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LEYBOLD

LEYBOLD VACUUM PRODUCTS INC.

Part Number 722-78-047 ■ Edition C

TMP151/361 Turbopumps & NT150/360 Converter

MANUAL

1TN-6.1A

Contents*

*See the index at the back of this manual to help find specific information.

Important:

Failure to comply with the following could cause premature failure of your turbopump or converter and void your warranty.

- Don't run the pump without the inlet screen installed in the high-vacuum flange. The inlet screen prevents objects from falling into the pump and damaging the rotor.
- Avoid contaminating the turbopump with oil vapors as follows:

  If you rough the chamber through the turbopump, install an adsorption trap in the fore-vacuum line. When pumping down large chambers, use the backing pump to rough the chamber through a separate line before starting the turbopump.

  Ensure that the backing pump or fore-vacuum line has an anti-suckback valve to prevent oil from being drawn into the turbopump during shutdown.

  Always vent the pump during shutdown as described in Section 3.5. Failure to vent the pump can result in premature failure of its bearings or in oil backstreaming into the turbopump from the backing pump.
- If you will be pumping corrosive or aggressive gases or gas containing abrasives or dirt, you must use the TMP151C or TMP361C pump model and you must purge and vent with inert gas through the turbopump's purge port as described in Section 3.7. Purging and venting prevents the grease from becoming contaminated and protects the bearings from premature failure.
- Ensure that air flow around the converter is unrestricted. The maximum ambient temperature for the converter is 110°F (45°C).
- Ensure that the converter's fuse and voltage are correct for your AC power source as described in Section 2.2.1.
- Don't expose the turbopump to external shocks or vibration while its rotor is spinning. We recommend using bellows or flexible tubing for the fore-line to prevent transmitting vibration from the backing pump.
- When installing the turbopump within a magnetic field, ensure that the magnetic induction measured at the surface of the pump housing doesn't exceed 50 gauss [5 mT (millitesla)] in a radial field and 150 gauss (15 mT) in an axial field. If these values are exceeded, the resulting eddy currents might overheat the rotor; therefore, suitable magnetic shielding of the turbopump will be necessary.
- The standard pump is radiation resistant up to 10^5 rad. If higher radiation resistance is required, please contact Leybold.
- Ensure that the ambient and bakeout temperature are below the maximums listed in Table 3-A.

Table I — TMP151/361 151/361C Turbopump Specifications

Pump Model	*TMP151/151C*	*TMP361/361C*
Compression Ratio:		
For Nitrogen	>1 x 10^9	>1 x 10^9
For Helium	2 x 10^4	6.5 x 10^4
For Hydrogen	8.5 x 10^2	3.5 x 10^3
Maximum Pressure at High-Vacuum Flange	5 x 10^{-1} mbar	1 x 10^{-1} mbar
Ultimate Pressure per DIN 28 400 and DIN 28 428	<10^{-10} mbar	<10^{-10} mbar
Fore-Vacuum Pressure:		
Recommended	10^{-2} to 10^{-3} mbar	10^{-2} to 10^{-3} mbar
Maximum	1 mbar	5 x 10^{-1} mbar
Recommended Backing Pump†:		
without purge flow	TRIVAC® D4B	TRIVAC® D16B
with purge flow	TRIVAC® D16BCS	TRIVAC® D25BCS
Rotational Speed	50,000 rpm	45,000 rpm
Start-Up Time	1.5 minutes	2 minutes
Lubrication	Life-long supply of grease	Life-long supply of grease
Cooling*:		
Method	Water (Air optional)	Water (Air optional)
Minimum Water Flow at 15°C (59°F) .	5.3 gal/hr (20 ltr/hr)	5.3 gal/hr (20 ltr/hr)
Water Pressure	<60 psig	<60 psig
Water Temperature (see Fig 2-7) . .	50 to 86°F (10 to 30°C)	50 to 86°F (10 to 30°C)
Water Connection, Hose Nozzle . . .	13⁄32 inch (10 mm)	13⁄32 inch (10 mm)
Fore-Vacuum Port Fitting	DN 25 KF	DN 25 KF
Maximum Bakeout Temperature		
at CF High Vacuum Flange	212°F (100°C)	212°F (100°C)
at Rotor and Fore-Vacuum Flange . .	175°F (80°C)	175°F (80°C)
Maximum Magnetic Induction at Pump Housing (1mT = 10 Gauss)		
For a Radial Field	B = 5 mTesla	B = 5 mTesla
For an Axial Field	B = 15 mTesla	B = 15 mTesla
Mounting Position	In any desired position	In any desired position
Maximum Vibration Velocity	<0.10 mm/sec	<0.10 mm/sec
Weight (approximate)	17.6 lbs. (8 kg)	26.5 lbs. (12 kg)
Dimensions	See Leybold Catalog	See Leybold Catalog

†The recommended backing pump can vary widely depending on the gas load, the required pumpdown time, and the conductance of the foreline. Contact Leybold for recommendations for your particular process.

*See Section 3.1 for information on temperature limits.

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Table I — TMP151/361 Turbopump Specifications (continued)

Pumping Speed (Volume Flow Rate — liters/second)				
Process Gas	**TMP151 & TMP151C - High Vacuum Flange**		**TMP361 & TMP361C- High Vacuum Flange**	
	63 ISO-K & 2-inch ASA	100 ISO-K & 100CF	*100 ISO-K &* *100* CF	*160 ISOK,160CF, & 4-inch ASA*
Nitrogen	115	145	345	400
Helium	120	135	340	380
Hydrogen	110	115	340	370

NOTE: The actual pumping speed varies depending on the inlet flange (see above table).

Performance Curves

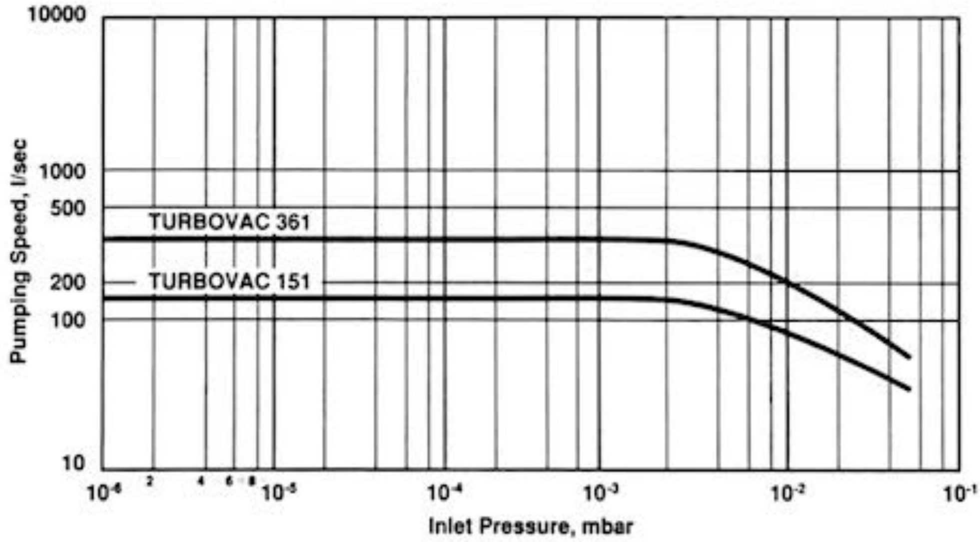

Table II — NT150/360 Converter Specifications

Power Source	
Input Voltage, Selectable Single Phase	100/120/220/240 V AC, ±10%
The NT150/360 P/N 85472-5	100/120/200/220/240 V AC ±10%
Input Frequency	47 to 63 Hz (50/60 Hz)
Power Consumption:	
Transient (<0.5 sec)	750 VA
During Acceleration (max. 30 minutes)	680 VA
Normal Operation (maximum)	480 VA
Fuse Chassis:	
100/120 V AC	3AG/10A
220/240 V AC	3AG/5 A
Output Values	
Output Voltage (maximum)	3 x 45 V AC r.m.s.
Overload Current Limitation	3.5 A
Rated Output Frequency:	
TMP151	840 Hz
TMP361	760 Hz
Normal Operation Relay Contact Ratings:	
Maximum	8A @ 24 V DC and 10A @ 250 V AC
Minimum	1 mA @ 5 V DC
Inductive Load	24 V DC/5A and 220 V AC/5A
Environment	
Operating Temperature Range	32° to 110° (0° to 45° C)
Storage Temperature Range	-100° to +185°F (-40° to +85° C)
Weight	21 lbs (9.5 kg)
Dimensions	8 3/8 x 5 1/16 x 11 7/16 Inch (213 x 129 x 290 mm)

Front Matter

Table III — Ordering Information for Pumps and Converters

TMP151 Pumps	*Part Numbers*
Standard Pump Models	
TMP151 with 63 ISO-K Flange	85630
TMP151 with 100 ISO-K Flange	85631
TMP151 with CF100 Flange	85632
TMP151 with 2-inch ASA Flange	89413
Corrosive-Series Pump Models	
TMP151**C** Pump with 100 ISO-K Flange	85635
TMP151**C** Pump with 100 CF Flange	899252
TMP361 Pumps	***Part Numbers***
Standard Pump Models	
TMP361 with 100 ISO-K Flange	85670
TMP361n with 160 ISO-K Flange	85672
TMP361 with CF100 Flange	85671
TMP361 with CF160 Flange	85673
TMP361 with 4-inch ASA Flange	89423
Corrosive-Series Pump Models	
TMP361**C** with 100 ISO-K Flange	85675
TMP361**C** with 160 ISO-K Flange	85677
TMP361**C** with 100 CF Flange	899253
TMP361**C** with 160 CF Flange	899254
TMP150/360 Frequency Converter	***Part Numbers***
Standard NT150/360 Converter	85472-3
Modified NT150/360 200 V AV ± 10%	85472-5
NT20 Converter	85562-1

Table IV - Ordering Information for Accessories

Accessories	*Part Number*
Gaskets and Clamps for the High-Vacuum Flange	See Table 2-A
Fuses for Frequency Converter	
120-Volt, 10-Amp Fuse	721-95-000
240-Volt, 5-Amp Fuse	721-95-001
Air Cooler* (see Appendix A.1)	
115 V AC	89408
220 V AC	85531
Water Refrigeration Unit (see Appendix A.2)	99-239-003
Water Flow Switch (see Appendix A.3)	99-287-022
CF Flange Heaters (see Appendix A.4)	
100CF 115V	85428
100CF 220V	85427
160CF 115V	85438
160CF 220V	85437
Automatic KF10 Vent Valve (see Appendix A.5)	
115 V AC, Normally Open	899838
115 V AC, Normally Closed	899839
240 V AC, Normally Open	899840
240 VAC, Normally Closed	899841
Purge/Vent Valve (see Appendix A.6)	
115V	85518
220V	85519
Adsorption Trap (see Appendix A.7)	
KF®16 Trap	85414
KF25 Trap	85415
Al_2O_3 Adsorbent, 2-liter can	85410
Vibration Damping Bellows (see Appendix A.8)	
63 ISO-K	85425
100 ISO-K	85343
160 ISO-K	85344
100 CF	88595
160 CF	88596
NT150/360 Conversion Kit (see Appendix A.9)	728-40-005

*Contact the factory for information on the DC air cooler for high temperature processes.

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1 — Introduction

Contents

Section	Description	Page

This manual contains installation, operation, description, and service information for the TMP151/361 Turbomolecular Pumps and the NT150/360 Frequency Converter. The pump and converter function together to produce ultra-clean, hydrocarbon-free high vacuum.

This manual doesn't cover the model NT20 converter. See the TMP151/361/600/1000 & NT20 manual (P/N722-78-049) for information on the NT20.

"WARNING"statements in this manual indicate a potential hazard that may result in **serious injury**;

"CAUTION" statements indicate a potential hazard that may result in a **minor or moderate injury or in damage to equipment**.

NOTE: **ASA Flanges** — We refer to some of our intake-flange options as ASA. The bolt pattern of these flanges is compatible with standard 150-pound ANSI (formally ASA) flanges; however our flange doesn't meet ANSI standards because it is designed for vacuum processes rather than for high-pressure applications.

Use the form at the back of this manual when sending a pump to our factory or service centers. It includes instructions on preparing the pump for shipping.

1.1 Brief Description of Turbopump and Converter


WARNING!

Don't use the standard TMP151 or TMP361 for pumping corrosive, toxic, or aggressive gases or for gases that contain dirt or abrasives. Use the TMP151**C** or TMP361**C** model for these applications.

See the front of this manual for important precautions, specifications, and ordering information. See Section 6 for detailed descriptions of the TMP151/361 and the NT150/360.

1.1.1 TMP151/361 & TMP151/361C Turbopump

Turbomolecular pumps are used to evacuate a vacuum chamber or system to the high vacuum region. A turbopump must be used in conjunction with a backing pump to evacuate hydrogen and to avoid overloading the turbopump at higher inlet pressures. Features of the TMP151/361 are summarized below:

- **Grease-lubricated ceramic bearings** — Ceramic bearings are reliable, quiet, and maintenance-free. The bearings are grease lubricated for extended bearing life and unrestricted operating positions. The complete drive assembly including bearings and motor is located in the fore-vacuum space.
- **Dynamic balancing of the turbopump's rotor assembly** — This produces silent running with minimal vibration. Don't modify the rotor or it will affect its precision balancing. Also avoid blows and isolate the pump from heavy vibration which could result in accelerated bearing wear.
- **Standard water cooling and optional air cooling** — (See Appendix A.1 for a description of the optional air-cooling unit.)
- **Thermal protection** — The turbopump motor is protected from overheating by a thermal switch which turns off the frequency converter if the water or optional air cooling is inadequate.
- **Purge and vent ports (see Figure 2-6)** — All turbopump models have a vent port. The TMP151C and TMP361C models also have a purge port. It is important to vent all turbopumps during shutdown to prevent the backing-pump oil from contaminating the turbopump and to prevent premature bearing failure.

  If the pump will be exposed to corrosive or aggressive process gases or gases that contain dirt or abrasives, use the TMP151C or TMP361C model. Seal off its vent port and use dry inert gas to purge and vent the pump through its purge port as described in Section 3.7. The inert gas forms a protective gas seal around the motor/bearing cavity, thus protecting the bearings and grease from corrosive or abrasive attack. A larger capacity backing pump is required to handle the increased gas load resulting from the purging.

- **High-vacuum flange/inlet screen** — The top rotor blade of the turbine is located just below the high-vacuum flange to minimize the loss of conductance due to the impedance of the intake port. A screen in the high-vacuum flange protects the turbopump from foreign objects that could fall into the pump and severely damage the rotor.

1.1.2 NT 150/360 Frequency Converter

The frequency converter converts single-phase, 100-240 V AC, 50/60 Hz power into three-phase, variable voltage, variable frequency power as required by the turbopump's induction motor. The turbopump is turned "on" and "off" by the converter's front panel START and STOP pushbuttons. External control and monitoring devices can be connected to the converter's rear panel terminal block. Other features of this frequency converter include:

- **Universal Applicability** - The standard NT150/360 converter (P/N 85472-3) can be used with the TMP 151, TMP 361, TMP150V, or the TMP360V pump models.

- **LED Display/Self Tests** - Front panel POWER, ACCELERATION, NORMAL OPERATION, and FAILURE indicators show the status of the converter. During normal start-up, all LED indicators turn ON for the first few seconds. As soon as the converter completes the self-tests, all indicators except POWER turn off. When the START pushbutton is pressed, the ACCELERATION LED turns ON and stays ON until the turbopump achieves its rated rotational speed. Then, the NORMAL OPERATION LED lights and the ACCELERATION LED turns off.

  If the converter fails its initial self test, all the LED will stay ON during start-up indicating a converter malfunction. If a problem develops with the converter or the pump during operation, the FAILURE LED lights and the converter shuts down the turbopump. The source of the failure is indicated by the flash rate of the FAILURE LED as summarized in Table 3-D. After the problem is remedied, the converter must be reset by pressing the STOP button or cycling the power.

  You can have the converter do a series of static tests to determine the circuit or component causing the fault. Static tests exercise all the circuitry, one block at a time to aid in troubleshooting. If the converter fails a static test, all the LEDs will light continuously. See Section 5.3 for detailed information on the static tests.

- **No Calibration** - No calibration is required to set the frequency, voltage, or current setpoints in this unit or to compensate for the turbopump's cable length. All are determined by the internal software.

- **Long Cable Drive Capability** - The converter is designed to drive a turbopump at distances as far as 328 feet (100 m). The unit automatically establishes the necessary voltage corrections to compensate for the cable losses and maintain maximum output power.

1.2 *Unpacking and Inspection*

Proceed as follows to unpack and check the turbopump and frequency converter for shipping damages as soon as you receive it.

1. Inspect the outside of each shipping container for visible damage. If you will be making a damage claim, keep the shipping container and packing materials.

CAUTION: Don't remove the protective covers from the turbopump high-vacuum or fore-vacuum flanges until it is ready for connection to the vacuum system. The pump is filled with dry nitrogen to protect it from corrosion and contamination during shipping.

2. Carefully unpack the turbopump and frequency converter and inspect it for damage.

3. If you find any evidence of damage, proceed as follows:

   - Save the shipping container, packing material, and damaged part for inspection.
   - Notify the carrier that made the delivery within 7 days of delivery.
   - File a claim with the carrier for the damage. Any damage in transit is the responsibility of the carrier because all equipment is transported from our factory by private carriers.
   - Contact our Order Services Department in Export, PA or your nearest Leybold representative to order replacement parts.

2 — Installation

This section contains information on how to install the frequency converter and the turbopump. Also included is a procedure which checks the turbopump's direction of rotation (see Section 2.2.8).

Contents

2.1 Utility and Site Requirements

- Ensure the correct AC power source is available for the converter and any accessories. Avoid powering the converter from an AC line source that is noisy from line-voltage drop outs and transient spikes. Also avoid mounting the converter near electrostatic discharge devices which can cause the converter to operate erratically.

- If the turbopump will be located more than 15 ft. (4.5 m) from the frequency converter, additional lengths of pump cable will be required.

- A vent valve (see Appendix A.5) is required for standard applications. A source of dry inert gas and a Purge/Vent Valve (see Appendix A.6) are required for the TMP151C and TMP361C turbopumps if you will be pumping corrosive or aggressive gases or gas containing abrasives or dirt.

- You will need a source of clean tap water, the optional water-flow switch (see Appendix A.3), and 7⁄16-inch hose and clamps for the standard water-cooled turbopump. If tap water isn't available, use the optional Water Refrigeration Unit (see Appendix A.1) or Air Cooling Unit (see Appendix A.1).

- The turbopump requires a backing pump for proper operation. A larger capacity backing pump is required if you will be purging the turbopump with inert gas, or if the turbopump will be operated continuously between 1.3×10^{-3} mbar and its maximum-rated pressure of 1×10^{-1} mbar. Otherwise, the foreline pressure exceeds its maximum of 5×10^{-1} mbar. See Table I for the recommended backing pumps. Contact Leybold for recommendations for your particular process.

- The turbopump must be protected from external shocks or vibration while its rotor is spinning. Bellows are recommended if the turbopump is connected to any vibrating components. Use bellows to connect the turbopump's fore-vacuum port to the backing pump. Refer to Appendix A.8 for information on bellows for the high-vacuum flange.

- In addition to bellows, some mounting hardware is required for installing the turbopump to the vacuum system. See Table 2-A for the P/N's of flange gaskets and clamps for the high-vacuum flange; see our catalog or contact us if your installation requires adapters.

- Ensure that adequate convection cooling is available for the converter (see Section 2.2.5). Its ambient temperature range is 32° to 113°F. If the turbopump is cooled with the optional AC air cooler, temperatures above 95°F at the air intake should be avoided (see Section 2.3.4).

- When installing the turbopump within a magnetic field, ensure that the magnetic induction measured at the surface of the pump housing doesn't exceed 50 gauss [5 mT (millitesla)] in a radial field and 150 gauss (15 mT) in an axial field. If these values are exceeded, the resulting eddy currents might overheat the rotor; therefore, suitable magnetic shielding of the turbopump will be necessary.

- The standard turbopump is radiation resistant up to 10^5 rad. If higher radiation resistance is required, please contact Leybold.

2.2 Frequency Converter Installation

This section includes the following:

2.2.1 AC Voltage and Fuse Selection

! WARNING— Electrical Shock !

To avoid personal injury from electrical shock, ensure that the converter isn't plugged into an AC service outlet during the following procedure.

Voltage selection, fusing, and power connection are accomplished from the rear panel. To select the voltage or change the fuse and plug, see Figure 2-1 and do the following:

1. **Voltage Selection** — Ensure that the printed circuit card is inserted in the connector assembly below the fuse so that the correct AC voltage is visible. The card has four voltages etched on its faces. If the correct voltage isn't visible, turn the card over or reposition it as necessary so that the visible voltage matches your power source.

2. **Fuse** — Ensure that the fuse value corresponds to your applied AC voltage as listed in Figure 2-1. One 5 amp and one 10 amp fuse are supplied with the converter. Fuses are removed by pushing the FUSE PULL mechanism to the left.

3. **Plug** — If your AC service is 240V 60-Hz, remove the standard 120V plug from the converter's linecord and replace it with the spare 250V, 20A right-angle plug provided with the converter.

