STARTERS	INLET & SUPPLY PIPING*	EXHAUST PIPING
2	3" MANIFOLD TO 1-1/2" INLET PIPING	3" EXHAUST PIPE(S) INTO 4" MANIFOLD
3	4" MANIFOLD TO 2" INLET PIPING	3" EXHAUST PIPE(S) INTO 6" MANIFOLD
4	4" MANIFOLD TO 2" INLET PIPING	3"-4" EXHAUST PIPE(S) INTO 6"-8" MANIFOLD
5	CONSULT FACTORY	CONSULT FACTORY

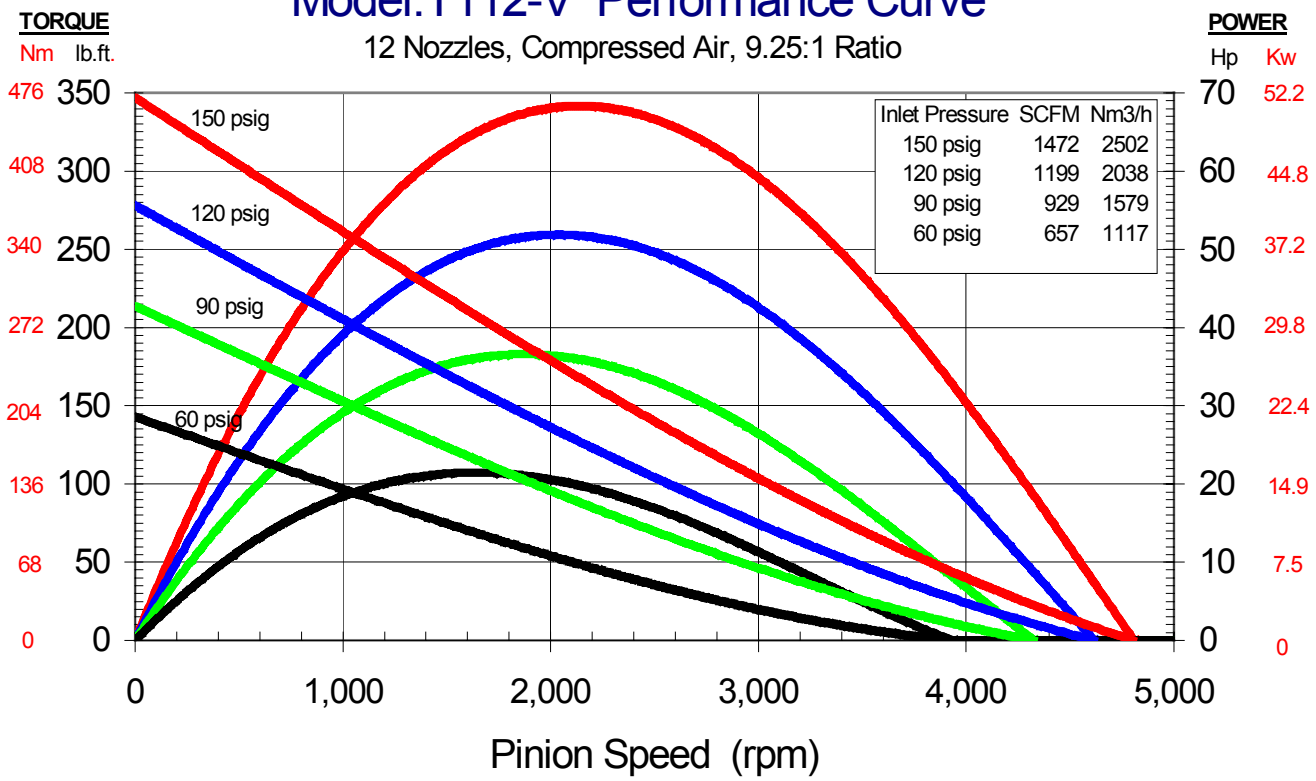
*See notes on air/gas Pressure Regulator requirements/selection.

**These are minimum pipe sizes for multiple installations of low-pressure (T121V) models.

Figure 5. T100-V *TURBOTWIN* Air Starter Installation Drawing (Multiple Starters)

Model:T112-V Performance Curve

12 Nozzles, Compressed Air, 9.25:1 Ratio



Model: T121-V Performance Curve

21 Nozzles, Compressed Air, 9.25:1 Ratio