2.2.2 Converter Bench Checkout

Before installing the converter, check it for proper operation as follows:

1. Ensure that the correct AC voltage is selected at the rear panel power connector as described in Section 2.2.1.

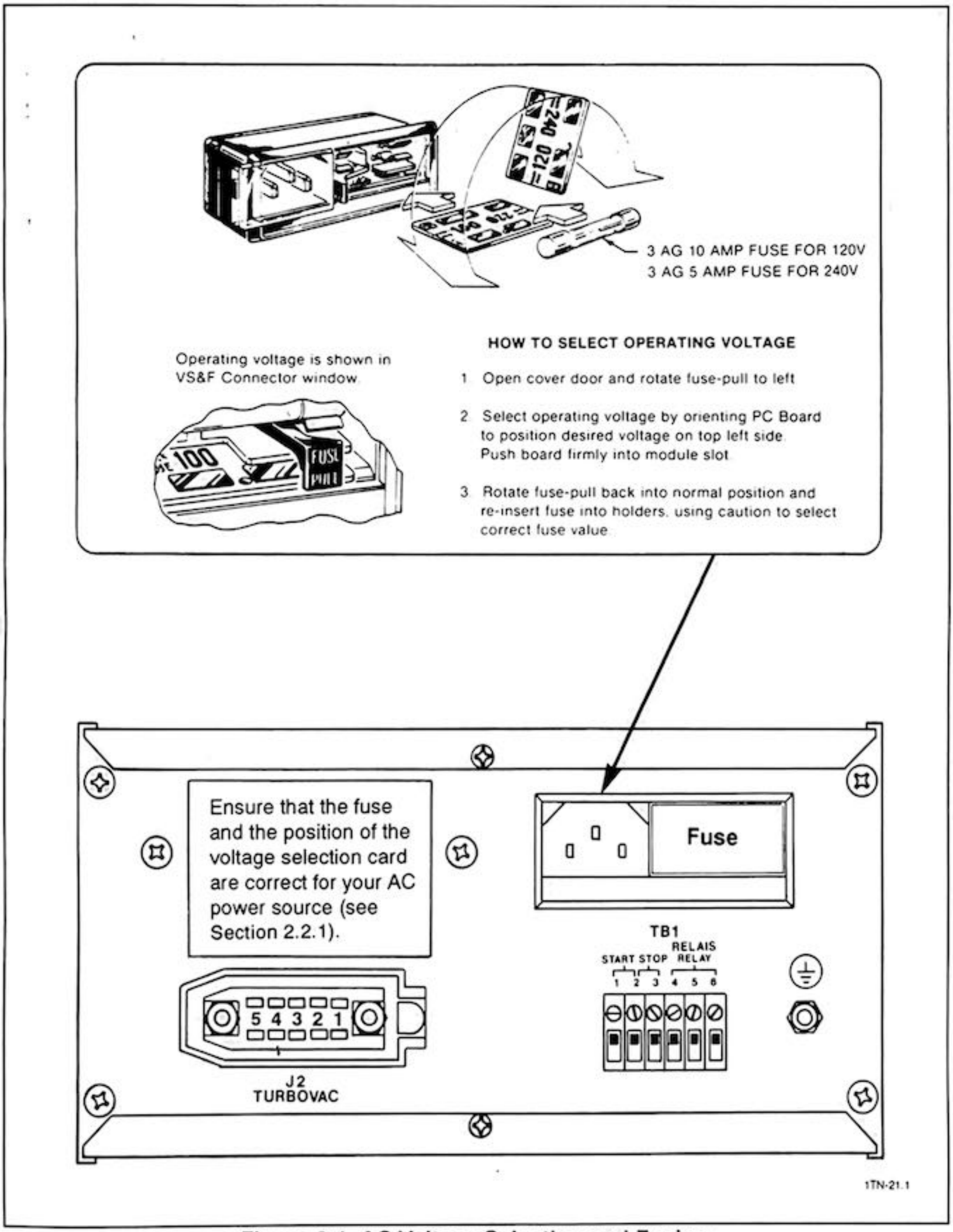


Figure 2-1. AC Voltage Selection and Fusing

Installation

2. Before installing the pump cable, apply power to the converter by plugging the AC power cord into the rear panel power connector (there is no power switch on the converter). Ensure that all four front panel indicators turn ON. The POWER indicator remains ON as long as AC power is applied.

3. The three front panel indicators (FAILURE, NORMAL OPERATION, and ACCELERATION) remain ON for approximately 4 seconds, after which one of the following occurs:

   - The three indicators may flash in sequence; ACCELERATION, NORMAL OPERATION, and FAILURE, in that order. If this is the case, your unit is functioning properly and may be installed.

   - The ACCELERATION indicator may remain ON continuously. This indicates that a jumper wire, normally connected between rear panel terminal block TB1-2 and -3 is missing or making poor contact. Correct this condition and try powering up again. Refer to Section 2.2.3.

   - The three indicators may remain ON continuously as long as AC power is applied. If, after several attempts of powering up, the indicators remain ON, then your unit is faulty and should be returned to Leybold.

2.2.3 Wiring the Converter's Rear Panel Terminal Block (TB1)

2.2.3.1 Initial Wiring

If you DON'T wish to use the remote start-stop features, ensure that a jumper wire is connected between rear panel terminals TB1-2 and TB1-3. See Figure 2-2(a).

2.2.3.2 Remote Starting and Stopping

Terminals TB1-1, -2, -3 are inputs to be used for starting and stopping the turbopump from a remote location. The following are two methods that the converter may be wired for remote starting and stopping:

1. The first method uses two momentary pushbutton switches which function the same way as the converter's front panel START/STOP controls. This wiring arrangement uses a momentary switch closure to start the turbopump, and a momentary switch open to stop the turbopump. Note that a short term power failure will reset the converter and stop the turbopump. Wire according to Fig. 2-2(b).

2. The second method uses a single toggle switch. With this wiring configuration, the turbopump starts when the switch is closed and stops when the switch is open. An advantage of wiring your system in this fashion is that following a short term power failure, the turbopump will automatically restart without operator involvement. Wire according to Figure 2-2(c).

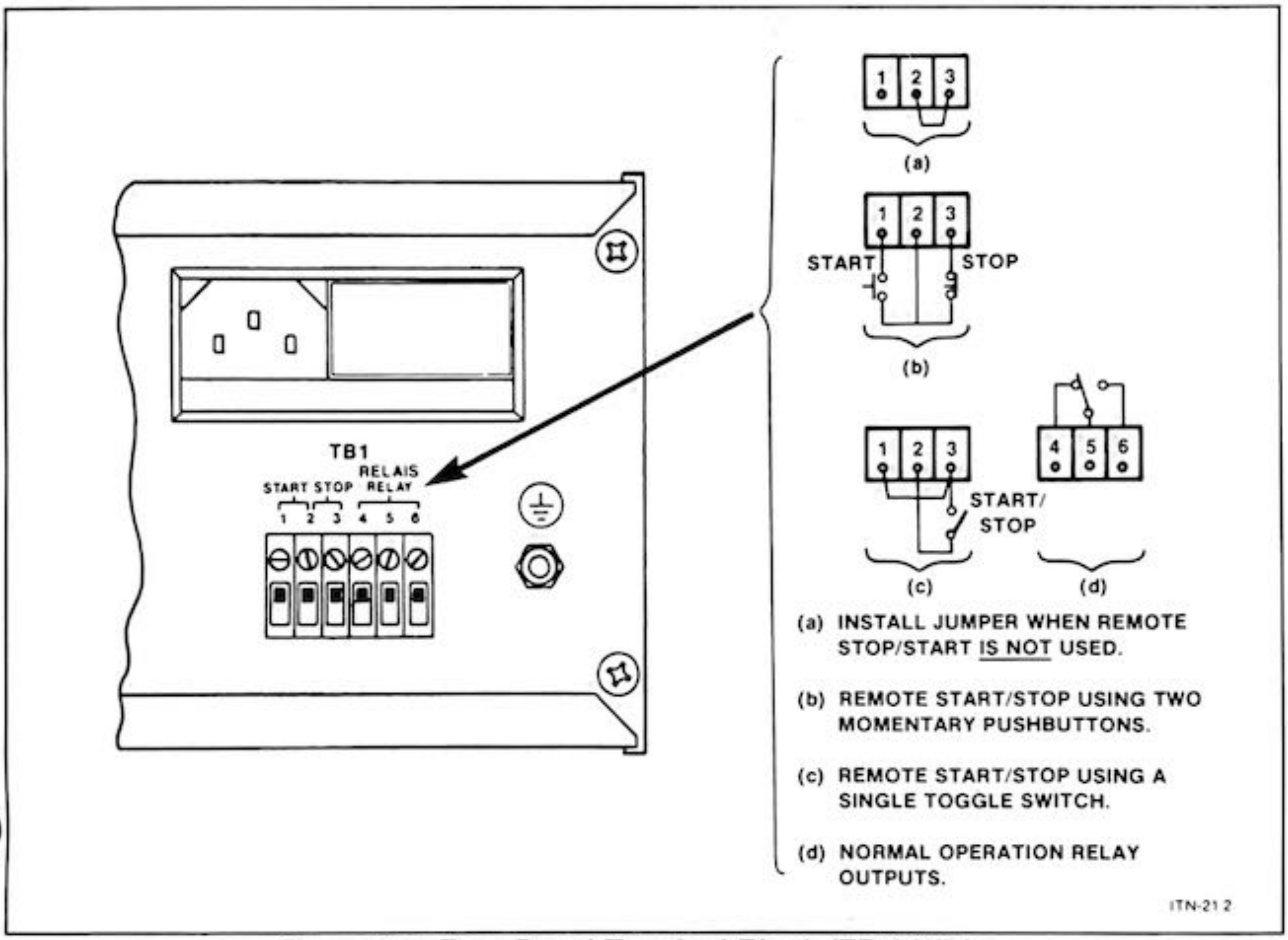


Figure 2-2. Rear Panel Terminal Block (TB1) Wiring

2.2.3.3 Remote Normal Operating Sensing

Rear panel RELAY terminals TB1-4, -5, and -6 are connected to the normally-open and normally-closed contacts of a relay which is energized when the converter switches to normal operation. External indicating or control devices can be activated by these relay contacts which have a maximum rating of 8 amperes at 240 V AC and 24 V DC. See Figure 2-2(d).

Example: A remote normal-operation lamp and its power source can be connected in series with terminals TB-5 & TB-6. This remote lamp will then light when the converter achieves normal operation.

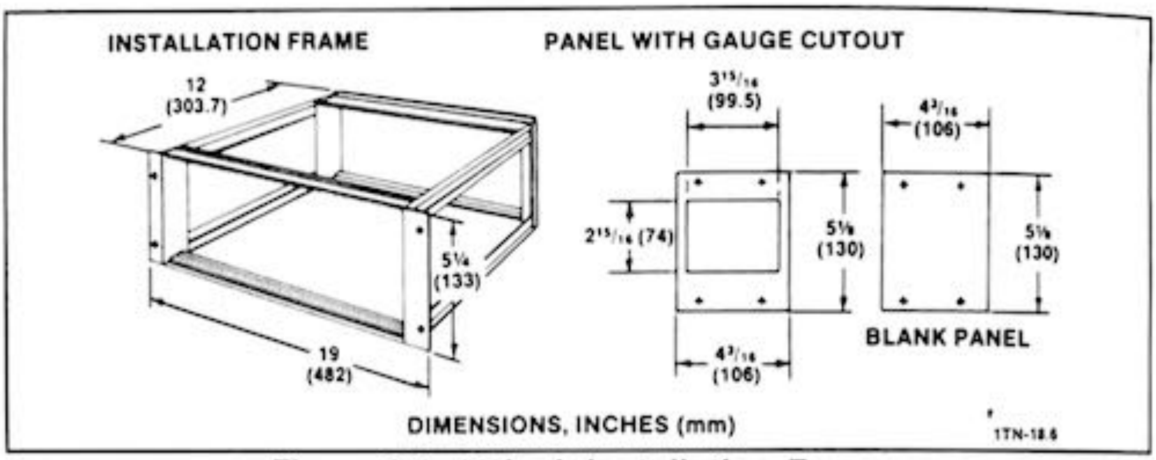


Figure 2-3. 19-Inch Installation Frame

2.2.4 Converter Mounting

The converter is supplied within a cabinet that has four rubber feet, allowing it to be placed on any hard surface up to 15 ft. (4.5 m) away from the turbopump. For greater distances [up to 328 ft. (100 m)], additional pump cable with connectors can be ordered from Leybold.

For mounting the converter in a standard 19-inch rack, an Installation Frame (P/N 16100) should be used (Figure 2-3). The converter is mounted in the Installation Frame using its four front panel mounting holes. See the Leybold catalog for converter dimensional data.

The remaining space within the Installation Frame can then be covered using Blank Panels (Part No. 16102). Or the space can be used for mounting up to two Leybold Vacuum Gauge Control Units, using Gauge Port Cutout Panels (Part No. 16101).

2.2.5 Converter Cooling

The converter depends primarily on convection cooling to maintain an acceptable internal operating temperature. This temperature is easily achieved if air flow around the converter isn't restricted and if ambient air temperatures don't exceed 110°F (45°C).

Use care when installing the unit in an electrical enclosure. The ambient air temperature within the cabinet must not exceed the converter's maximum rated operating temperature and the air flow around the converter package must not be restricted. Provide at least 4 to 5 inches above and below the converter if it is rack mounted.

Excessive operating temperatures due to restricted air flow voids the warranty, may result in premature failure of the converter, and definitely degrades the reliability of the converter.

2.2.6 Grounding

The converter should be grounded to reduce the possibility of electrical shock, and to prevent a malfunction of the converter due to electrical noise.

Use the 4-mm grounding stud on the converter's rear panel to connect the converter chassis to the enclosure in which it is installed, or to a nearby earth ground. Note that this ground connection is in addition to the ground wire contained in the converter's AC power cord.

Installation

Keep the inductance of the ground connection as low as practicable by using a short lead made of copper braid or heavy wire.

2.2.7 Turbopump and Converter Interconnection

The turbopump and converter are interconnected by a standard 15 ft. (4.5 m), 6-conductor pump cable which is supplied with the converter. Note that cable lengths of up to 328 ft. (100 m) are possible without any modifications to the converter. Additional pump cable with connectors can be ordered from Leybold.

Connect the cable's rectangular plug (at an angle) into the converter's TURBOVAC J2 connector so that the plug's tab mates with the slot in the connector. Then push the cable-end of the plug until the plug snaps in place.

Insert the octal plug on the other end of the cable into the mating connector on the turbopump ensuring that the key and keyway of these connectors are aligned.

2.2.8 Checking the Turbopump's Direction of Rotation

Before installing the turbopump, check its rotation direction as follows:

! WARNING — Electrical Shock !

This equipment has voltages which are dangerous and may be fatal if contacted. Use extreme caution when any of its protective covers are removed. To reduce the possibility of electrical shock, always connect the equipment to a low impedance ground.

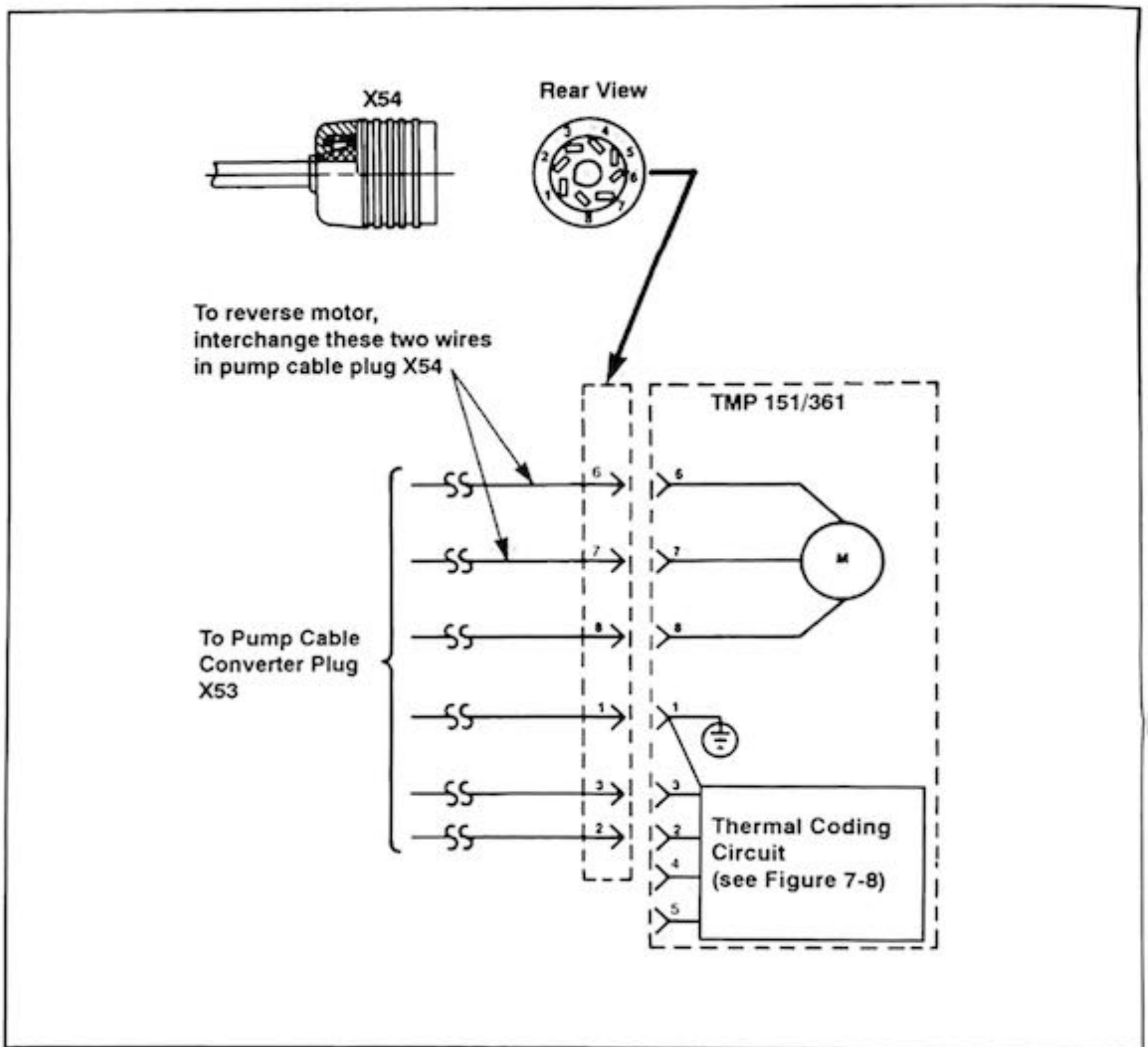


Figure 2-4. Rewiring the Pump Cable to Change the Rotation

CAUTION: Before plugging the converter into an AC service outlet, ensure that the converter has been set up to operate from the applied AC line voltage, and that the correct fuse is installed as described in Section 2.2.1.

1. Install the pump cable between the turbopump and converter as described in Section 2.2.7.

2. Plug the converter into an AC service outlet. Observe that the front panel POWER indicator should be ON.

3. Press START, observe rotor rotation through the high-vacuum flange, then press STOP.

4. The rotor should be turning clockwise (as observed through the high-vacuum flange). If the rotor is turning in the wrong direction, proceed as follows:

   a. Unplug the converter from the AC service outlet.

   b. Disassemble the pump cable's round octal plug.

   c. Interchange the wires connected to plug terminals 6 and 7 (see Figure 2-4).

   d. Reassemble the octal plug and repeat steps 2 through 4 to ensure that the rotor is turning in the correct direction.

5. After completing this procedure, unplug the converter. If the turbopump isn't being installed at this time, remove the pump cable(s) and place the turbopump back into its protective shipping material and store in a dry location.

2.3 Turbopump Installation

This section contains the following:

Figure 2-5 is a diagram of a typical pumping system containing a turbopump.

To install the turbopump, you must make connections to its high-vacuum flange, fore-vacuum port, and water nozzles (water-cooled turbopumps only).

For standard applications, you should add a valve to the vent port as described in Section 2.3.6.1.

For pumping process gas that are corrosive or aggressive or that contain abrasives or dirt, you must use a TMP151C or TMP361C model; connect a purge/vent valve and a source of inert gas to the purge port as described in Section 2.3.6.2.

2.3.1 Turbopump Mounting Positions

These grease-lubricated turbopumps can be mounted and operated in any position.

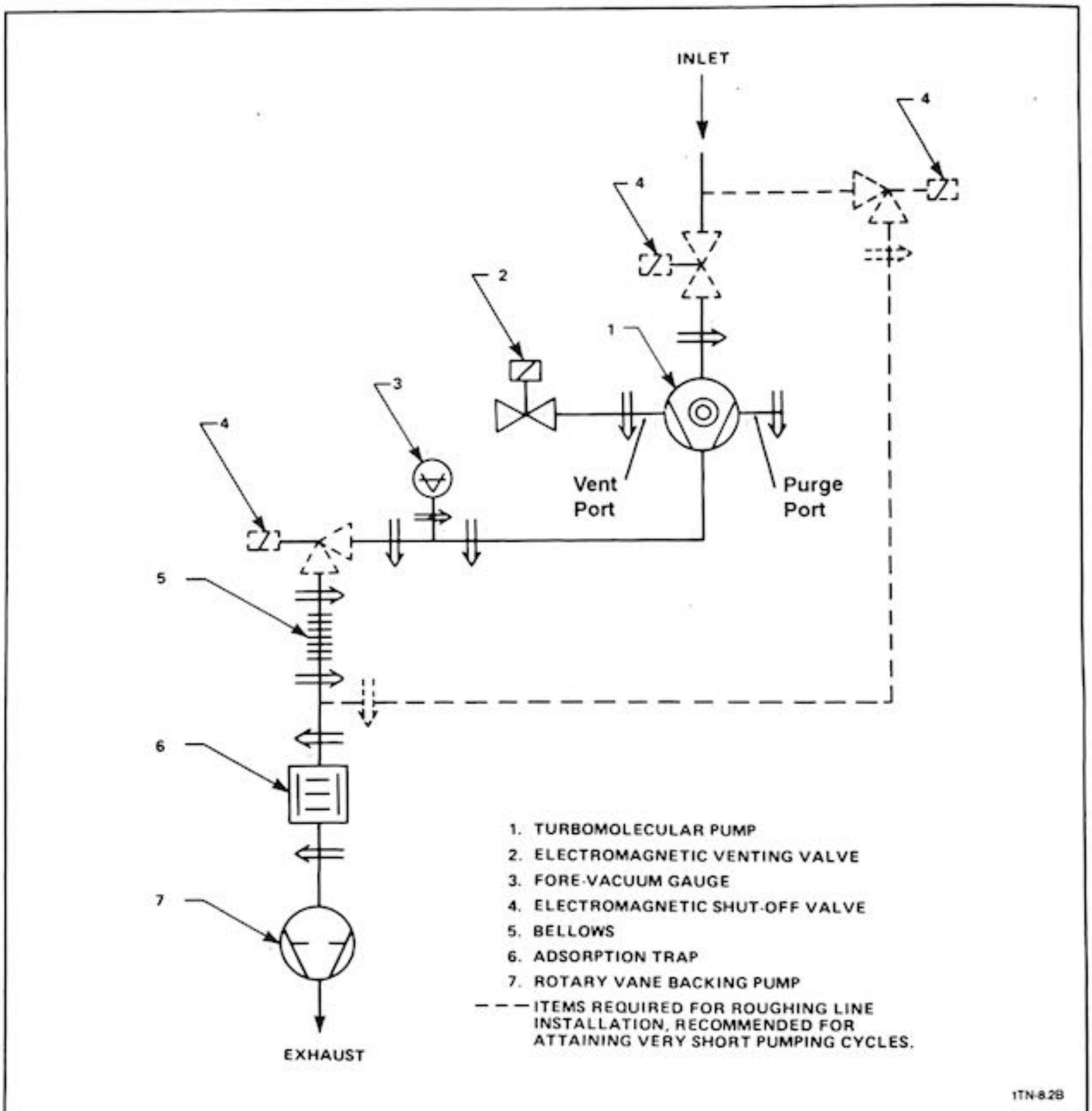


Figure 2-5. Typical Installation Schematic

2.3.2 High-Vacuum Flange Connection

WARNING!

Ensure that the turbopump's high-vacuum flange is bolted or clamped securely to the vacuum system. If the turbopump crashes and the flange isn't bolted or clamped, rotor blades could fly out and cause injury or damage.

The high-vacuum flange of the TURBOVAC is either ASA, ISO-K, or CF.

ASA-flanged pumps are supplied without mounting hardware. See Table 2-A for the part number of the required sealing disc.

NOTE: The bolt pattern of our ASA flange is compatible with a standard 150-pound ANSI (formally ASA) flange; however our flange doesn't meet ANSI standards because it is designed for vacuum processes rather than for high-pressure applications.

ISO-K flanged turbopumps are supplied with a centering ring, an O-ring, an outer ring, and two of the four flange clamps (P/N 26701) required for the high-vacuum connection. If not already done, fit the O-ring evenly over the centering ring without twisting the O-ring; then add the outer ring. Insert the assembly between the pump's high-vacuum flange and your system's flange. Use four clamps to secure the flange connection. Adapters are available to connect ISO-K flanges to ASA, ISO-F, or DIN type flanges. See our catalog for more information.

CF-flanged pumps are required for ultra-high vacuum applications. Ensure that there aren't any fingerprints or other residue in the pump's high-vacuum area that would prolong pumpdown; wipe with reagent alcohol as necessary. To achieve the lowest possible ultimate pressure, CF flanges should be baked out (see Appendix A.4) and the copper gaskets should be replaced each time you disconnect the flange. No mounting hardware is supplied with the CF flanged pumps. See Table 2-A for the part number of the required copper gasket.

Table 2-A— Part Numbers of Gaskets and Clamps for the High-Vacuum Flange

ASA Sealing Discs	ISO-K			CF Copper Gaskets
		Clamps (set of 4)	Centering Ring	
2-inch ASA - 910-181-614	63 ISO-K -	26701	88705	100CF - 83945-1
4-inch ASA - 910-181-617	100 ISO-K -	26701	88706	160CF - 83946-1
	160 ISO-K -	26701	88707	

TMP151C

Figure 2-6. Turbopump Connections (TMP151C pump model shown)

In many cases the turbopump is mounted directly by its high-vacuum flange to the vacuum system.

Connecting vibration-damping bellows to the pump's high-vacuum flange is necessary only if this flange is connected to a system that is vibrating heavily or to instruments that are highly sensitive to vibration. Vibration-damping bellows are available for the most of pump models that have an ISO-K or CF high-vacuum flange (refer to Appendix A.8). In addition to absorbing vibration, the bellows listed in Table IV are strong enough to support the weight of the turbopump when mounted vertically. However, additional structural support is required for other mounting positions. Don't use bellows that can't support the weight of your turbopump model.

Before making the high-vacuum connection, remove the shipping cover and ensure that the inlet screen is inserted into the turbopump's high-vacuum flange. Also ensure that all the sealing surfaces are clean.

2.3.3 Fore-Vacuum Port Connection

A 25KF clamp and centering ring with O-ring are included with the pump. Assembly information for this and other types of vacuum fittings is located in the Leybold Catalog.

You must install an adequate backing pump at the turbopump's fore-vacuum port to achieve fast pump down times and low operating pressures. To achieve the turbopump's rated ultimate pressure, the backing pump must be capable of producing a pressure of 1×10^{-3} mbar at the turbopump's fore-vacuum port.

If you will be purging the turbopump with inert gas, you will need a larger capacity backing pump to handle the increased gas load. We recommend a TRIVAC BCS. It is constructed to withstand corrosive gases and has an optional inert-gas purge system.

See Table I for recommended backing pumps. The recommended backing pump can vary widely depending on the gas load, the required pumpdown time, and the conductance of the foreline. Contact Leybold for recommendations for your particular process.

The recommended TRIVAC backing pumps have an internal anti-suckback device which automatically closes the fore-vacuum line when the backing pump is switched off. This device prevents oil from being sucked out of the backing pump and into the turbopump during shutdown or during a power failure. If another type of backing pump is used, install a vent/isolation valve that seals off the backing pump's inlet during shutdown or during a power failure. We recommend using the Leybold SECUVAC® valve.

To ensure that the fore-vacuum space of the turbopump remains free from oil vapors during operation, we recommend installing an adsorption trap in the fore-vacuum line. See Appendix A.7 for information on the adsorption trap.

To prevent vibrations from being transmitted from the backing pump to the turbopump, use bellows or flexible tubing to connect these two pumps. Vibrations can result in premature failure of the turbopump's bearings.

2.3.4 Turbopump Cooling

The turbopump is normally water cooled using a clean source of tap water connected to its water nozzles (see Figure 2-6). Installation instructions for water cooling are given in Section 2.3.4.1.

The optional Air Cooling Unit should be used when tap water isn't available or if the water is contaminated or the water temperature is above 86 °F (30°C). The maximum ambient temperature for a pump being baked out with air cooling is 95°F (35°C) while the ambient temperature for unheated air-cooled pumps at operating pressures lower than 10^{-3} mbar is 113°F (45°C).

The Water Refrigeration Unit should be used if tap-water cooling isn't possible and the ambient temperature exceeds limits for air cooling. Refer to Section 2.3.4.3 for installation instructions for the water refrigerator.

2.3.4.1 Water Cooling Connection

Connect a source of clean tap water to one of the turbopump's water nozzles; it doesn't matter which one is used (see Figure 2-6). The minimum cooling water consumption is about 0.3 l/minute (5.3 gal/hr). The higher the cooling-water temperature, the higher the required cooling-water flow. The maximum water pressure is 60 psig. Use 13⁄32-inch (10-mm) ID hose to make the water connection. Connect a second hose from the nearest water drain to the turbopump's other water nozzle. Use hose clamps to secure both hoses to the water nozzles.

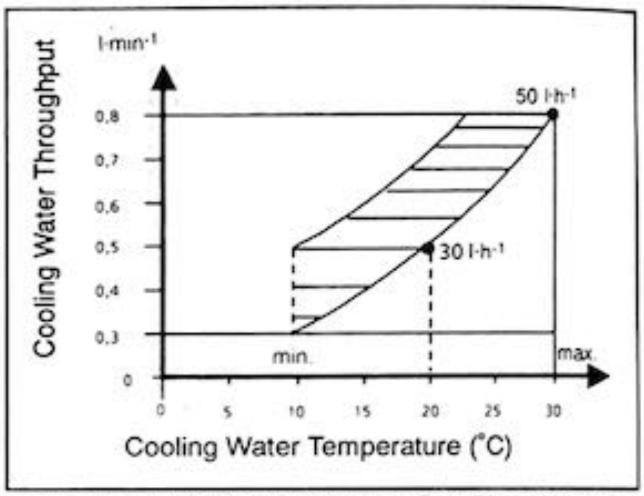


Figure 2-7. Determining Cooling Water Throughput

To ensure that clean water is being fed through the turbopump, we recommend installing a fine mesh strainer or automotive fuel filter in the cooling-water supply line. Check this filter periodically to ensure it isn't clogged.

We also recommend installing the optional Water-Flow Switch in the cooling-water **drain** line as described in Section 2.3.5.

2.3.4.2 Installing the Optional Air Cooler

Where water cooling isn't possible, the Air Cooler (refer to Appendix A.1) can be used to cool the turbopump. Mount the air cooler on the side of the turbopump as shown in Figure A-1. Ensure that the turbopump's cooling-air intake is unobstructed and isn't near the heated air flowing from the backing pump. Maintain at least 8 inches (20 cm) between the fan and the nearest wall.

Connect the Air Cooling Unit to a source of either 115 or 220 V AC (depending on model ordered), single-phase power that can be switched on and off simultaneously with the turbopump. See the Air Cooling Unit's electrical specification label for the specific voltage required. If you have the DC air cooler, see the instructions that come with it for installation information.

2.3.4.3 Installing the Water Refrigeration Unit

Where neither water cooling nor air cooling is possible, the Water Refrigeration Unit (see Appendix A.2) can be used to cool the turbopump. Connect the water lines of the Water Refrigeration Unit to the water nozzles of the turbopump using 13⁄32-inch (10-mm) ID hose. Use hose clamps to secure both hoses to the water nozzles. Detailed installation and operating instructions are supplied with the Water Refrigeration Unit.

2.3.5 Installing the Water-Flow Switch

In addition to the installation instructions presented below, also refer to the instruction sheet supplied with the Water-Flow Switch.

1. Install the Water-Flow Switch in the turbopump's water-drain line using the switch's Low-Flow-Range "In" and "Out" connections [0.1 – 1.0 gal/minute (0.4 – 3.8 ltr/min)]. These connections are 1/4-inch NPT female. The unused connections should be sealed using the plugs supplied with the switch. Observe that the water-switch rotor should spin in a clockwise direction when the water lines are correctly installed.

2. Adjust the potentiometer inside the Water-Flow Switch to shut down the turbopump at a minimum water flow rate of 0.1 gal/min (0.4 l/min).

   NOTE: There is hysteresis in the switching process causing the trip point to be slightly different for rising and falling flow rates. For a precise measurement of the trip point, make the measurement while reducing the flow rate so that it falls through the trip point.

3. Electrically connect the Water-Flow Switch to the remote STOP terminals on the rear panel of the converter as follows (see Figure 2-2):

   - If a jumper is installed between remote STOP pins 2 and 3 of terminal X1, remove this jumper and connect the normally open (N.O.) relay contacts of the Water-Flow Switch between these two terminals.

   - If a remote stop switch is connected to pins 2 and 3 of terminal X1, connect the normally open (N.O.) relay contacts of the Water-Flow Switch in series with the remote stop switch.

In operation, as long as there is sufficient water flowing through the turbopump, the Water-Flow Switch will be closed and allow the turbopump to operate normally. However, if the water flow should fall below 0.1 gal/min (0.4 l/min), this switch opens and causes the converter to shutdown the turbopump.

2.3.6 Installing Vent and Purge Devices

Turbopumps should be vented to atmospheric pressure immediately when switched off to prevent oil from backstreaming from the foreline or from the turbopump's fore-vacuum space into the high-vacuum sections of the system. Venting also prevents premature bearing failure.

The standard TMP151/361 pump models have a 10KF vent port on the pump housing. The corrosive-series TMP151C and TMP361C pump models have a 10KF purge port in addition to the vent port; the lower 10KF port on the base flange is the purge port (see Figure 2-6).

If your pump will be exposed to corrosive or aggressive process gases or to process gases containing abrasives or dirt, you must use the TMP151C or TMP361C pump model; seal the vent port with a blank flange, and purge and vent through the purge port as described in Section 2.3.6.2.

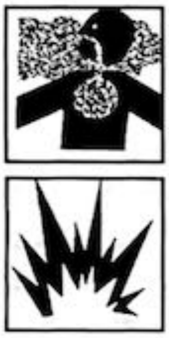
2.3.6.1 Installing a Vent Valve for Standard Applications

For standard applications, install the optional vent valve as follows:

1. **For the TMP150C and TMP360C pump models only**, ensure that the purge port is sealed with its blank flange (see Figure 2-6). The standard TMP151 and TMP361 pump models don't have a purge port.
2. Ensure that the sintering nozzle is in place inside the vent port. The nozzle controls the flow of venting gas in accordance with the pressure rise graph (Figure 3-3).
3. Use the 10KF centering ring and clamp ring to connect the vent valve to the turbopump's vent port (see Figure 2-6).
4. Either leave the vent valve's other 10KF port open to the atmosphere, or preferably, connect it to a bottled source of venting gas such as dry nitrogen. DO NOT exceed a venting pressure of 7 psig when using a pressurized venting line. Ensure that the venting gas is dry to avoid condensation in the pump.
5. Wire the vent valve to appropriate AC power source such that the valve will close when the turbopump is running. Then when the turbopump is shut down, the valve automatically opens to allow the venting gas to enter the turbopump through its vent port. Both normally-closed and normally-open valves are available (see Table IV in the front of this manual.)

2.3.6.2 Connecting Purge/Vent Gas for Corrosive Applications

You must use a TMP151C or TMP361C pump model when pumping corrosive, toxic, or aggressive gases or to pump gas containing abrasives or dirt. Purge and vent with inert gas through the purge port. Purging and venting with dry inert gas such as nitrogen protects the grease and the bearing from harmful process gases.



WARNING!

It is essential that the Purge/Vent Valve is connected to a source of inert gas or is sealed when pumping toxic or reactive process gas. The Purge/Vent Valve isn't a shutoff device. If its inlet port is left open, toxic process gas could escape after shutdown or air could enter the pump and have a dangerous reaction with aggressive process gas.

For corrosive application, install the optional Purge/Vent valve as follows (see Figures 2-6):

1. Ensure that the vent port is sealed with its blank flange (see Figure 2-6).

2. Ensure that the sintering nozzle is in place inside the purge port. The nozzle controls the flow of venting gas in accordance with the pressure-rise graph (Figure 3-3).

3. Use the 10KF centering ring and clamp ring to connect the Purge/Vent Valve to the turbopump's purge port. Ensure that the Purge/Vent Valve is mounted so that the arrow sticker on the valve housing points toward the turbopump.

   The standard TMP 151/361 pump models don't have a purge port and thus can't be used for these applications.

4. Connect the solenoid of the Purge/Vent Valve through an on/off switch to the correct power source. In operation, the valve's solenoid should be energized when the turbopump is running, and should be de-energized when the turbopump is shutdown.

   If you will also be venting the vacuum chamber, ensure that the trubopump is vented before or at the same time as the vacuum chamber.

   Ensure that venting continues long enough to prevent the turbopump's bearings from being exposed to particles or reactve gases from the process chamber or turbopump.

Table 2-B - Purge Gas Inlet Pressures & Flow Rates*

Purge Gas Inlet Pressure (psig)	Standard Purge Gas Flow (sccm)
0.0 psig	12.0 sccm
2.0 psig	13.6 sccm
5.0 psig	16.0 sccm
7.5 psig (max. recommended)	18.1 sccm

*If the purge pressure is above 14.5 psig (2 bar), it could damage the filter on the optional purge/vent valve in addition to causing high purge-gas flow.

5. Connect the input side of the Purge/Vent Valve through a regulator and valve to a bottled source of dry inert gas. Ensure that the supply of inert gas is continuous to avoid exposing the grease and bearings to harmful gas, and ensure that the purge gas is dry to avoid condensation in the pump. The absolute moisture content of the purge gas shouldn't exceed 10 ppm.

   Note that the Purge/Vent Valve has been sized to allow an inert-gas flow rate of 12 standard cubic centimeters per minute (sccm) at atmospheric pressure. This flow rate maintains the motor cavity at a pressure that is about ten times higher than the normal foreline pressure. Other flow rates at elevated purge-gas inlet pressures are listed in Table 2-B. Be certain that the backing pump is capable of handling this purge gas flow, in addition to the normal throughput of the turbopump and any expected process gas inflow.

6. Disengage the locking pin on the Purge/Vent Valve body by turning it to the horizontal position; when the locking pin is pressed in and turned to the vertical position, the vent portion of the valve can't open.

2.3.7 Installing the optional CF Flange Heater

Use the CF flange heater when operational pressures of 10^{-8} mbar or lower are required (see Figure A-4). It can't be used on pumps with ISO-K high-vacuum flanges because their pump housings are made of aluminum; the pump housing on CF-flanged pumps are stainless steel.

Position the flange heater around the pump's CF high-vacuum flange and secure it in place by tightening its clamp screw.

Connect the flange heater's power cord to a source of either 115 or 220 VAC (depending on model ordered), single-phase power. It has a thermal switch that keeps the CF flange temperature within the acceptable range. Power consumption is 100 watts for the 100CF flange heater, and 150 watts for the 160CF flange heater.

3 — Operation

WARNING!

Death or serious injury can result from the improper use or application of this pump. If the pump will be exposed to toxic, explosive, pyrophoric, highly corrosive, or other hazardous process gases including greater than atmospheric concentrations of oxygen, contact Leybold for specific recommendations.

This section contains information on how to start, operate, and shutdown the TMP 151/361 vacuum pumping system. Information on turbopump operating temperatures, purging, venting, and bakeout is also presented.

Contents

3.1 Operating Temperatures and Pressures

Table 3-A summarizes the temperatures for the turbopump and converter.

Table 3-A — Temperatures

Normal Operating Temperature at Ultimate Pressure*	
With water cooling	95°F (35°C)
With air cooling and air temperature of 68°F (20°C)	105°F (40°C)
Maximum Temperature at High-Vacuum Flange†	212°F (100°C)
Maximum Temperature at Rotor†	175°F (80°C)
Maximum Temperature at Fore-Vacuum Port	175°F (80°C)
Maximum Ambient Temperature for an Air-Cooled Pump‡	
When being baked out	95°F (35°C)
When operating below 10^{-3} mbar without bakeout	113°F (45°C)
Maximum Operating Temperature*	130°F (55°C)
Ambient Temperature Range for Frequency Converter	32° to 113°F (0° to 45°C)
Storage Temperature Range for Frequency Converter	-100° to 185°F (-40° to 85°C)

*Measured in the small bore just below the purge port on the turbopump's base flange (see Figure 2-6).
†Use shields to avoid heat radiation from the vacuum chamber if necessary.
‡Avoid air temperatures exceeding 95°F at the air intake of the optional AC air cooler. A "DC" air cooler is available for use at higher temperatures. However, water cooling must be used if the operating temperature* exceeds 130°F.

There is a thermal switch inside the turbopump's base housing near the motor coil that shuts down the turbopump if the temperature exceeds 158°F (70°C).

To quickly reach pressures of 10^{-8} mbar, we recommend baking out the CF-flanged pump and the vacuum chamber. The flange heater's thermal switch maintains the flange temperature within the acceptable range.

Don't use a bakeout jacket; bakeout jackets can damage the heat-sensitive parts in the bearing.

Table 3-B summarizes the pressure characteristics of the turbopump. To achieve an inlet pressure of $<10^{-10}$ mbar, you must use the pump models that have a CF high-vacuum flange, the high-vacuum flange must be baked out, and the backing pressure must be at least 1×10^{-3} mbar.

Table 3-B — Pressures

Ultimate Pressure for Turbopumps with a CF High-Vacuum Flange	$<10^{-10}$ mbar
Ultimate Pressure for Turbopumps with an ASA or ISO-K High-Vacuum Flange	$<10^{-9}$ mbar
Fore-Vacuum Pressure Needed to Achieve the Ultimate Pressure	$<1 \times 10^{-3}$ mbar
Starting Pressure (maximum pressure at the fore-vacuum port)	
TMP151 and TMP151C	<1 mbar
TMP361 and TMP 361C	$<5 \times 10^{-1}$ mbar
Maximum Pressure at the High-Vacuum Flange	
TMP151 and TMP151C	5×10^{-1} mbar
TMP361 and TMP 361C	1×10^{-1} mbar

Operation

3.2 NT150/360 Front Panel Controls and Indicators

The NT150/360 front panel controls and indicators are shown in Figure 3-1 and their functions are listed in Table 3-C.

Table 3-C — Front Panel Control and Indicator Functions

Pushbutton Controls	Function
START	Press the START button to initiate acceleration of the turbopump. The converter may be started even if it is connected to a turbopump whose rotor is already turning.
STOP	Press the STOP button to turn off power to the turbopump and to reset the converter's failure latch circuit. When a fault is detected, the converter remains latched in a nonfunctioning state until the STOP button is pressed. If the FAILURE LED lights continuously, you must unplug the convert and reconnect it to reset it.
Indicators	**Function**
HOURS Meter	Indicates the total time of turbopump operation. The meter increments once when power is applied and once every 1/100th hour for as long as the turbopump is being driven. Note that the rightmost two digits (colored red) indicate tenths and hundredths hours.
POWER LED (yellow)	Indicates the presence of power to the converter's electronics. If no other indicators are ON, then the converter is operating in its idle mode.
ACCELERATION LED (green)	Indicates that the turbopump is accelerating to rated speed. Acceleration time may vary anywhere from a few seconds to a maximum of 10 minutes depending on the initial rotational speed and load of the turbopump.
NORMAL OPERATION LED (yellow)	Indicates when the turbopump has attained its rated rotational speed.
FAILURE LED (Red)	Indicates the detection of a fault and subsequent turbopump shutdown. Four types of faults are indicated by the flash rate of this indicator (see Table 3-D). The failure mode is a latched mode; after the fault condition is remedied, you must reset the converter by pressing the STOP button or Cycling the AC power.

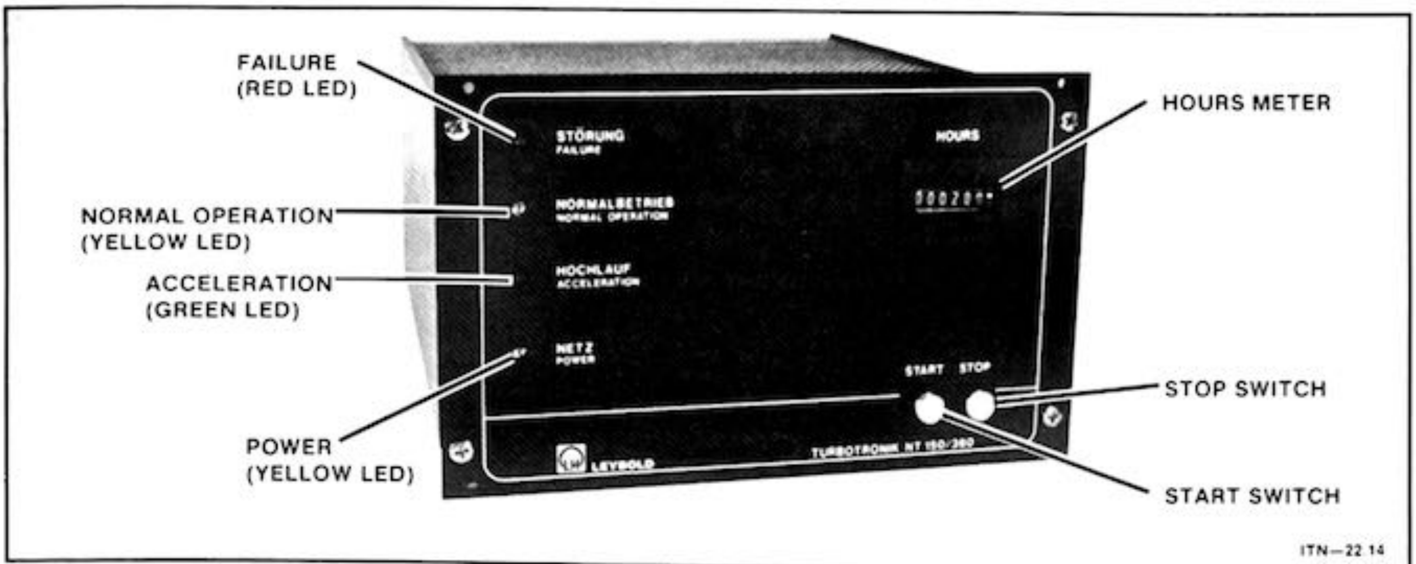


Figure 3-1. NT150/360 Front Panel Controls and Indicators

Table 3-D— Fault Flash Rate Code for FAILURE LED

Flash Rate	*Fault*	*Reset Procedure*
Constant	Output Short*	Cycle AC Power*
1 Hz (once/second)	Pump Overload†	Press STOP Button
2 Hz (twice/second)	Pump Overtemperature‡	Press STOP Button
4 Hz (4 times/second)	Internal#	Press STOP Button

* Output Short - refers to the short circuiting of any one of the three-phase motor outputs to either of the other phases or to ground. To reset the converter when the FAILURE LED is lit constantly, you must unplug the converter and reconnect it.

† Pump Overload - refers to an unusually low output frequency, indicating a probable overload of the pump.

‡Pump Overtemperature - indicates a probable motor overtemperature. It is detected by a thermal switch inside the motor housing.

#Internal - indicates a probable failure of the converter electronics.

Operation

3.3 Start-up

Proceed as follows to start the turbo pumping system:

1. Before start-up, ensure that the frequency converter and turbopump have been correctly installed as described in Sections 2.2 and 2.3.

2. Plug the converter into an AC service outlet.

   The converter spends the first few seconds performing initialization and self-test routines during which its outputs are turned off, and all four front panel LED indicators are turned ON. As soon as the converter completes the initialization and self-test tasks, all indicators except POWER are turned off. If all the indicators stay ON for more than a few seconds, then the converter has failed to perform the above tasks. This indicates a defective unit.

3. Ensure that the optional Venting Valve is closed.

   For TMP151/361**C** models that are exposed to corrosive or aggressive process gases or gases that contain dirt or abrasives, open the purge-gas line and ensure that the optional Purge/Vent Valve is energized.

4. Turn ON the turbopump's cooling-water flow or its optional Air-Cooling Unit.

5. Start the backing pump.

6. **If the turbopump has been operated in the past two months**, skip this step and proceed to Step 7.

   If the turbopump is new or hasn't been operated in the past two months, jog it as follows it to ensure that grease is properly distributed in the bearings:

   a. Press the converter's START button and allow the turbopump to accelerate for about 15 seconds; then, press the converter's STOP button and wait for about 5 minutes before proceeding to Step b.

   b. Press the converter's START button and allow the turbopump to accelerate for about 30 seconds; then, press the converter's STOP button and wait for about 5 minutes before proceeding to Step c.

   c. Press the converter's START button and allow the turbopump to accelerate for about 45 seconds; then, press the converter's STOP button and wait for about 5 minutes before proceeding to Step 7.

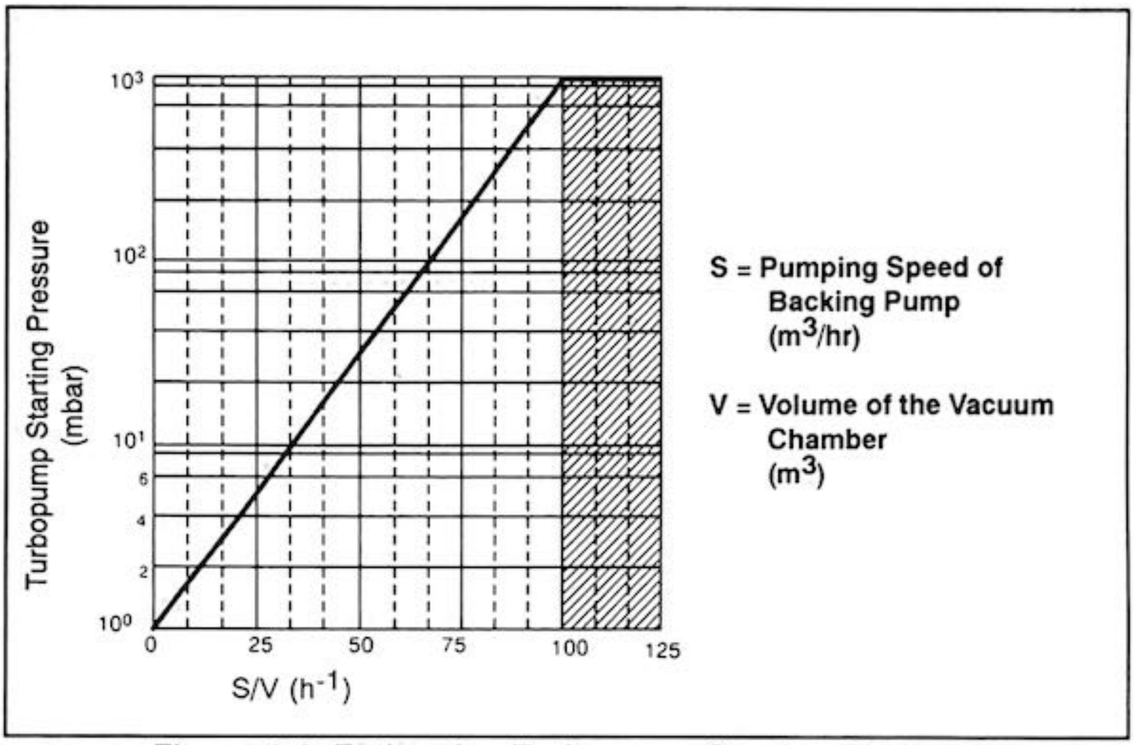


Figure 3-2. Estimating Turbopump Starting Pressure for Large Chambers

7. Determine when to start the turbopump as follows:

The turbopump can normally be started after the foreline pressure reaches 5×10^{-1} mbar. If the turbopump has been run within the past two months, it can be switched ON at the same time as the backing pump provided that the chamber is small enough to be evacuated to 5×10^{-1} mbar within 10 minutes.

If you know the backing pump speed **S** (m^3/hr) and the chamber volume **V** (m^3), you can determine when to start the turbopump as follows:

If S/V >100/hr, then you can start the turbopump and the backing pump at the same time.

If S/V $\leq$ 100/hr, then you must start the backing pump or a roughing pump before starting the turbopump; otherwise, the turbopump may not accelerate fast enough to avoid an overload failure. Refer to the graph (Figure 3-2) to estimate the start-up pressure for the turbopump when evacuating large volumes. Roughing can be accomplished either through the turbopump while it is at a standstill, or through a separate roughing line. However, if you rough the chamber through the turbopump, you must install an adsorption trap in the foreline to prevent oil from contaminating the turbopump and vacuum chamber.

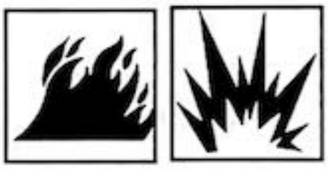
8. Start the turbopump by pressing the converter's START pushbutton. The converter's ACCELERATION indicator should light. (The turbopump can also be remotely started; refer to Section 2.2.3.2).

9. If operational pressures in the 10^{-8} mbar range are required, bakeout the vacuum chamber and use the optional CF flange heater to bakeout the turbopump as described in Section 3.4. We don't recommend using a bakeout jacket on the pump housing because the high temperatures could damage the bearing.

10 As soon as the turbopump achieves its rated rotational speed, the NORMAL OPERATION indicator lights and the ACCELERATION indicator turns off. (Remote normal operation sensing is possible by using the normal-operation relay outputs at the rear of the converter; refer to Section 2.2.3.3).

3.4 Operation

WARNINGS!



DON'T pump oxidizers or higher than atmospheric concentrations of oxygen with the TMP151/361 or TMP151/361C, or with any pumps containing hydrocarbons. Oxygen can react with the hydrocarbon grease in the turbopump's bearings resulting in a fire or an explosion.

Many process gases are toxic, corrosive, or explosive. Some hazardous process gases have dangerous reactions with the air or with the hydrocarbon grease in the pump. In addition, some gases can react with air, moisture, or grease in the pump to form damaging deposits, acids, or tar. The harmful effects of such process gases can be reduced by purging and venting the pump with nonreactive gas such as dry nitrogen (see Section 3.7).

CAUTION: Never operate the turbopump without the inlet screen installed in its high-vacuum flange. This screen prevents small foreign objects from entering the pump and causing major damage to the rotor. Any damages that result from foreign objects entering the rotor region are excluded from the warranty.

Sudden, heavy external vibration and blows or shocks during pump operation should be avoided.

3.4.1 Failures

If the turbopump loading is increased after reaching normal operating speed, the converter increases first the drive current and then the drive voltage in an attempt to maintain full rotational speed. If full rotational speed can't be maintained, the converter begins to lower the drive frequency to maintain maximum motor torque.

If the load on the turbopump is excessive and the drive frequency drops below about 150 Hz, an overload fault is recognized. The converter then enters the failure mode and shuts down the turbopump.

The converter also enters the failure mode if it can't bring the turbopump up to its rated rotational speed within 10 minutes of acceleration.

In addition, the converter enters the failure mode if the turbopump's motor temperature becomes excessive as detected by the thermal switch mounted within the motor housing, or if the converter senses a fault within itself.

The fault condition leading to the failure mode is indicated by the flash rate of the FAILURE indicator (see Table 3-D).

The failure mode is a latched mode, which means that the converter remains in the failure mode until it is manually unlatched by an operator. The failure mode is usually unlatched by pressing the STOP button except when the FAILURE LED is lit continuously. When the FAILURE LED is constantly lit, you must unplug and reconnect the plugs to reset the converter.

3.4.2 Restarting After an Interruption of Operation

If the turbopump is interrupted during operation by pressing the STOP button or by a power failure, it can be restarted at any rotational speed by pressing the START button. (Automatic restart after a power failure is possible by connecting an external start switch at the rear of the converter as described in Section 2.2.3.2).

3.5 Shutdown

Proceed as follows to shutdown the turbopump:

1. Stop the turbopump by pressing the converter's STOP pushbutton.

2. Turn off the cooling-water flow or air-cooling fan as soon as possible to avoid condensation of vapors within the turbopump.

3. Switch off the TRIVAC backing pump.

   Its anti-suckback device automatically closes the fore-vacuum line to prevent backstreaming of oil vapor into the turbopump.

   If another type of backing pump is used, close the external airing/isolation valve before switching off the backing pump.

   If a Leybold SECUVAC valve is installed in the fore-vacuum line, this valve automatically closes when the backing pump is switched off.

CAUTION: Failure to vent the turbopump during shutdown can result in premature bearing failure or in oil backstreaming from the backing pump into the turbopump.

4. Vent the turbopump immediately after shutting down the pump.
   For standard processes, the pump is vented through its vent port.
   If you have the TMP151C or TMP361C pump model and the optional Purge/Vent Valve, de-energize the valve to vent the pump through the pump's purge port.
   For additional venting information, refer to Section 3.6.

5. If the pump was exposed to corrosive or toxic gases, continue to purge the pump with inert gas for as long as several hours after shutdown depending on the aggressiveness of the process gas. Purging the TMP 151C or TMP361C model after shutdown protects the bearings from corrosive process gases. Purging is required before opening a pump that has been exposed to toxic or hazardous gases to dilute and/or force the toxic gases from the pump.

WARNINGS:

It is essential that the Purge/Vent Valve is connected to a source of inert gas or sealed when pumping toxic or reactive process gas. The Purge/Vent Valve isn't a shutoff device. If its inlet port is left open, toxic process gas could escape after shutdown or air could enter the pump and have a dangerous reaction with aggressive process gas.

If the pump has been exposed to toxic or reactive process gas, you must purge it with inert gas before opening the pump.

6. If the turbopump is removed from the vacuum system after venting with dry gas, seal off its high-vacuum flange and all of its ports with blank flanges to avoid contamination or corrosion. Also, when storing the turbopump for prolonged periods, place the turbopump into its polyethylene shipping bag with moisture adsorbent and store in a dry location.

Use the form at the back of this manual if you will be sending the pump to our factory or to one of our service centers.

3.6 Venting

Venting prevents the back-streaming of the process gas and/or oil vapors from the fore-vacuum area into the high-vacuum side of the turbopump. Venting also prevents the rotor from spinning for long periods after shutdown which could cause premature bearing failure.

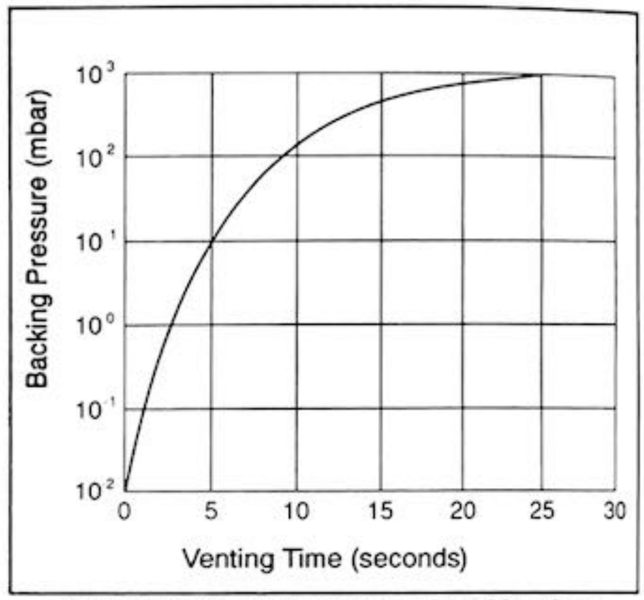


Figure 3-3. Recommended Venting Pressure Rise

Although venting directly from the atmosphere is possible, venting from a bottled source of dry air or nitrogen is recommended because it prevents condensation of water vapor in the pumping system. The absolute moisture content of the venting gas should be less than 10 ppm. If a pressurized venting line is used, DON'T exceed a vent-line pressure of 7 psig.

Using inert gas for venting and purging is essential if the process gas could have a hazardous or undesirable reaction with air, or if process gas is toxic.

For standard applications, the turbopump can be vented to atmospheric pressure through its vent port or through its high-vacuum flange. The nozzle in the vent port regulates the flow of venting gas in accordance with Figure 3-3. If you vent the pump through its high-vacuum flange, we recommend that you control the pressure rise in accordance with Figure 3-3. Shock venting should be avoided, but it can be done in an emergency without damaging the turbopump.

When pumping corrosive or aggressive gases or gases containing dirt or abrasives, use the TMP151**C** or TMP361**C** pump model and vent the turbopump with dry inert gas through its purge port using the optional Purge/Vent Valve (see Section 3.7). The purge port also contains a nozzle that avoids shock venting by regulating the flow of venting gas in accordance with Figure 3-3. Venting is accomplished by increasing the purge-gas flow rate through the Purge/Vent Valve to 4,800 sccm when the turbopump is switched off. Thus, the motor/bearing cavity is vented before the rest of the turbopump to prevent any corrosive gases or abrasive reaction products from being sucked into this cavity.

If you are also venting the vacuum chamber, ensure that the turbopump is vented before the vacuum chamber or that both are vented simultaneously. If the vacuum chamber is vented before the pump, the turbopump's bearing and grease could be exposed to harmful process gases.

3.7 Purging

When pumping corrosive or aggressive gases or gases containing dirt or abrasives, you must use the TMP151C or TMP361C turbopump model. Purge and vent the pump through its purge port using the optional Purge/Vent Valve. See Section 3.6 for information on venting.

The Purge/Vent valve allows a constant flow of inert gas into the motor/bearing cavity which keeps the cavity pressure ten times higher than the normal foreline pressure (see Table 2-B for purge gas inlet pressures and flow rates). This pressure difference prevents harmful process gas from entering the motor/bearing cavity during operation. It also prevents backstreaming oil vapors from contaminating the turbopump.

If the pressure in the motor/bearing cavity drops below the foreline pressure, then the turbopump's bearings and grease are exposed to the harmful process gases. We recommend the following to prevent contaminants from damaging the bearings:

- Ensure that you have a continuous supply of dry inert gas to the Purge/Vent Valve.
- Check the Purge/Vent Valve periodically to ensure that its nozzle and filter aren't clogged. The filter element (P/N 200-17-876) should be replaced before the purge-gas flow falls below 90% of its throughput.
- Ensure that the backing pressure is acceptable.
- If you will also be venting the vacuum chamber, ensure that the trubopump is vented before or at the same time as the vacuum chamber.
- Ensure that venting continues long enough to prevent the turbopump's bearings from being exposed to particles or reactve gases from the process chamber or turbopump.
- If the process gas is corrosive or toxic, continue to purge the pump with inert gas for as long as several hours after shutdown depending on the aggressiveness of the process gas. Purging after shutdown protects the bearings from corrosive process gases.

Purging is also required before opening a pump that has been exposed to toxic or hazardous gases to dilute and/or force the toxic gases from the pump.



WARNING!

It is essential that the Purge/Vent Valve is connected to a source of inert gas or sealed when pumping toxic or reactive process gas. The Purge/Vent Valve isn't a shutoff device. If its inlet port is left open, toxic process gas could escape after shutdown or air could enter the pump and have a dangerous reaction with aggressive process gas.

If the pump has been exposed to toxic or reactive process gas, you must purge it with inert gas before opening the pump.

3.8 Bakeout

To attain operational pressures of 10^{-8} mbar or lower, the turbopump flange and the connected vacuum system should be baked out at the same time.

Only TURBOVAC models that have the CF flange can be baked out because they have a stainless steel housing and use a copper flange gasket.

CAUTION: ISO-K flanged turbopumps can't be baked out because their housing is made of aluminum.

Our optional flange heater is recommended for baking out the CF-flanged TURBOVACs. The flange heater's thermal switch maintains the flange temperature within the acceptable range. See Table IV in the front of this manual for the part numbers of the CF flange heaters.

Don't use a bakeout jacket; bakeout jackets can damage the pump by overheating the heat-sensitive parts in the bearing.

As the water vapor and other contaminants outgas from the chamber walls during bakeout, the pressure may rise by as much as two decades and then decline at a rate that depends on the nature and degree of contamination. The flange heater can be switched off once the pressure continues to fall further below the starting pressure.

Normally a bakeout time of 5–6 hours for the turbopump is sufficient. Longer baking times won't, as a rule, significantly improve the base pressure.

During bakeout, ensure that the components above the turbopump are baked at a slightly higher temperature than the turbopump to avoid condensation in the system. The turbopump's high-vacuum flange temperature must not exceed 212°F (100°C) and its rotor and fore-vacuum must not exceed 175°F (80°C). Take precautions to protect against direct heat radiation from other heaters attached to the vacuum system. When baking out components at the fore-vacuum side such as an adsorption trap, make sure that the temperature of turbopump's fore-vacuum port doesn't exceed 175°F (80°C).

A water-cooled turbopump can be continuously baked out while running if its operating pressure is less than 10^{-3} mbar and the ambient air temperature doesn't exceed 113°F (45°C). For an air-cooled pump, check the operating temperature in the small bore in the base housing just below the purge port; if this temperature exceeds 130°F (55°C), you must use water cooling.

Power consumption is as follows:

100CF flange heater ..... 100 watts
160CF flange heater ..... 150 watts

4 — Maintenance

WARNINGS!

The NT150/360 Frequency Converter contains potentially lethal voltages and should only be serviced by qualified technicians.

If the pumping system has been exposed to corrosive, toxic, reactive, or hazardous gases, take proper safety precautions to protect personnel before removing the pump from the system or before disassembling the pump. Proper precautions could include inert gas purging; gloves or protective clothing to avoid skin contact with toxic or highly corrosive substances; specially ventilated work areas; fume hoods; safety masks; breathing apparatus; etc.

Contents

4.1 Preventive Maintenance

The TMP 151/361 and 151/361C turbopumps contain life-time lubricated bearings which don't require regreasing. Service is required only if the pump becomes contaminated, or if its replaceable rotor/spindle assembly becomes damaged.

The NT150/360 Frequency Converter is also maintenance free. There are no internal controls that need periodic readjustment. Maintenance is required is only if the converter is operated in a dusty environment, causing an excessive dust buildup to occur within the unit. Dust acts like a thermal insulator and prevents efficient heat dissipation. As necessary, remove the converter's top cover and clean the interior of the unit using a brush.

WARNING!

Poisonous or explosive gas can collect in filters and traps when pumping hazardous process gases. Use proper precautions to protect personnel when maintaining filters and traps.

Optional Adsorption Trap — If you have an adsorption trap in the foreline, replace the activated alumina about every 3 months depending on operating conditions. If you don't replace the alumina periodically, it could become clogged resulting in oil vapors backstreaming through the turbopump and reduced pumping speed. The part number of a 2-liter can of activated alumina is 85410.

See Appendix A.7 for more information on the optional Al_2O_3 adsorption trap.

Optional Purge/Vent Valve — The optional purge/vent valve must be checked periodically to ensure that its filter isn't clogged. The filter element (P/N 200-17-876) on its inlet port should be replaced before the purge-gas flow falls below 90% of its throughput.

See Appendix A.6 for more information on the optional Purge/Vent valve.

4.2 Turbopump Cleaning

If the turbopump contamination is minor (such as an oil film), you can clean it as described in Steps 1 through 7 below without disassembly.

If the turbopump is heavily contaminated, you must first disassemble it as described in Section 4.3 and then wipe the stator disk halves and stator rings with cleaning solvent. To clean the rotor, hold the turbopump upside down and apply solvent to the rotor blades with a brush. DON'T turn the turbopump upright until all the cleaning solvent has evaporated. For CF-flanged pumps, wipe the top of the rotor and the upper portion of the pump housing with reagent alcohol to remove any fingerprints or other residue that would prolong pumpdown.

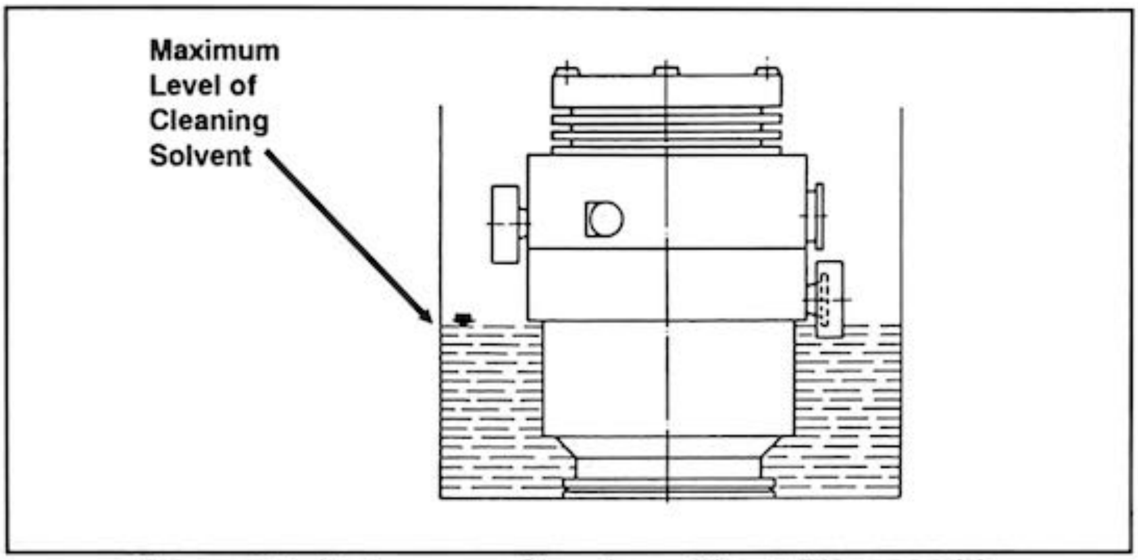


Figure 4-1. Turbopump Cleaning without Disassembly

To clean the turbopump without disassembly, proceed as follows:

CAUTION: DON'T apply cleaning solvent to the O-rings. Some solvents such as acetone will dissolve or cause swelling and cracking of the O-ring material. Also, DON'T allow the cleaning solvent to enter the ball bearing assemblies.

1. Dismount the turbopump from the pumping system and remove its inlet screen and the high-vacuum flange O-ring or copper seal.

! WARNING — Fire Hazard !

Many cleaning solvents including acetone, alcohol, and petroleum ether are a fire hazard. Others including triethane are a health hazard.

CAUTION: In the following step, DON"T allow the venting port to be submerged in the cleaning solvent; the cleaning solvent level must be below the rim of the venting port as shown in Figure 4-1. This prevents cleaning solvent from entering into the ball bearing assembly.

3. Slowly lower the turbopump upside down into a container filled with a suitable solvent such as acetone. Freon TF works well but isn't recommended because of environmental concerns (see Figure 4-1).

4. Allow the cleaning solvent to react for about 15 minutes. During this period, GENTLY lift and lower the turbopump several times to flush the rotor and stator components.

5. Repeat Steps 3 and 4 at least once using fresh solvent. If you use a solvent that leaves a residue (such as petroleum ether) rinse with reagent-grade alcohol to remove the residue.

CAUTION: After cleaning, DON'T turn the turbopump right-side up until all cleaning solvent has been removed as described in Step 6. This prevents cleaning solvent from draining into the ball bearing assembly.

6. After cleaning, place the turbopump, with its high-vacuum port facing down, on a piece of cardboard for at least 2 hours to allow the solvent to drain and completely evaporate. During this period, place the turbopump for a short time on its side, and roll it around its axis to allow the solvent to drain from between the stator package and pump housing.

7. When the turbopump is completely dry, replace the inlet screen and O-ring and then remount the turbopump to your system.

4.3 Turbopump Disassembly/Reassembly
(For trained personnel only)

This Section contains the following:

WARNING!


If the pumping system has been exposed to corrosive, toxic, reactive, or hazardous gases, take proper safety precautions to protect personnel before removing the pump from the system or before disassembling the pump. Proper precautions could include inert gas purging; gloves or protective clothing to avoid skin contact with toxic or highly corrosive substances; specially ventilated work areas; fume hoods; safety masks; breathing apparatus; etc.

CAUTION: When disassembling, cleaning, and reassembling the turbopump, don't make any modifications to the rotor; it has been precision balanced and any change on any rotor part requires that the rotor be rebalanced by Leybold.

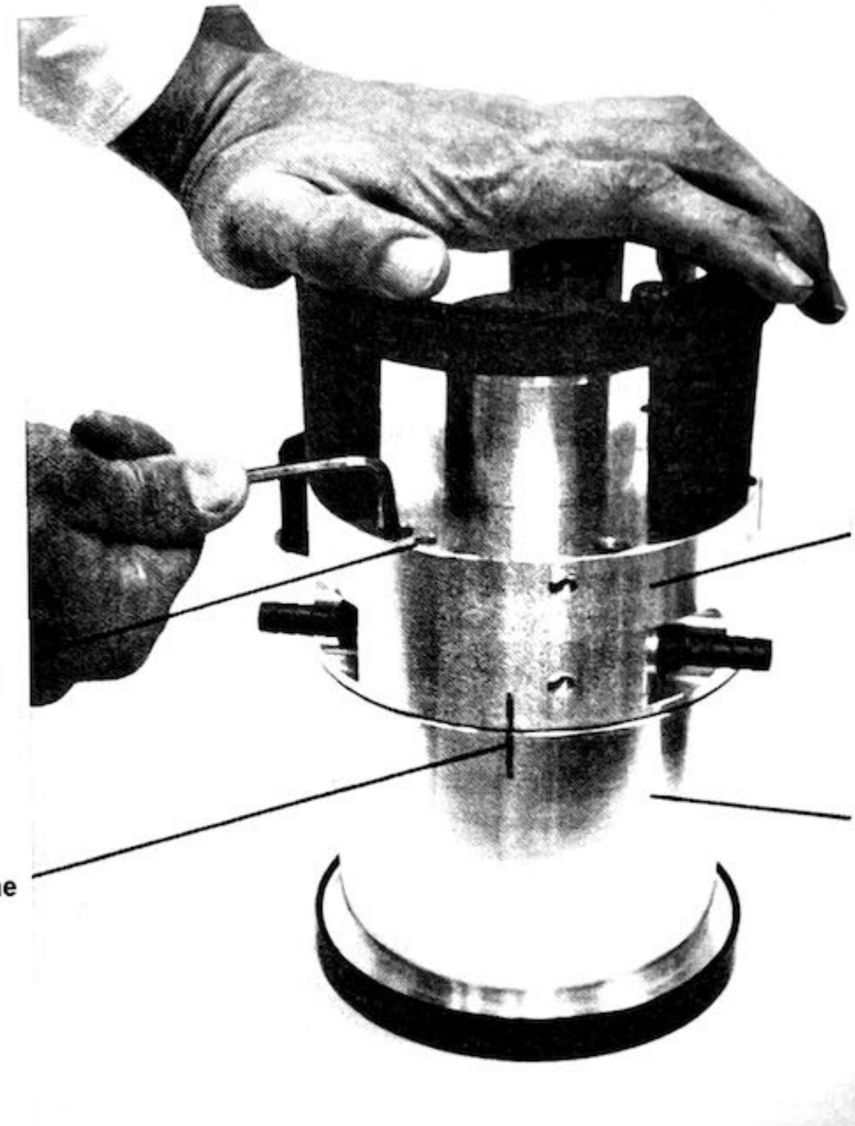
The turbopump should only be disassembled when it is heavily contaminated and requires cleaning. The following sections describe how to disassemble and then reassemble the turbopump. Please read all of these instructions before starting disassembly.

4.3.1 Tools and Materials Required

The following tools and materials are required to disassemble/ reassemble the turbopump.

- 6-mm Allen Wrench
- Small Flat Blade Screwdriver
- Feeler Gauges
- Pencil or Other Marker
- Suitable Solvent - See Section 4.3.4.
- Pump Housing O-ring:
  P/N 239-50-224 for the TMP151 O-ring,
  P/N 239-70-327 for the TMP361 O-ring

TMP151



4-2. Removing the Pump Housing (TMP151 pump model shown)

4.3.2 Removing the Pump Housing

After dismounting the pump and removing the inlet screen, remove the turbopump's housing as follows (see Figure 4-2):

1. Draw a perpendicular line about 1-inch long between the pump base and pump housing. This line will be used during reassembly to align the screw holes.

2. Carefully set the pump upside down so that its high-vacuum flange is resting on a cloth or something soft that won't scratch the flange.

3. Using an allen wrench, loosen the six pump-housing screws from the pump base (see Figure 4-2).

4. Insert two of the pump-housing screws removed in Step 3 into the two jack-screw holes; don't use the washers. Tighten these two screws uniformly until the pump base lifts off the pump housing by nearly ⅛ inch (3 mm). Then remove these jack screws.

5. Turn the pump right-side up;
   then, grasp the pump housing and pull it straight up from the pump base.

NOTE: Often the pump housing and pump base can be pulled apart by hand or CAREFULLY pried apart using a flat blade screwdriver.

6. Remove the inlet screen from the pump's high-vacuum flange.

To disassemble the stator package, proceed to Section 4.3.3.

Maintenance

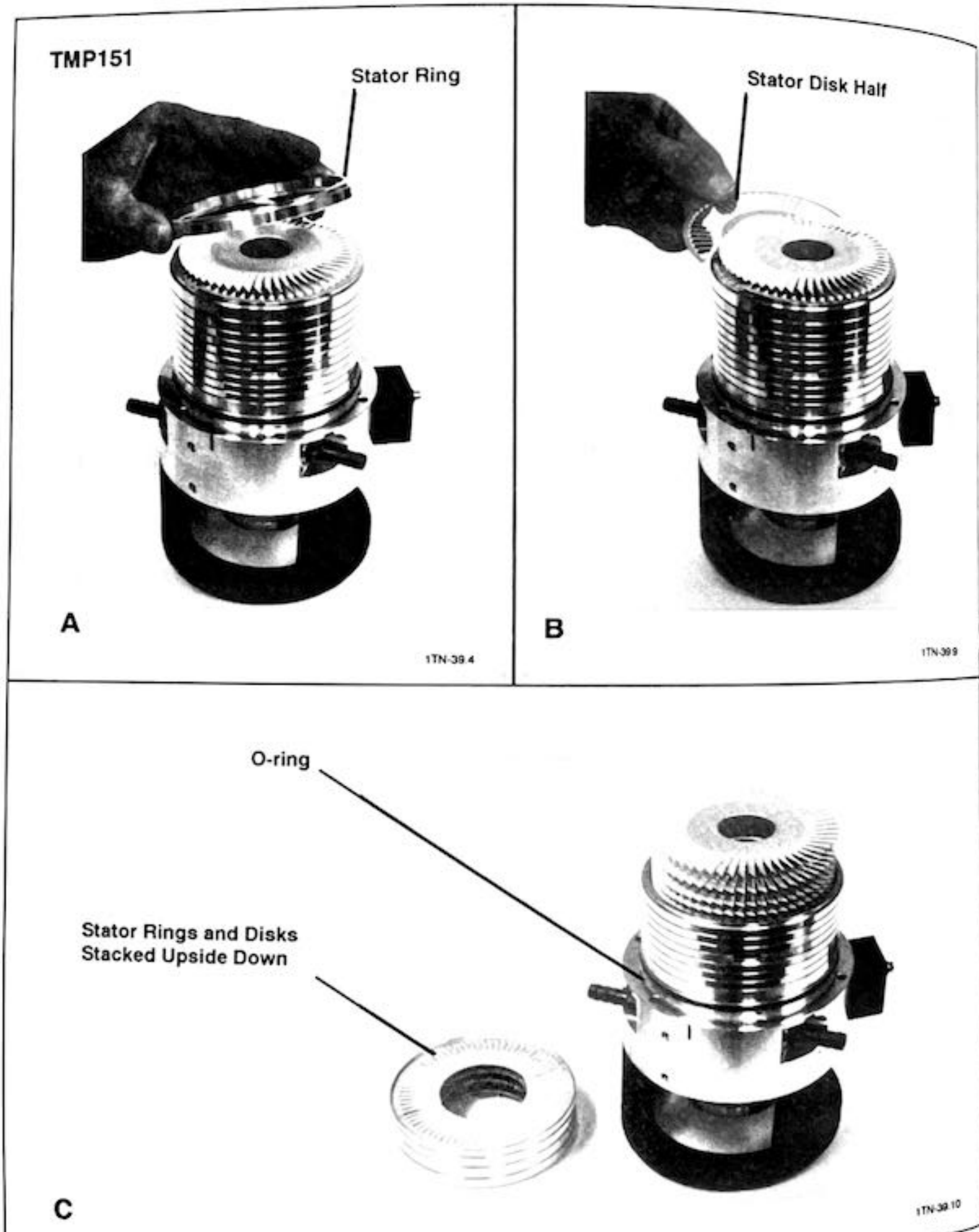


Figure 4-3. Removing the Stator Rings and Disks

4.3.3 Stator Package Disassembly

Disassemble the stator package as follows:

NOTE: During disassembly of the stator package, check for damaged stator rings and stator disk halves. Look for friction marks, cold welds, and deformed parts. If the edge of the stator disk is flattened and elongated, file it square. Also inspect the inside of the stator rings. If there are grooves caused by the rotor rubbing against the stator rings, the pump should be sent to Leybold for repair and rebalancing. Repair or replace any damaged part(s) before reassembling the pump.

1. If not already done, remove the pump housing as described in Section 4.3.2.

2. Carefully lift off the first stator ring (Figure 4-3A) and place it upside down next to the turbopump (Figure 4-3C). Note that if the stator rings cling together, use a small flat-blade screwdriver to CAREFULLY pry the rings apart.

CAUTION: To avoid damaging the stator disk halves in the following step, compress the stator package with your fingers to allow enough clearance so the stator disks can be easily removed. DO NOT force the removal of any part.

3. Carefully pull out the first two stator disk halves (Figure 4-3B) and place them upside down in the first stator ring (Figure 4-3C).

4. Continue to lift off the stator rings and pull out the stator disk halves until the complete stator package is stacked upside down next to the turbopump. If you continue to stack them upside down on the previously removed rings and discs as you remove them, they will be stacked in the correct order for reassembly.

5. Refer to Section 4.3.4 to clean the stator package and rotor, then proceed to Section 4.3.5 to reassemble the turbopump.

4.3.4 Cleaning and Inspecting the Disassembled Pump


! WARNING — Fire Hazard !

Many cleaning solvents including acetone, alcohol, and petroleum ether are a fire hazard. Others including triethane are a health hazard.

CAUTION: Don't apply cleaning solvent to any of the O-rings. Some solvents such as acetone will dissolve or cause swelling and cracking of the O-ring material. Also, don't allow the cleaning solvent to enter the ball bearing assemblies.

CAUTION: Don't change the order in which the stator package is stacked!

1. Inspect the parts as follows:

   a. Inspect the edge of each stator disk to ensure it isn't bent or elongated. If the end is flattened and elongated, file it square.

   b. Spin the rotor and watch each row of blades to ensure that none is bent up or down. If a blade is bent, carefully bend it back into alignment with the rest of the blades in the row. If the rotor has any damage other than slight misalignment of blades, then the pump should be sent to Leybold for repair and rebalancing.

   c. Inspect the inside of the stator rings. If there are grooves caused by the rotor rubbing against the stator rings, send the pump to Leybold for repair and rebalancing.

2. To clean the rotor, hold the turbopump upside down and apply a suitable solvent to the rotor blades with a brush. DON'T turn the turbopump upright until all the cleaning solvent has evaporated. A convenient place to set the turbopump while drying is inside the pump housing, which has been placed upside down on its high-vacuum flange. When cleaning the fore-vacuum area, ensure that cleaning solvent doesn't enter the motor vent hole located under the rotor in the upper bearing cap.

   Wipe clean the O-ring groove in the base flange.

   Acetone can be used on the metal parts but must not come into contact with O-rings. Freon TF works well but isn't recommended because of environmental concerns. If you use a solvent that leaves a residue (such as petroleum ether), rinse with reagent-grade alcohol to remove the residue.

3. Immerse the stator disks in solvent and clean them with a brush. Don't reuse any disks that are stained or etched.

   Wipe the stator rings, pump housing, and base flange with a suitable solvent to remove all oil and dirt. Be sure to wipe down the entire inside surface of the pump housing. If ultrasonic cleaning equipment is available, also clean these parts in an ultrasonic bath.

4. Seal all the cleaned parts in a plastic bag so that they remain clean until you are ready to install them.

4.3.5 Turbopump Reassembly

Assemble the turbopump on a clean ventilated bench to prevent dust from collecting on the parts. Work with gloves to ensure the pump remains clean and is capable of producing an ultra-high vacuum. Any fingerprints, oil, or chemicals that remain in the pump will outgas and affect the ultimate pressure.

Be very careful that you install the stator disk halves and stator rings in the proper order. If the stator package was stacked upside down in sequence as it was disassembled, there shouldn't be a problem in reassembling the package in the correct order. However, if the stator disks or rings do get out of sequence, refer to Figure 4-6 or 4-7.

Be sure to inspect the stator disks and the rotor blades as described in Section 4.3.4 before reassembling the pump.

Proceed as follows to reassemble the pump:

1. Apply a thin film of high-vacuum grease to the pump housing O-ring being careful to avoid getting any grease on the rotor. Wipe clean the O-ring groove and install the O-ring, being careful not to twist it (see Figure 4-3C). If the O-ring doesn't have a grease film, the pump housing will be difficult to install and the O-ring could be damaged as you seat the pump housing.

   The part number of the pump-housing O-ring is 239-50-224 for the TMP151 and 239-70-327 for the TMP361.

2. Reinstall the stator disks and rings as follows:

   a. Remove the top two stator disk halves from the upside down stacked stator package, and then reinsert the disks into the turbopump so that their outer edges lay on top of the pump base. **Ensure that the abutting joints of the stator disk halves DON'T overlap.** If they overlap or if they do not meet evenly, turn one of the blade halves over so that it is flush with its mating blade half.

      Stator disks starting with pump S/N A 91 11 have a rounded lip along the outside edge which locks into the chamfer on the stator ring. This design prevents the disks from overlappping or shifting out of position during reassembly.

Maintenance

NOTE: Disk overlapping isn't a problem for pumps with S/N's starting with A 11 91. These versions have a rounded lip on the outside edge of each disk that locks in place on a stator-ring chamfer.

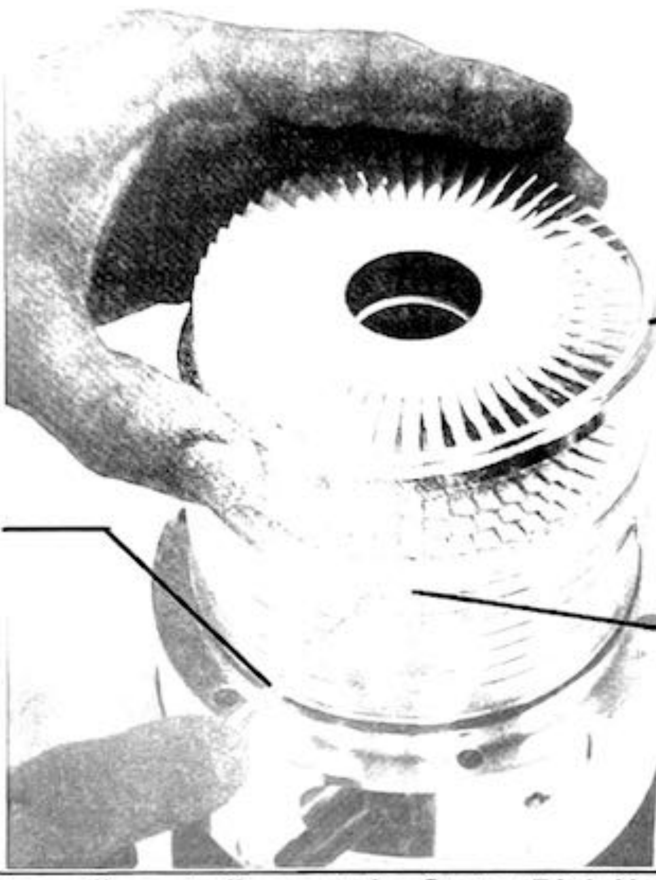


Figure 4-4. Using a Screwdirver to Prevent the Stator-Disk Halves from Overlapping as You Install the Stator Ring

b. Remove the top stator ring from the upside-down stator stack and install it over the rotor as follows:

1) Place one side of the stator ring down tight against the stator disks where they abut.

2) Use a small screwdriver as shown in Figure 4-4 to keep the other abutting ends of stator disks from overlapping until you snap the ring down in place.

c. Using your fingers, compress the stator package and alternately place stator disk halves and stator rings one above the other by repeating steps 2a and 2b until the entire stator package is reassembled onto the turbopump. After installing the stator ring, check that the gap between it and the next lower stator ring is the same all around the circumference of the ring. If the gap is bigger on one side, it means that the tips of the stator discs are overlapping. As you install new stator disks, hold the previously installed ring in place so that it doesn't shift.

Note that there is an opening in the fifth stator ring from the bottom for evacuating the space between the stator rings and the inside of the pump housing. It doesn't matter which direction this opening faces.

The rotor can't normally be turned by hand after the stator package is installed. This is because the spacer rings aren't yet sufficiently compressed downward to form the correct clearances between the stator and rotor blades. However, the rotor should move freely after the pump housing has been installed and tightened down.

CAUTION: To prevent the stator package from becoming dislocated, DO NOT invert or turn the turbopump on its side before the pump housing has been replaced and tightened down.

3. Reinstall the pump housing as follows:

   a. Slowly lower the pump housing directly over the stator package, being careful to avoid bumping the stator rings and knocking them out of place. Align the pencil marks that you made during disassembly to ensure that the housing's six screw holes are positioned over the mating holes in the pump's base. This hole alignment is essential since the pump housing O-ring prevents you from easily rotating the pump housing once it has been seated.

   b. Seat the pump housing by uniformly pressing down on the turbopump's high-vacuum flange. Ensure that the housing is straight relative to the stator stack. If the gap between the top stator ring and the pump housing is larger on one side, straighten the housing so that this gap is uniform.

      If you have difficulty seating the housing all the way down on the pump base, apply a little vacuum grease on the O-ring and press down firmly.

   c. **With the turbopump setting upright**, hand tighten the six pump housing screws with washers. It may be necessary to tap the pump base to align the screw holes.

   d. Using an Allen wrench, uniformly crosstighten the six pump housing screws. While tightening the screws, ensure that the housing is straight relative to the stator stack. If there is an uneven gap between the top stator ring and the pump housing, straighten the housing so that this gap is uniform.

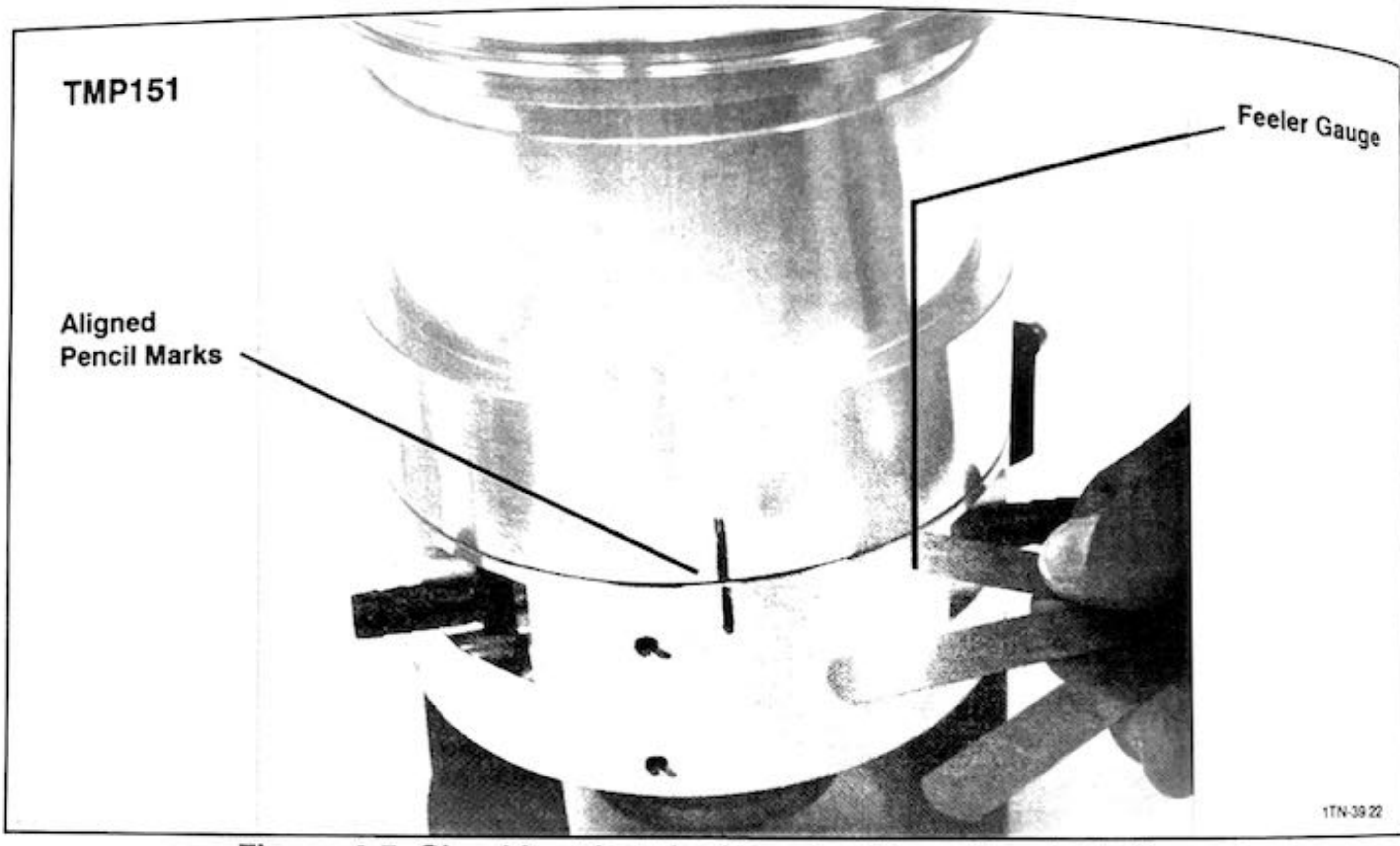


Figure 4-5. Checking that the Housing/Base Gap is Uniform

e. Check the gap between the pump base and housing as follows:

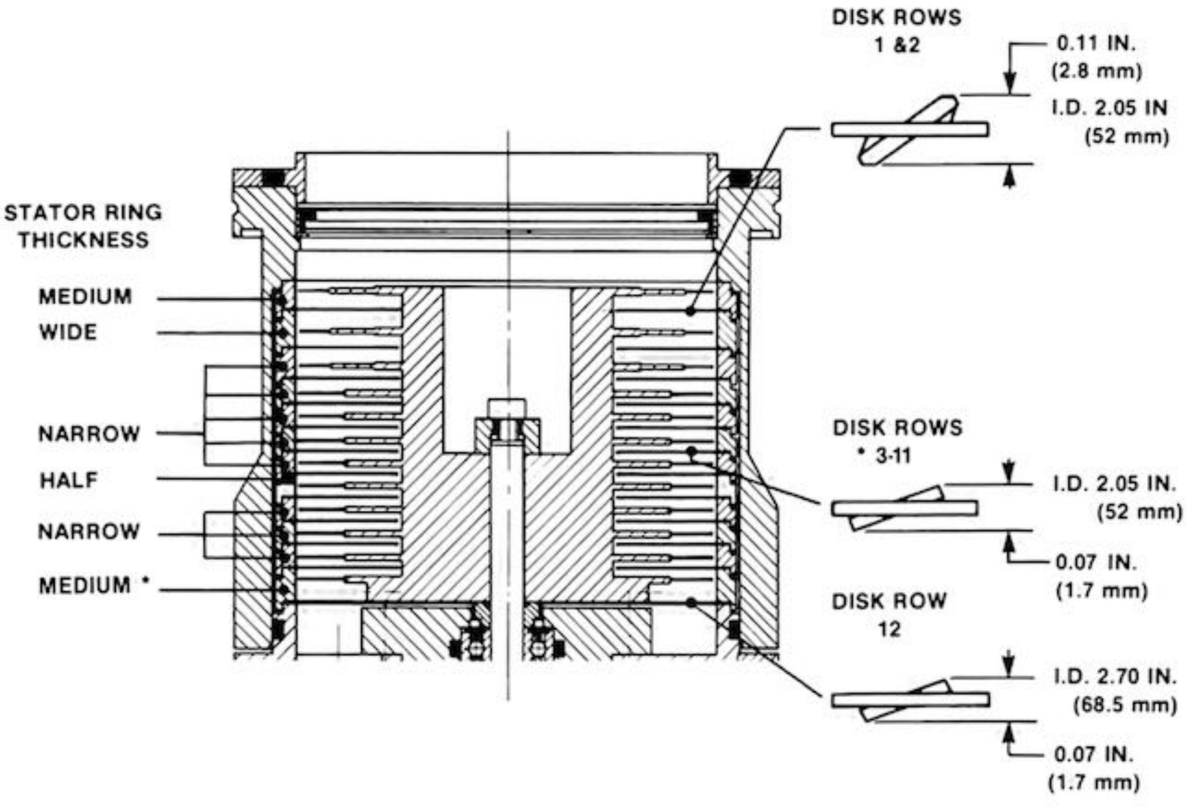
- Using a feeler gauge, ensure that there is a gap between the pump base and pump housing (Figure 4-5) and that this gap is uniform around the circumference of the pump base (the size of the gap isn't critical).

- If the gap isn't uniform, loosen the pump housing screws and retighten them again uniformly; then refer to the previous step to check if the gap is uniform. If still unsuccessful, remove the pump housing and check whether any stator rings have slipped off from their position or whether any stator disk halves are overlapped; then repeat steps 3c, d, and e.

4. After installing the pump housing, check for smooth running of the rotor by slightly pushing at the rotor hub. There should be no pinging noises and no perceptible resistance in the rotor bearings as the rotor spins.

5. If the inlet screen is damaged, use a new one.
Wipe the top of the rotor and the upper portion of the pump housing with reagent alcohol to remove any fingerprints or other residue that would prolong pumpdown. Clean the inlet screen and install it into the high-vacuum flange.

Proceed to Section 4.3.6 to ensure that the turbopump has been reassembled correctly.



* This drawing applies to TMP151 turbopumps with serial number A 9111 . . . . .;
see Figure 4-12 of manual 722-78-036 if your pump's serial number is A 9101 . . . . . .

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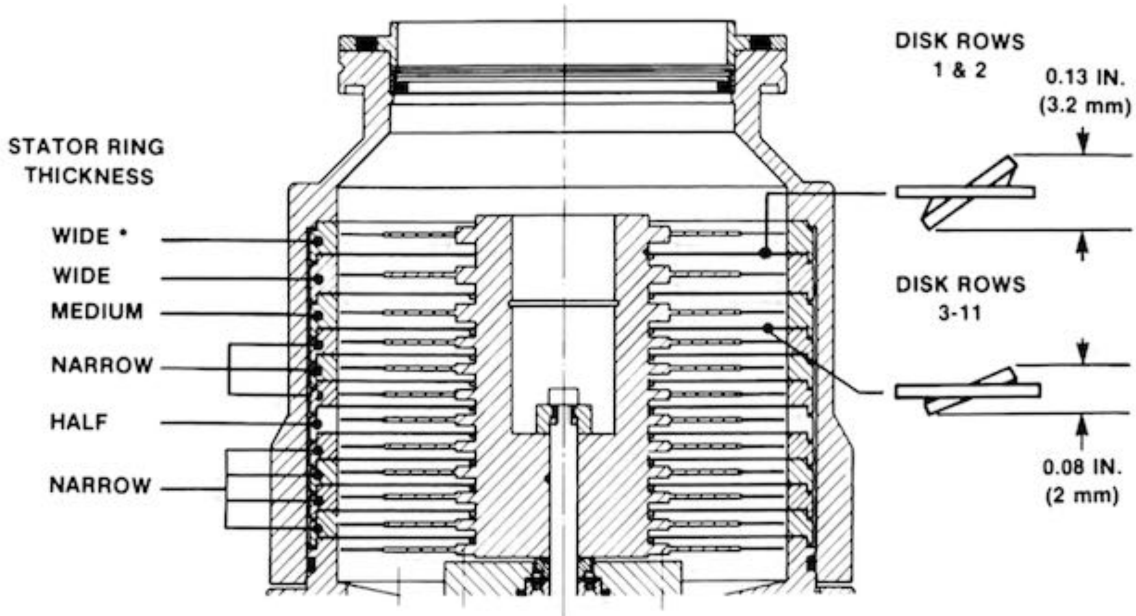
Figure 4-6. TMP151 Stator Disk and Ring Placement



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* This drawing applies to TMP361 turbopumps with serial number A 9111 . . . . .;
see Figure 4-13 of manual 722-78-036 if your pump's serial number is A 9101 . . . . . .

Figure 4-7. TMP361 Stator Disk and Ring Placement

4.3.6 Turbopump Running Tests

After reassembling the turbopump, perform the following Run-Up Test, Leak Test, and Venting Test procedures.

Run-Up Test

1. Install a blank flange on the high-vacuum flange.
2. Connect a suitable backing pump to the fore-vacuum port.
3. Connect the turbopump to its frequency converter and start both the backing pump and turbopump.
4. Observe that within 1.5 minutes for the TMP151 and 2 minutes for the TMP361, the converter should switch from ACCELERATION to NORMAL OPERATION. A longer run-up time indicates improper assembly or a leak.

Leak Test

1. Install a blank flange on the high-vacuum flange.
2. Connect the turbopump to a helium leak detector. If a helium leak detector isn't available, the working pressure of the turbopump can be measured as an indication of any leaks. A turbopump that has a blank flange attached to its high-vacuum flange should attain a working pressure of $<1 \times 10^{-6}$ mbar.
3. Start the leak detector and turbopump.
4. Leak check the turbopump; the leak rate should be $<1 \times 10^{-8}$ mbar· ltr/sec.

Venting Test

1. Switch off the turbopump.
2. Vent the turbopump.

CAUTION: Use extreme care to avoid scratching the turbopump's flange when prying the blank flange off of the high vacuum flange.

3. After the turbopump pressure begins to rise (in about 30 seconds), carefully pry off the blank flange from the high-vacuum flange. While detaching the blank flange, listen for any pinging noises.

   If you don't hear pinging noises, the pump is ready for operation.

   If you hear any pinging noises, disassemble the turbopump and check for proper assembly of the stator rings and stator disk halves. After reassembling the turbopump, repeat all of the running tests described in this section (Section 4.3.6).

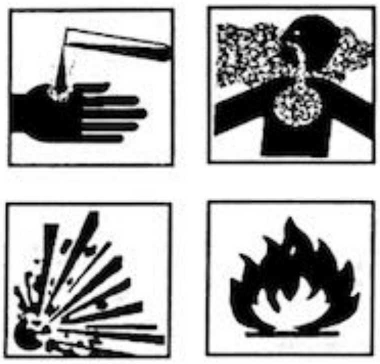
5 — Troubleshooting

Contents

- Section 5.1 is a brief checklist to help locate and eliminate any simple problems.
- Table 5-A is a detailed troubleshooting chart; the chart refers to Sections in this manual that have information related to the problem or solution. If the source of the problem is the converter, it refers you to Section 5.3 for instructions on the converter self-test program.
- Section 5.2 contains handling precautions for the converter PC boards to avoid damaging them, and
- Section 5.3 has instructions on how to use the Frequency Converter's self-test program. This program tests the converter's various electronic circuits and gives a visual indication of that circuit's status.
- See Section 7 for the parts lists for the turbopump and frequency converter, and for the board layout and electrical schematics of the converter. Figure 7-9 has useful troubleshooting information in the form of voltage levels and waveforms.

WARNINGS!

The Frequency Converter contains potentially lethal voltages and should only be serviced by qualified technicians.



If the pumping system has been exposed to corrosive, toxic, reactive, or hazardous gases, take proper safety precautions to protect personnel before removing the pump from the system or before disassembling the pump. Proper precautions could include inert gas purging; gloves or protective clothing to avoid skin contact with toxic or highly corrosive substances; specially ventilated work areas; fume hoods; safety masks; breathing apparatus; etc.

Before sending a pump to our factory or to one of our service centers, complete the form in the back of this manual. The form is used to notify us of any toxic or other harmful products that may be in the pump, its oil, or its filters. It includes instructions on preparing the pump for shipping.

CAUTION: Don't remove the rotor/spindle assembly unless you have the training and equipment to dynamically balance it after reassembly. A vibration velocity of >0.10 mm/second results in premature bearing failure.

5.1 Check-Out

When you have a problem with the turbopump/converter, we recommend that you first go through the following checklist of simple problems before assuming that source of the problem is a turbopump or converter failure. See Table 5-A for a detailed troubleshooting chart and Section 5.3 for converter self-test procedures.

☐ Is the turbopump receiving power?

- Ensure that the converter linecord is plugged in correctly.
- Ensure that your AC power source is OK.
- Ensure that the converter's voltage-selection card and fuse match your AC power source (see Section 2.2.1).
- Ensure that the cable connecting the turbopump to the converter is plugged in securely.

☐ Did you jog the turbopump before start-up if it has been idle for more that 2 months (see Section 3.3, Step 6)?

- ☐ Are the turbopump and converter being properly cooled?
  - Ensure that the air flow isn't restricted and that the ambient temperature for the converter doesn't exceed 113°F (45°C).
  - For the standard water-cooled pumps, ensure that the cooling water temperature and flow rate is correct (see Figure 2-7), that the water-flow lines aren't clogged, and that the water flow monitor is functioning properly. You can temporarily bypass the water-flow monitor to check if it is the source of the problem.
  - Ensure that the temperature doesn't exceed 212°F (100°C) at the turbopump's high-vacuum flange, or 175°F (80°C) at the rotor or fore-vacuum port.
  - For pumps with the optional air cooler, ensure that it is receiving power and that the turbopump and converter have an unrestricted source of cooling air. Check the operating temperature in the small bore in the base housing just below the purge port; if this temperature exceeds 130°F (55°C), you must use water cooling.
- ☐ Is the vacuum system leak tight?
- ☐ Is your vacuum gauge operating properly? Is it accurate for your particular vacuum range?
- ☐ Is the backing pump adequate?

  The backing pressure should be lower than 1×10^{-1} mbar. For attaining the pump's ultimate pressure, a backing pump pressure of 1×10^{-3} mbar is required. If you are purging the turbopump, a larger capacity backing pump is required to handle the purge-gas flow.
- ☐ Are there any restrictions in the foreline?
- ☐ Is the turbopump contaminated?
  - Ensure that you vent the turbopump during shutdown and that the backing pump has an anti-suckback valve.
- ☐ Is the turbopump's rotor rotating smoothly?

  Turn the turbopump rotor by hand; if it rotates smoothly, the frequency converter is probably the source of the problem.

Contents of Troubleshooting Chart

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
1. POWER indicator doesn't light	**a.** AC power	Converter isn't receiving AC power.	Check for the presence of voltage at AC service outlet.	
	b. Fuse	AC input voltage selection card isn't installed to agree with the applied AC voltage.	Measure AC line voltage and install card correctly.	Sec. 2.2.1 Figure 2-1
		Incorrect fuse size.	Install correct fuse.	Sec. 2.2.1, Fig. 2-1
		Short circuit in converter power supply.	Troubleshoot power supply.	Sec. 6.4.2 Fig 7-5
	c. POWER indicator	POWER LED burned out.	Check for +5 V at POWER LED. If +5 V is present, replace LED.	Fig. 7-5
	d. Power Supply	Defective power supply.	Troubleshoot power supply.	Fig. 7-5.
		Short Circuit on the +5 V buss.	Isolate +5 V buss, then locate and repair area of short circuit.	Fig. 7-5.
2. With the turbopump disconnected, the front panel indicators (except POWER) flash in sequence	No problem		The converter is in its self-test mode, and is indicating that it is operating properly.	Sec. 2.2.2 Sec. 5.3
3. With the turbopump disconnected, the POWER and ACCELERATION indicators turn ON continuously.	Converter rear panel connections.	External start/stop bypass jumper isn't installed.	Connect a jumper to rear panel STOP terminals TB1-2 and -3 when not using remote control.	Sec. 2.2.3 Fig. 2-2

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
4. With the turbopump connected, the front panel indicators (except POWER) flash in sequence.	**a.** Pump cable	There is an open wire in the pump cable.	Check continuity of pump cable using an ohmmeter. Repair or replace the cable.	Fig. 2-4
	b. Motor stator	Motor stator is defective.	Using an ohmmeter, check the stator inter-phase resistance at turbopump connector terminals 6+7, 7+8, 6+8. If the ohmmeter shows an open circuit, contact Leybold to arrange for repair.	
	c. Converter	Component on converter PC board has failed.	Perform converter self test procedure to isolate the defective circuit. Repair or replace the PC board.	Sec. 5.3 Fig. 7-5
5. All front panel indicators turn ON after applying AC power, even after repeated attempts.	Converter	Component on converter PC board has failed.	Perform converter self test procedure to isolate the defective circuit. Repair or replace the PC board.	Sec. 5.3 Fig. 7-5
6. Turbopump doesn't start.	**a.** Converter	No converter output.	Refer to Symptoms 7 through 11.	
	b. Turbopump	Pump rotor can't turn due to obstruction in rotor blades or defective motor bearings.	Remove pump from system. Turn the pump rotor by hand and check for smooth running. If the rotor turns stiffly, is noisy, or turns irregularly, contact Leybold to arrange for repair.	Sec. 4.3
		Thermal switch or current leadthru is malfunctioning.	Place a jumper across pins 5a and 5b of the converter cable's rectangular plug. If the pump now operates, it means the pump's thermal switch is the problem. If the pump doesn't operate with the jumper installed, then the problem is in the current leadthrough.	
		Motor stator is defective.	Using an ohmmeter, check the stator's inter-phase resistance at pump connector terminals 6+7, 7+8, and 6+8. If the ohmmeter shows an open circuit, contact Leybold to arrange for repair.	Fig. 7-9

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
7. ACCELERATION indicator doesn't light after pressing START.	**a.** Rear panel connections	External start/stop bypass jumper isn't installed.	Connect a jumper to the rear panel STOP terminals TB1-2 & -3 when not using remote control.	Sec. 2.2.3 Fig 2-2
	b. STOP switch	The front panel or remote STOP switch is open.	Ensure that the STOP switch(es) are closed. Repair or replace any malfunctioning switch.	
	c. Optional water-flow switch	Insufficient water flow through the pump has caused the optional water-flow switch to open.	Check for clogged water lines, clogged water filter, or low water pressure.	Sec. 2.3.4.1
		Water-flow switch is misadjusted.	Adjust the water-flow switch for a minimum flow rate of 0.1 gal/min (0.4 ltr/min).	Sec. 2.3.5
		The water-flow switch is defective.	Replace the water-flow switch.	
8. FAILURE indicator is flashing once per second (1 Hz) (gas overload indication).	**a.** Fore-vacuum pressure	Fore-vacuum pressure is greater than 10^{-2} mbar.	Check the operation of the backing pump as described in its manual. A larger pump may be necessary.	Sec. 2.3.3
			Ensure that the turbopump's vent or purge port isn't open to atmosphere and that the optional vent valve is closed.	Sec. 2.3.6
			Leak test the fore-vacuum line and repair any leaks found.	
			Ensure the pump's electrical connector screws are tight.	
	b. High-vacuum pressure	High-vacuum pressure is greater than 10^{-1} mbar.	Evacuate chamber with backing pump to at least 1×10^{-1} mbar before turning ON turbopump.	Sec. 3.3
		Leak in vacuum chamber.	Leak test the vacuum system; repair leaks as required.	

Trouble-Shooting

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
8. FAILURE indicator is flashing once per second (1 Hz) (gas overload indication). (continued)	**c.** Turbopump	Leak at purge or vent port.	Ensure that the vent or purge ports isn't open to atmosphere and that the optional vent valve is closed.	Sec. 2.3.6
		Pump motor is rotating in the wrong direction.	Check the direction of motor rotation and reverse it if necessary.	Sec. 2.2.8
		Motor bearing failure.	Remove the pump from the system. Turn the rotor by hand and check for smooth running. If the rotor turns stiffly, contact Leybold to arrange for repair. Ensure that the pump is jogged after it has been idle for >2 months. If the pump was exposed to abrasive or corrosive process gas, use the TMP 151/361**C** models and purge the pump with dry nitrogen to prevent premature bearing failure. Ensure that the nozzle and filter in the optional Purge/Vent Valve aren't clogged.	Sec. 3.7. Sec. 3.3, Step 6.
9. FAILURE indicator is flashing twice per second (2Hz) irregularly (turbopump overtemperature indication).	**a.** Turbopump	Pump overtemperature resulting from insufficient cooling.	Check for clogged water lines, a clogged water filter, or low water pressure. Ensure that the water temperature doesn't exceed 85°F (30°C). Use optional Water Refrigeration unit if required.	Sec. 2.3.4.1 Appendix A.2
			When using the optional air cooler, ensure that the operating temperature doesn't exceed 130°F measured in the bore just below the purge port in the base housing. If this temperature is exceeded, you must use water cooling. Also ensure that the turbopump's cooling air intake is unobstructed and isn't near the heated air flowing from the baking pump.	Sec. 2.3.4.2
		Pump overtemperature resulting from inadequate lubrication.	If a TMP151/361 pump model has been idle for 2 months or more, ensure that you jog it before start-up.	Sec. 3.3 Step 6

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
9. FAILURE indicator is flashing twice per second (2Hz) irregularly (turbopump overtemperature indication) (continued)	**a.** Turbopump (continued)	Bakeout temperature high.	Don't exceed 212°F on the high-vacuum flange or 176°F on the fore-vacuum flange. Don't bakeout an ISO-K flanged pump and don't use a bakeout jacket on any pump model.	Section 3.8, Appendix A.4
		Pump became too hot due to high magnetic fields around the pump.	Install magnetic shielding around the pump.	Sec. 2.1
		Failure of the overtemperature switch.	Connect a jumper to converter output terminals J2-5a & -5b. If the pump now starts, contact Leybold to arrange for factory repair.	Fig. 7-9
	b. Vacuum system	Pump became too hot due to the pressure exceeding 10^{-1} mbar.	Leak test the vacuum system and repair any leaks.	
		Room temperature is too high.	Lower the room temperature.	Sec. 2.3.4
		Heat radiating from the vacuum chamber is excessive.	Install shielding between the vacuum chamber and the turbopump.	Table 3-A
	c. Converter	Failure of 1-Ohm board resulting in output voltage dropping from 40 to 20 VAC which leads to TMP151 overheating.	Replace 1-ohm board.	Sec. 6.4.10
10 FAILURE indicator is flashing four times per second (4 Hz) (converter failure indication).	Converter	Component on converter PC board has failed.	Perform converter self test procedure to isolate defective circuit. Repair or replace PC board. Ensure that the converter's ambient temperature doesn't exceed 110°F (45°C) and that the converter is grounded properly.	Sec. 5.3 Fig. 7-5

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
11 FAILURE indicator stays ON continuously. (output short circuit indication).	**a**. Turbopump or pump cable	Converter in overcurrent failure mode due to shorted pump motor winding or shorted pump cable.	Determine what is shorted and repair. Reset converter by cycling its AC power.	Fig. 7-8 & Fig. 7-9
	b. Converter	Component on converter PC board has failed.	Perform converter self test procedure to isolate defective circuit. Repair or replace PC board. Reset the converter by unplugging its AC power and reconnecting it..	Sec. 5.3 Fig. 7-5
12 The pump stops and all front panel indicators except POWER turn off. (If the POWER indicator also goes out, check that your AC power source is OK and that the converter linecord is plugged in.)	**a**. Optional water-flow switch	Insufficient water flow through the pump has caused the optional water-flow switch to open.	Check for clogged water lines, a clogged water filter, or low water pressure.	Sec. 2.3.4.1
		The optional water-flow switch is misadjusted.	Adjust the water-flow switch for a minimum flow rate of 0.1 gal/minute (0.4 ltr/min).	Sec. 2.3.5
		The optional water flow switch is malfunctioning.	Replace the water-flow switch. You can temporarily bypass the water flow switch to see if it is the source of the problem.	
	b. FAILURE indicator	FAILURE LED is burned out.	Perform test #0 of the converter's self test procedure to check all indicators. Troubleshoot and repair the defective circuit as required.	Sec. 5.3.1
	c. Converter	Component on the converter's PC board has failed.	Perform the converter self test procedure to isolate the defective circuit. Repair or replace the PC board.	Sec. 5.3 Fig. 7-5
	d. Cable	One of the connectors on the cable connecting the converter to the turbopump is loose.	Ensure the connectors are plugged in securely.	

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
13 NORMAL OPERATION indicator doesn't light after 10 minutes of acceleration.	**a**. Fore-vacuum pressure	The fore-vacuum pressure is greater than 10^{-2} mbar.	Check the operation of the backing pump as described in its manual. A larger pump may be required.	Sec 2.3.3
			Ensure that the vent port or purge ports isn't open to atmosphere and that the optional vent valve is closed.	Sec. 2.3.6
			Leak test the fore-vacuum line and repair any leaks.	
			Ensure the pump's electrical-connector screws are tight.	
	b. High-vacuum pressure	Vacuum chamber is too large.	Evacuate the chamber with a backing pump to at least 1×10^{-1} mbar before turning ON the turbopump.	Sec.3.3
		Leak in vacuum chamber.	Leak test the vacuum system and repair any leaks.	
	c. Pump cable	The cable length was changed without reinitializing the converter.	Reset the converter by unplugging the AC power and then reconnecting it.	
		The cable length is greater than 328 ft. (100m).	For longer cable runs, a larger diameter cable is required to reduce the voltage drop. Contact Leybold for the correct pump cable.	
		The cable is shorted or miswired.	Check the pump cable wiring.	Fig. 7-8
	d. Converter	A component on a converter's PC board has failed.	Perform the converter self test procedure to isolate the defective circuit. Repair or replace the PC board. Reset the converter by unplugging the AC power and then reconnecting it.	Sec. 5.3 Fig 7-5
	e. Turbopump	The direction of rotation of the pump's motor is incorrect.	Check the direction of rotation.	Sec. 2.2.8

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
13 NORMAL OPERATION indicator doesn't light after 10 minutes of acceleration. (continued)	**e.** Turbopump (continued)	The friction in the motor bearing is too high.	Remove the pump from the system. Turn the rotor by hand and check for smooth running. If the rotor turns stiffly, contact Leybold to arrange for repair. Also see Symptom 8c.	
14 Turbopump is noisy or vibrates.	**a.** Pumping system	Pump runs in natural frequency with pumping system.	Change configuration of pumping system.	
			Install damping bellows at pump's high-vacuum flange and fore-vacuum port.	Appendix A.8 Sec. 2.3.3
	b. Turbopump	Motor bearings are failing, the rotor has become unbalanced, or the rotor is damaged from foreign object falling into the pump.	Remove the pump from the system. Turn the rotor by hand and check for smooth running. If the rotor turn stiffly, is noisy, or turns irregularly, contact Leybold to arrange for repair.	Sec.4.3
15 Turbopump or vacuum chamber is contaminated with oil.	**a**. Backing pump	Oil from the backing pump was sucked into the turbopump during shutdown because the backing pump's anti-suckback valve failed to close.	Check that the fore-vacuum line valve or backing pump 's anti-suckback valve automatically closes when the backing pump shuts down. Repair or replace as necessary.	Sec. 2.3.3
		Small quantities of oil mist are backstreaming from backing pump into the foreline during operation.	Install an adsorption trap on the backing pump inlet.. See 16b through 16d below for other contributing causes of oil backstreaming.	Appendix A.7
	b. Purging and/or venting system	Turbopump isn't being vented properly during shutdown.	Ensure that the vent valve opens after the turbopump is switched off. Repair or replace, if necessary.	Sec. 2.3.6
		For the TMP151/361C models, the purge gas supply is depleted, or the filter or nozzle in the optional Purge/Vent valve is clogged.	Check the purge gas supply and clean the filter and nozzle in the optional Purge/Vent valve.	Sec. 3.7

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
15 Turbopump or vacuum chamber is contaminated with oil. (continued)	**c.** Turbopump	The turbopump is running too slow, allowing oil vapors to migrate into the high-vacuum area.	Ensure that the turbopump is operating at its rated rotational speed.	
	d. System operation	The backing pump is pumping for extended periods while the turbopump is at a standstill.	Evacuate the vacuum chamber using a separate roughing line.	
16 The turbopump fore-vacuum pressure is too high (>10^{-2} mbar).	**a.** Vacuum gauge	The vacuum gauge is malfunctioning or contaminated or it isn't accurate for your vacuum range.	Ensure that the vacuum gauge is operating correctly before assuming a problem exists in the pumping system.	
	b. Backing pump	The backing pump is malfunctioning or is too small.	Check the operation of the backing pump as described in its manual. A larger pump may be necessary especially if you are purging the turbopump.	Sec. 2.3.3
	c. Venting system	The vent or purge port or the optional vent valve is open.	Ensure that the vent and purge ports are sealed. If you have the optional vent valve, ensure that it closes when the turbopump is switched ON. Repair or replace,if necessary.	Sec. 2.3.6
		The optional vent valve is leaking.	Leak test the vent valve. Repair or replace, if necessary.	
	d. Fore-vacuum space	The fore-vacuum line is leaking.	Leak test components in the fore-vacuum line and repair any leaks.	
	e. Turbopump	Leak around the vent or purge ports, the pump housing, or the electrical connector.	Leak test the turbopump and repair any leaks.	
	f. Adsorption Trap	Optional trap on backing pump inlet is saturated with water or is contaminated.	Clean the trap and add new activated alumina.	Appendix A.7

Trouble-Shooting

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
16 The turbopump fore-vacuum pressure is too high (>10^{-2} mbar). (continued)	**g**. Vacuum chamber or system	Vacuum leak or contamination in vacuum chamber or system.	Leak test and clean.	
			If you need to produce pressures in the 10^{-8} mbar range, use high-vacuum gaskets and bake out the system, gauge, and pump.	Table 2-A, Sec. 3.8
17 The pumping speed is inadequate.	**a**. Fore-vacuum space	The fore-vacuum pressure is too high.	Refer to Symptom 16.	
	b. Fore-vacuum line of backing pump	The line is too long.	Use a shorter line.	
		The conductance of the line is inadequate.	Check for restrictions in the line. Ensure that the inside diameter of the line is adequate.	
	c. High-vacuum space	The vacuum chamber is too large.	Evacuate the chamber with a backing pump before starting the turbopump.	Sec. 3.3
		The vacuum chamber contains large quantities of water vapor.	Bake out the vacuum system and the pump's CF high-vacuum flange to dry the system. Be sure to vent the pump and system with dry air or nitrogen during shutdown to keep moisture out of system.	Sec. 3.8, Sec. 3.6
	d. Turbopump	The turbopump is contaminated.	Clean the pump. Also see Symptom 15.	Sec. 4.2 Sec. 4.3
		Water vapor has condensed in the turbopump	Seal off the high-vacuum flange and run the turbopump and backing pump until the water evaporates and is pumped out. Purging with dry nitrogen and baking out using the CF-flange heater accelerate the process and prevent reoccurrence of the problem. Ensure that you shutoff the turbopump's cooling-water flow or air-cooling fan immediately after shutting down the turbopump to prevent water vapors from condensing in the pump.	Sec. 3.7 Sec. 3.8

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
17 The pumping speed is inadequate. (continued)	**d.** Turbopump (continued)	The turbopump's inlet screen is clogged.	Disconnect the pump from the system and clean the inlet screen	
		Vacuum leaks in the turbopump.	Leak test the turbopump and repair any leaks	
			Ensure that the vent and purge ports are sealed tightly and that the optional vent valve is closed.	Sec. 2.3.6
		The pump isn't assembled correctly.	Perform the turbopump run-up test as described in Section 4.3.6. If necessary, disassemble and then reassemble the pump.	Sec. 4.3.6 Sec. 4.3
		Rotor is slugish because of damaged bearings.	Send the turbopump to Leybold Service to have bearings replaced.	
	e. Optional Purge/Vent Valve for the TMP151/361**C** models	Inert gas supply is depleted or the valve's nozzle or filter is clogged.	Check the inert gas supply and clean the valve nozzle and filter.	Sec. 3.7
	f. Frequency converter	Failure of converter.	Send converter to Leybold Service for evaluation and repair.	
18 The turbopump doesn't attain the desired ultimate pressure.	**a.** Vacuum gauge	The vacuum gauge is malfunctioning or is inaccurate in the ultra-high vacuum range.	Ensure that the vacuum gauge and gauge head are clean and operating correctly before assuming a problem exists in the pumping system.	
	b. Vacuum system	The vacuum system is dirty or outgassing.	Clean and/or bake out the vacuum system. Bakeout of the system and turbopump CF flange is required to achieve pressures in the 10^{-8} mbar range.	Sec. 3.8
		Leak in vacuum system	Leak test the vacuum system and repair any leaks.	
	c. Fore-vacuum space	Fore-vacuum pressure is too high (>10^{-2} mbar).	Refer to Symptom 16.	

Trouble-Shooting

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
18 The turbopump doesn't attain the desired ultimate pressure. (continued)	**d**. Turbopump	Vacuum leak in turbopump.	Leak test the turbopump and repair any leaks.	
			Ensure that the vent and purge ports are sealed tightly and that the optional vent valve is closed.	Sec. 2.3.6
		Vacuum leak at high-vacuum flange.	On CF-flanged models, use a new copper gasket each time you break the high-vacuum connection.	Table 2-A.
		High vacuum space is contaminated.	Clean the pump. Also see Symptom 15.	Sec. 4.2 Sec. 4.3
		Water condensation in the turbopump.	Seal off the high-vacuum flange and run the turbopump and backing pump until the water evaporates and is pumped out. Purging with dry nitrogen and baking out using the CF-flange heater accelerate the process and prevent reoccurrence of the problem. Ensure that you shutoff the turbopump's cooling-water flow or air-cooling fan immediately after shutting down the turbopump to prevent water vapors from condensing in the pump.	Sec. 3.7 Sec. 3.8
		Pump isn't assembled correctly.	Perform turbopump run-up test described in Section 4.3.6. If necessary,disassemble and then reassemble the pump.	Sec. 4.3 Sec. 4.3.6
	e. Optional Purge/Vent Valve on the TMP151/361C models only	Inert gas supply is depleted or the valve's nozzle or filter is clogged.	Check the inert gas supply and clean the valve nozzle and filter.	Sec. 3.7
19 The turbopump emits pinging noises during venting.	Rotor and stator	The rotor blades are hitting the stator disks due to incorrect assembly.	Disassemble the pump and check for overlapping of stator-disk halves.	Sec. 4.3
		The rotor or stator blades are bent.	Contact Leybold to arrange for repair.	Sec. 4.3.4, Step 4

5.2 NT150/360 Component Handling Precautions

CMOS integrated circuits can be damaged by static discharge to their inputs. This static discharge is the same phenomenon that produces the unpleasant shock when one grabs a door knob after walking across a carpet. The likelihood of static buildup is proportional to the dryness of the air and can be particularly troublesome in cold, dry climates, or hot desert climates.

In order to minimize the chance of discharging your body charge into the IC inputs, always handle circuit boards by their edge, avoiding contact with the connector area. When moving a board from one surface to another, always touch the new surface of location before laying down or inserting the boards, so that you, the board, and the surface or equipment are all at the same electrical potentials. In dry climates, it is always wise to minimize the amount of movement when handling or replacing ICs in circuit boards. When handing a circuit board or IC to another person, always touch the person first.

Wood and paper are the most forgiving surfaces to work on. Plastic should be avoided. Metal is acceptable as long as the metal is always touched with the hands prior to laying down the ICs or circuit boards.

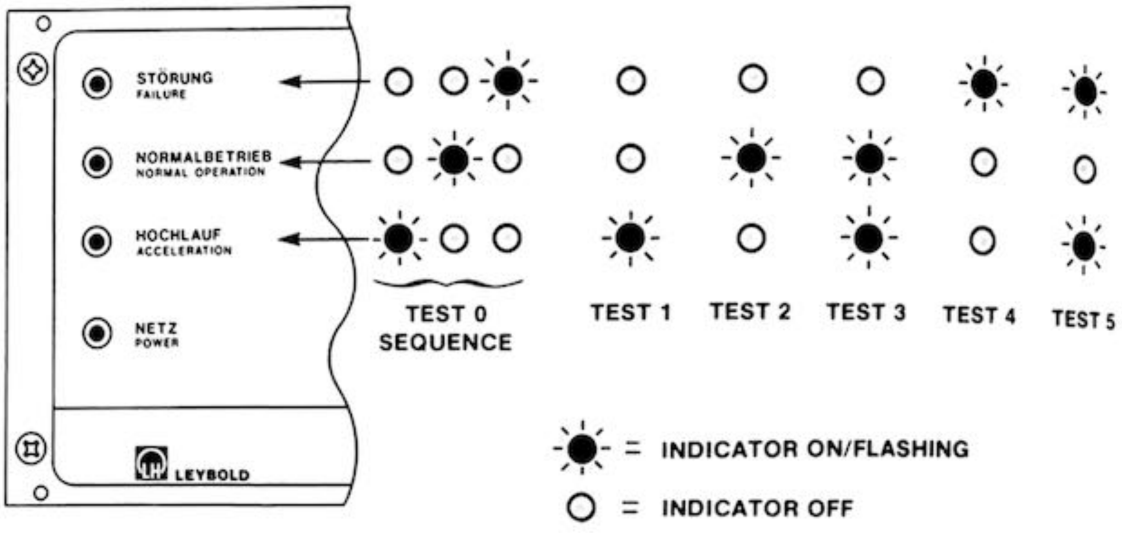
PC boards or ICs should never be placed in plastic bags unless they are of the conductive plastic type intended for this use. These bags are typically black or pink and are normally labeled as conductive or anti-static. If no conductive plastic bags are available, boards or ICs may be wrapped in aluminum foil, and then placed in plastic bags or shipping bags; touch the foil with your hand before allowing the foil to contact the IC or board.

If the above precautions are observed, the chance of damage from static discharge is minimal.

5.3 NT150/360 Self Test to Isolate Component Failures

To simplify troubleshooting and checkout, a section of the computer program is set aside to implement what is called a self test procedure. This procedure is a sequence of tests, each test exercising some part of the total circuitry. Exercising circuitry in this way enables the operator to isolate the fault at worst to the particular circuit section being tested and at best to individual components. Furthermore, the test equipment needed is minimal. Required is a voltmeter or oscilloscope and several dummy loads which replace the actual turbopump motor.

During some tests, more than one section of circuitry is exercised and verified. Furthermore, some circuits are exercised in more than one test to verify all phases of that circuit's operation. For example, the output transistors are checked for both leakage current and saturation voltage at full load. Both tests can't be done at the same time, therefore the conditions required for these tests are set up in separate tests.



TEST 0 - LAMP TEST
TEST 1 —VOLTAGE CONTROL CHECK
TEST 2 - A/D CONVERTER TEST, LINK VOLTAGE CHANNEL
TEST 3 - OUTPUT DRIVER LEAKAGE CURRENT TEST, PULL DOWNS
TEST 4 - PULL UP LEAKAGE, 12 V DC, DISCRETE I/O TEST
TEST 5 - OUTPUT DRIVER SATURATION VOLTAGE TEST, SHORT CIRCUIT PROTECTION

NOTE: EXCEPT FOR TEST 0, THE FRONT PANEL INDICATORS DISPLAY THE CURRENT TEST NUMBER IN BINARY.
EXAMPLE: TEST 5 = 101.

1TN-21.14

Figure 5-1. Front Panel Indicator Function During Self Test

Circuit functions are tested in a fixed sequence; it is necessary that certain blocks be functioning correctly before others are tested. For example, the power supply must be operating properly before checking the output devices which require defined DC link voltages.

To initiate the self test procedure simply apply AC power without a pump cable connected to the converter. During the first few seconds after power is applied, the converter's computer recognizes that no turbopump has been connected. Under this condition, and this condition only, the computer executes the self test procedure. The unit continues executing the self test procedure until power is removed.

There are six tests to be completed. The individual tests are selected by manually depressing the start button. Depressing the start button for less than one second will halt the current test and initiate the start of the next test. If certain tests are to be skipped, then the start button should be depressed for a long time. The converter will sequence quickly through the various tests until the start button is released, leaving the unit executing the desired test.

For convenience, the six tests are identified by number 0 through 5. The current test number is displayed in a binary coded format by means of the three front panel indicators (ACCELERATION, NORMAL OPERATION, and FAILURE), see Figure 6-1. Under normal circumstances, these indicators will flash ten times per second. A failed test is indicated when the front panel indicators are continuously turned on. The exception to the above indicator operation is test 0. During this test the front panel indicators are tested by sequentially turning on the ACCELERATION, NORMAL OPERATION, and FAILURE indicators.

The following sections contain detailed descriptions of each test, including measurements to be made and troubleshooting aids.

5.3.1 Test #0 - Indicator Test

Background:

This is the first test executed after AC power is applied with no pump cable connected. All electrical outputs are off.

During this test, the operation of the front panel indicators and their drivers are checked. The operation of the start and stop discrete input circuitry is also verified.

The front panel indicators will flash, one at a time, in fixed sequence. Depressing the stop switch will halt the flashing, leaving the ACCELERATION indicator turned on as long as the stop switch is depressed. When the indicators and stop switch (local and remote) have been checked, the start switch must be used to proceed to the next test, thus checking the operation of the start switch.

What's Tested:

- The front panel LED indicators,
- The LED driver circuits,
- The start and stop discrete input circuits.

To Complete Test #0:

1. Verify that the front panel indicators flash in the following sequence:

   1 - ACCELERATION
   2 - NORMAL OPERATION
   3 - FAILURE

   The illusion should be that of a light moving upward through the three indicators.

2. Verify operation of the STOP switch.

   The acceleration indicator should remain turned ON as long as the stop switch is depressed. The other two, NORMAL OPERATION and FAILURE should remain off.

3. Verify operation of the START switch.

   Depressing the START switch transfers operation to the next test. The ACCELERATION indicator should starting flashing at 10 Hz.

Failures and Possible Causes:

1. Symptom: All four indicators remain ON continuously even upon repeated at tempts of powering up.

   Sources:
   - Failed component in the computer reset circuitry, CR19, C30, RP2.
   - Failed computer IC, U7.
   - Failed component in A/D converter block (TP3 and TP4 should never measure less than 35 mV DC).

2. Symptom: Without depressing the STOP switch, only the ACCELERATION indicator is turned ON.

   Sources:
   - The remote stop jumper wire is missing at the rear panel terminal block (remote stop switch is open).
   - Failure in the discrete input circuit associated with STOP switch S2.

3. Symptom: One or more of the front panel indicators are extremely dim or out.

   Sources:
   - Failed driver IC, U5.
   - Damaged resistors R20 through R23.
   - Damaged indicator, light emitting diodes DS1 through DS4.

4. Symptom: Depressing the START switch has no effect.

   Source:
   - Failure in the discrete input circuit associated with START switch S1.

5.3.2 Test #1 - Voltage Control Check

Background:

Test #1 verifies performance of the DC link power supply. It is essential that the link supply be tested at this point, because of the need for generating DC link voltages in all subsequent tests.

The firing angle of the controlling SCR, Q1, is fixed such that a link voltage of between 14 and 34 V DC is generated. This can be measured at TP1 (VLINKHI).

The link voltage is both AC line voltage and load dependent. The computer won't correct for these variations. To do so would require the operation of the A/D converter. Not including the A/D converter in this test simplifies troubleshooting in the event of a failure.

What's Tested:

- DC link voltage supply,
- Drive circuitry for SCR, Q1.

To Complete Test #1:

1. Verify that the ACCELERATION indicator is flashing.

   NOTE: If you do not wish to remove the converter's top cover, the following measurements can also be made at the rear panel TURBOVAC connector, J2. Measure at pins 1b, 2b, or 3b. This measurement also requires that the output transistors and drivers are functioning properly.

2. Measure the DC voltage at TP1.

   The voltage should measure 24 +/-10 V DC if your AC power is 60 Hz, or 55 +/-10 V DC if your AC power is 50 Hz.

3. Measure the AC voltage at TP1.

   The voltage measured should be less than 200 mV RMS.

Failures and Possible Causes:

1. Symptom: Failure at Step 2 of the above procedure - measured DC voltage at TP1 is out of range.

   Sources:
   - Looking at TP6 with an oscilloscope, verify a pulse train of high duty cycle. The negative pulses should measure about 1.5 milliseconds with 60 Hz AC power and 3.25 milliseconds with 50 Hz AC power.
   - If off by more than 0.5 mS, then there is likely a failure in the computer IC, U7, oscillator crystal, Y1, or in the zero crossing detector block.
   - If the waveform at TP6 is correct, then the failure is in the SCR BUFFER block or power supply.

2. Symptom: Failure at Step 3 of the above procedure - measured AC voltage at TP1 is out of range.

   Sources:
   - Failure in the POWER SUPPLY block. SCR, Q1, and associated circuitry.
   - Large current path from VLINKHI to ground. Possibly the Output Drivers block.

5.3.3 Test #2 - A/D Converter Test, Link Voltage Channel

Background:

In this test the A/D converter is partially verified. For further tests, relatively accurate control of the output voltage is necessary. The A/D converter is the circuit that translates the output (DC link) voltage and current levels to a digital form which can be processed by the computer. For the computer to control the link voltage accurately, it must receive accurate data from the A/D converter block.

Two A/D characteristics are checked, the monotonicity and linearity. For a monotonic converter, the binary data output always increments as the analog input increases and always decrements as the analog input decreases. Linearity is the constancy of the transfer characteristic (gain) through the entire range of the A/D converter's operation.

Monotonicity is checked first. At the beginning of this test, the DC link voltage is automatically set to maximum and then allowed to ramp down to zero by turning off the SCR, Q1. This allows resistor R2 to discharge capacitors C1 and C2 across which the link voltage is defined. As the link voltage decreases, the computer automatically checks the A/D converter's output for a continuously decrementing binary number, a monotonic transfer characteristic. Progress of the test is to be monitored with the NORMAL OPERATION indicator. This indicator flashes as the least significant bit of the A/D converter output changes. This test takes approximately 20 seconds to complete. The flash rate of the indicator decreases as the voltage decreases. If the test is failed at any point, the indicator will remain on continuously. However, if the test is passed, the flash rate returns to 10 Hz when the test is concluded.

When the monotonicity test is completed, the next phase of the A/D check is entered automatically, the linearity check. For this test, the A/D converter's performance is verified at two points within its operating range. At each point, the computer simply controls the link voltage such that a predefined binary number is maintained at the A/D converter's output. If the A/D converter is faulty, then the measured link voltage will be out of tolerance.

The converter's mid DC link output voltage point is set in this test, #2; while its maximum voltage point is set in the next test, #3. The measured link voltages are to be 30 +/-1.5 V DC and 60.5 +/-3 V DC. The 30 V DC point will be maintained until the start button is depressed, incrementing to test #3.

What's Tested:

- A/D converter, voltage channel
- monotonicity
- linearity (partial)

To Complete Test #2:

1. Verify the NORMAL OPERATION indicator function.

   The indicator will begin flashing rapidly and continually slow down until approximately 20 seconds later when it will begin flashing at 10 Hz.

   This test may be repeated by depressing the STOP button.

   NOTE: If you don't wish to remove the converter's top cover, the following measurement can be made at the rear panel TURBOVAC connector, J2. Measure at pins 1b, 2b or 3b. At these pins, the measured voltage should be slightly lower than at TP1, 29.4 +/-1.5 V DC. This measurement also requires that the output transistors and drivers are functioning properly.

2. Measure the DC voltage at TP1 after the NORMAL OPERATION indicator begins flashing at 10 Hz.

   The voltage measured should be 30 +/-1.5 V DC.

Failures and Possible Causes:

1. Symptom: Failure at Step 1 of the above procedure - The monotonicity test fails after repeated attempts. This is indicated by the NORMAL OPERATION indicator staying on continuously.

   Sources:
   - Failed A/D converter IC, U4.
   - Possible large leakage current path from VLINKHI to ground either in the OUTPUT DRIVERS or POWER SUPPLY blocks. (If there is a large leakage current, the link voltage drops too rapidly for the computer to implement the monotonicity check.)

2. Symptom: Failure at Step 2 of the above procedure - The measured link voltage is out of tolerance.

   Source:
   - Failure in the A/D converter block.

5.3.4 Test #3 - Output Driver Leakage Current Test, Pull Downs

Background:

During this test, the A/D converter's functional test is completed and the OUTPUT DRIVERS block testing is begun.

The A/D converter test is the continuation of the linearity check begun in test #2. The DC link voltage is maintained at an approximate full scale value. It is to measure 60.5 +/-3 V DC.

The first items of the output drivers to be checked are the leakage currents of the pull down transistors Q10, Q11, and Q12. A high valued resistor is to be placed between the pull up and pull down of each phase's output driver pair, specifically pins 1a and 1b, 2a and 2b, and 3a and 3b of the rear panel TURBOVAC connector, J2. The output voltage (DC link) is held at 60.5 VDC. The output pull up transistors, Q7, Q8, and Q9 are turned ON and the pull downs, Q10, Q11, and Q12 are turned off. The voltage drop across each resistor is an indication of the leakage current through the pull down transistors, Q10 through Q12.

What's Tested:

- A/D converter linearity (completed),
- Q10, Q11, and Q12 leakage currents.

To Complete Test #3:

1. Verify that the NORMAL OPERATION and ACCELERATION indicators are flashing.

   NOTE: If you don't wish to remove the converter's top cover, the following measurement can be made at the rear panel TURBOVAC connector, J2. Measure at pins 1b, 2b or 3b. At these pins, the measured voltage should be slightly lower than at TP1, 59.9 +/-3 V DC. This measurement also requires that the output pull up transistors and drivers are functioning properly.

2. Measure the DC voltage at TP1.

   The voltage measured should be 60.5 +/-3 V DC.

3. Connect a 10 K ohm, 1/2 watt resistor between pins 1a and 1b of the rear panel TURBOVAC connector, J2.

   Measure the voltage across the 10 K ohm resistor.

   The voltage measured should be less than 5 V DC.

4. Repeat Step 3 above with the 10 K ohm resistor connected between TURBOVAC connector J2 pins 2a and 2b.

5. Repeat Step 3 above with the 10 K ohm resistor connected between TURBOVAC connector J2 pins 3a and 3b.

Failures and Possible Causes:

1. Symptom: Failure at Step 2 of the above procedure - The 60.5 V DC link voltage measurement is out of tolerance.

   Source: • Failure in the A/D converter block.

2. Symptom: Failure at Step 3, 4, or 5 of the above procedure - One or more of the voltage readings across the 10 K ohm resistor is high.

   Source: • Failure in the output driver block, specifically Q10, 11, 12, 14, 15, or 16.

5.3.5 Test #4 - Pull up Leakage, 12 V DC, Discrete I/O Test

Background:

In this test, the leakage currents of the output pull up transistors Q7, Q8, and Q9 are measured, the 12 V DC supply's average and ripple voltage is checked, and the remaining discrete I/O lines are exercised.

The leakage currents of the pull up transistors are verified in a similar manner to the pull downs in the previous test.

The 12 V DC supply is to be verified, both the ripple and average DC voltage, under load. The 12 V DC supply load is increased by energizing the HOURS meter upon entering this test. The state of the elapsed time meter is to be verified by the operator. The 12 V DC supply can be measured at TURBOVAC connector J2 pin 5b, as long as there is no other connection to that pin.

The discrete I/O is also to be tested. Discrete inputs consist of THERMAL SWITCH, PUMP SELECT, REMOTE START and REMOTE STOP. Discrete outputs consist of the three controlled front panel indicators, the elapsed time indicator (M1), and normal operation relay K1. To verify proper operation, various inputs are to be exercised, each of which engages all the discrete outputs except the normal operation relay. The computer will "try" to turn ON the relay; however, the flashing FAILURE indicator will prevent the relay from energizing through Q17. The normal operation relay will be exercised in test #5.

What's Tested:

- Q7, Q8, Q9 leakage currents,
- 12 V DC ripple under load,
- 12 V DC average value under load,
- Discrete Inputs block and Discrete Outputs block.

To Complete Test #4:

1. Verify that the FAILURE indicator is flashing.

2. Verify that the normal operation relay, K1, is turned off and the HOURS meter, M1, is turned ON. (The HOURS meter is turned ON if the right-most digit wheel is positioned halfway between two numbers.)

3. Connect a 10 K ohm, 1/2 watt resistor between pins 1a and 1b of the rear panel TURBOVAC connector, J2.

   Measure the voltage across the 10 K ohm resistor. The voltage measured should be less than 5 V DC.

4. Repeat Step 3 above with the 10 K ohm resistor connected between TURBOVAC connector J2 pins 2a and 2b.

5. Repeat Step 3 above with the 10 K ohm resistor connected between TURBOVAC connector J2 pins 3a and 3b.

6. Measure the DC voltage at TURBOVAC connector J2 pin 5b.

   The measured voltage should be 11.5 +/-0.75 V DC.

7. Measure the AC voltage at TURBOVAC connector J2 pin 5b.

   The measured voltage should be less than 0.75 V RMS.

8. Jumper together TURBOVAC connector J2 pins 5a and 5b.

   Verify that the normal operation relay, K1, remains off.

   Verify that the HOURS meter, M1, is de-energized.

   Verify that the ACCELERATION and NORMAL OPERATION indicators both turn ON.

9. Jumper together TURBOVAC connector J2 pins 4b and 5b.

   Verify the same items as in Step 8 above.

Failures and Possible Causes:

1. Symptom: Failure at Step 3, 4, or 5 of the above procedure - One or more of the voltage readings across the 10 K ohm resistor is high.

   Source: • Failure in the output driver block, Q4, 5, 6, 7, 8, or 9; or U6.

2. Symptom: Failure at Step 6 or 7 of the above procedure - The 12 volt supply measurement(s) are out of tolerance.

   Source: • Failure in the power supply block, CR2 through 5, C5, C6, C7, VR1. If the supply voltage is low and the ripple high, there may be a heavy current path to ground somewhere on the PC board (possibly failed component).

3. Symptom: Failure at Step 8 or 9 of the above procedure - There is no result when TURBOVAC connector J2 pins 5a and 5b are connected together or when pins 4b and 5b are connected together.

   Source: • Failure in input DISCRETE INPUTS block or computer 1C, U7.

4. Symptom: The HOURS meter doesn't turn ON when this test is entered or, the HOURS meter doesn't turn off in Steps 8 and 9 above.

   Source: • Failure of the driver IC, U5, U6, or the computer IC. U7, or the HOURS meter.

5. Symptom: The normal operation relay turns ON when this test is begun.

   Source: • Failure of Q17 and/or associated components.

5.3.6 Test #5 - Output Driver Saturation Voltage Test, Short Circuit Protection

Background:

In this test, the output transistors' drive capability is checked simultaneously with the accuracy of the current channel of the A/D converter. Finally, the normal operation relay and the Output Short Circuit Protection block are exercised.

To test the output drivers and A/D converter's link current measuring accuracy, a dummy load is required. By generating a predefined output (DC link) voltage, the link current becomes a function of the dummy load. The link current is set to a specific value by using a known load. The computer measures the actual link current and compares it to the allowable limits. If the current is beyond the allowable limits, the front panel indicators, which normally flash, will remain ON continuously.

The dummy load consists of two low valued resistors (5 ohms, 1%, 50 watts, each) connected from PHI1 to PHI2 and from PHI2 to PHI3. HI and LO outputs of each phase must be connected together (see Figure 5-2). The outputs will switch between two states, holding each for a short time. For the first state, PHI1 and PHI3 will be low and PHI2 high; and for the second state, PHI1 and PHI3 will be high and PHI2 low. This exercises all output transistors.

To exercise the normal operation relay and drive circuitry, a state must be set up where the FAILURE indicator doesn't turn ON. This is done by changing the test back to either tests 1, 2, or 3. When done, the relay should be energized.

The last circuitry to be checked is the Output Short Circuit Protection block. The test is set again to test number 5; the dummy load is attached, and a 0.75 ohm, 10 watt resistor is connected from any output to ground for a short time. The short circuit protection latch will be set and all output functions will cease. The front panel indicators will stop flashing.

CAUTION: The load must not be connected before entering this test and must be removed before leaving this test. If this procedure isn't followed, the output stage may be damaged if the short circuit protection circuitry isn't functioning.

What's Tested:

- The output transistor saturation voltages at full rated load,
- The current channel of the A/D converter,
- The functioning of the normal operation relay,
- The Output Short Circuit Protection circuitry.

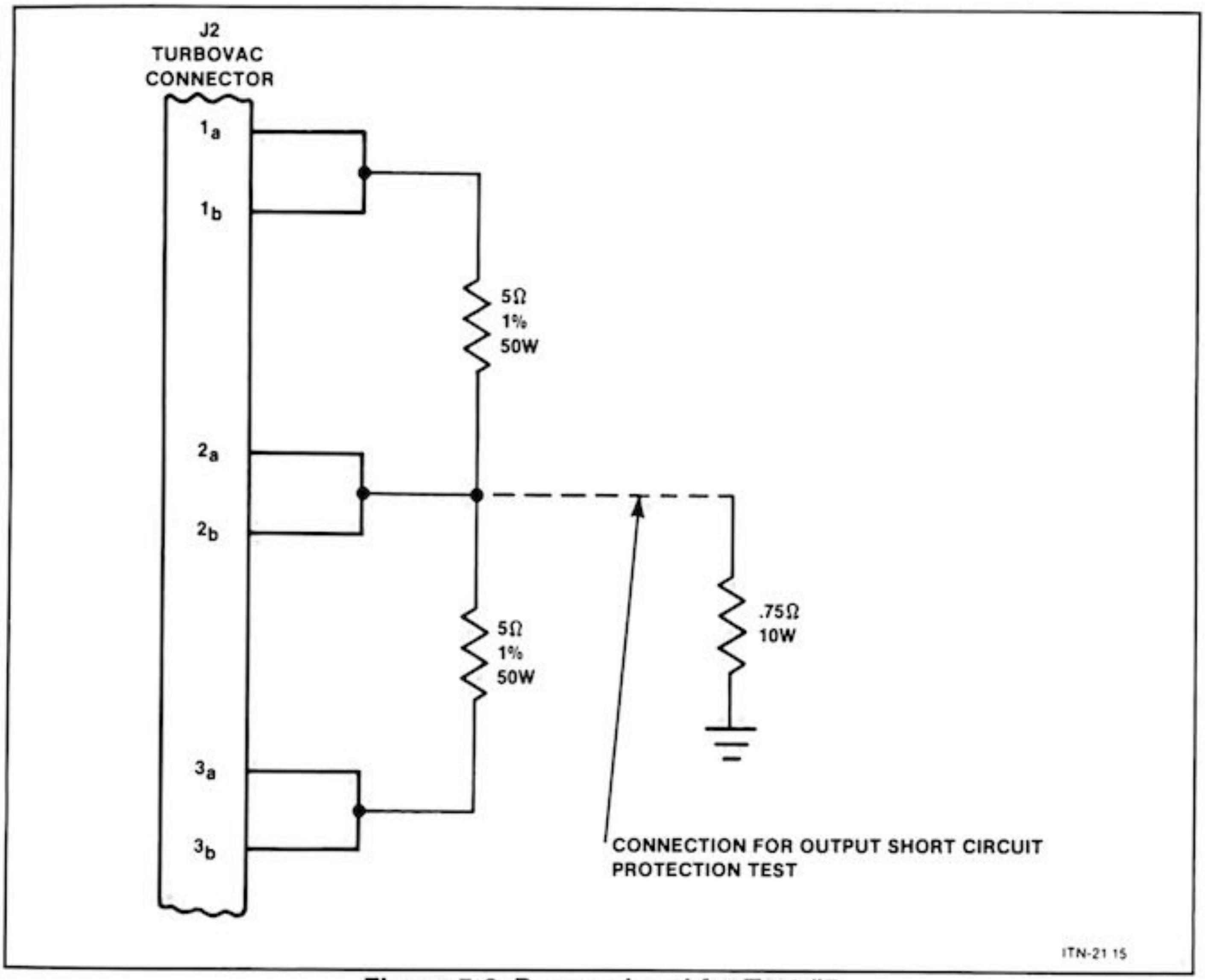


Figure 5-2. Dummy Load for Test #5

To Complete Test #5:

1. Verify that the FAILURE and ACCELERATION indicators are turned ON continuously.

2. Connect two 5 ohm, 1%, 50 watt resistors to TURBOVAC connector J2 as shown in Figure 5-2.

3. Verify that the FAILURE and ACCELERATION indicators are flashing.

4. Measure the AC voltage at TP1. The measured voltage should be less than 2.2 V RMS.

5. Remove the two 5-ohm resistors (applied in Step 2). Depress the start button and increment to either test #1, 2, or 3.

6. Verify that the normal operation relay is turned ON. Note that it will take approximately 4 seconds for the relay to energize once in test #1, 2, or 3.

7. Depress the start button and increment to test #5 again.

8. Connect, again, the two 5-ohm resistors to TURBOVAC connector J2 as described in Step 2.

9. Connect a 0.75 ohm, 10 watt resistor between TURBOVAC connector J2 pin 2b and ground.

10 Verify that the FAILURE and ACCELERATION indicators stop flashing and remain ON continuously.

Failures and Possible Causes:

1. Symptom: Failure at Step 3 of the procedure - Indicators don't flash.

   Sources:
   - A failed output transistor or associated drive circuitry, OUTPUT DRIVERS block
   - Failure in the output (DC link) current buffer circuitry. This is part of the A/D converter circuitry, U2A and associated components.
   - Failure in the OUTPUT SHORT CIRCUIT PROTECTION block, which leaves it too sensitive to output current.

2. Symptom: Failure at Step 4 of the procedure - The AC voltage at TP1 is high.

   Sources:
   - Failure in the DC link supply, CR1, C1, C2 and associated components.
   - Unusually large current path to ground from VLINKHI - If not already done, check the output transistors.

3. Symptom: Failure at Step 6 of the procedure - The normal operation relay doesn't turn ON.

   Source:
   - Failure of the normal operation relay, K1, drive circuitry, U5, U6, or switch Q17, and associated components.

4. Symptom: Failure at Step 10 of the procedure. The indicators don't stop flashing.

   Source:
   - A failure in the OUTPUT SHORT CIRCUIT PROTECTION block, Q2 and associated circuitry.

6 — Detailed Description

Contents

6.1 TMP151/361 and 151/361C Turbomolecular Pumps

This section applies to all TMP151/361 and TMP151/361C pump models. The only physical difference between the TMP151 and the TMP361 models is the size (and the associated pumping speed). The only difference between the standard TMP151/361 models and the corrosive-version TMP151/361C pump models is that the 151/361C models have the purge port (see Figure 6-1).

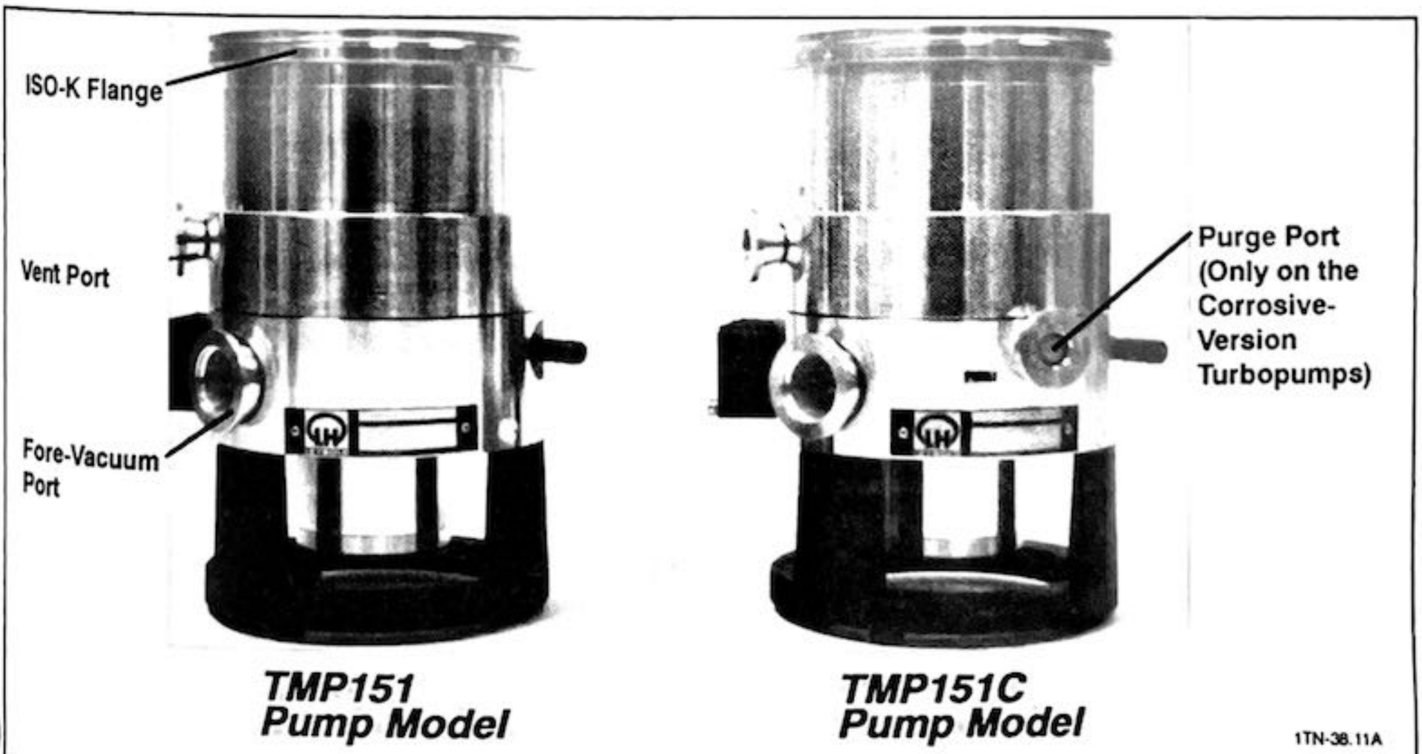


Figure 6-1. TMP151 and 151C Pump Models

Description

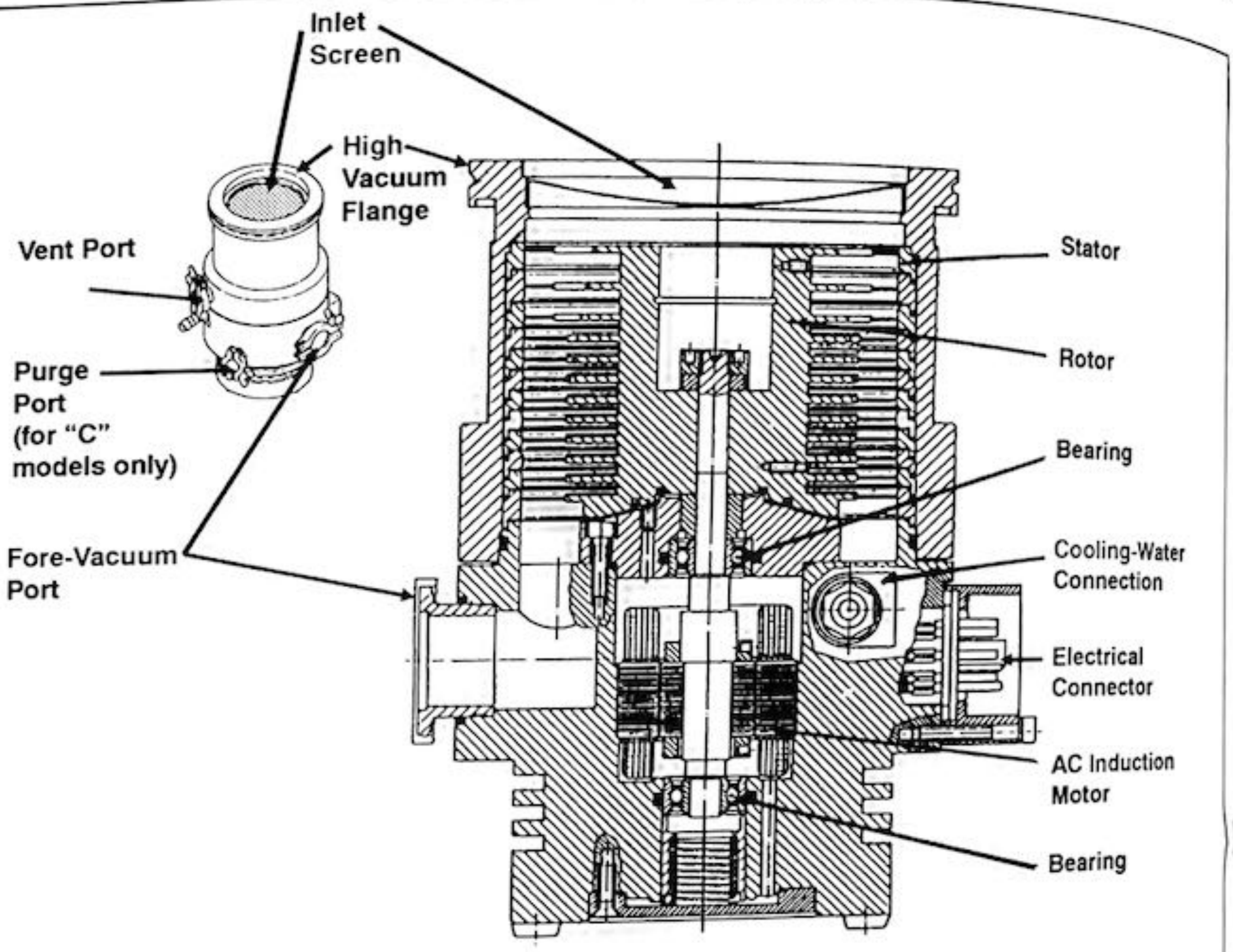


Figure 6-2. Sectional View of the TMP151

The TURBOVAC is a turbomolecular pump used to evacuate a chamber or system to the high vacuum region. Its pumping speed is very high for heavy molecules while it is considerably lower for light molecules such as hydrogen. Its pumping speed also decreases at pressures above 10^{-2} mbar. Thus, a backing pump is required to shorten the pumpdown time, to avoid overloading the pump at higher pressures, and to evacuate the hydrogen. The ultimate total pressure is mainly determined by the amount of hydrogen present. At very low pressures, most of the hydrogen originates from the metal walls of the vacuum chamber.

To obtain pressures in the 10^{-8} mbar range, the backing pressure must be at least 1×10^{-3} mbar, and the vacuum chamber and the inlet flange must be baked out. The CF-flanged turbopump models can be baked out because they have a metal inlet seal and a stainless steel housing. The ISO-K flanged pumps have aluminum housings and thus aren't suitable for bakeout. The ASA-flanged pump models have stainless steel housings; however, an ASA flange-heater isn't yet available for bakeout. The type of high-vacuum flange supplied is identified by the turbopump's catalog number (see Table III Ordering Information at the front of this manual).

The TURBOVAC pump consists of a multi-stage rotor/stator assembly and a drive assembly (see Figure 6-2). An inlet screen fits into the turbopump's high-vacuum flange to prevent foreign objects larger than 1.5 mm from falling into the pump and causing serious damage to the rotor.

The upper high-vacuum stages capture the process gas and the lower stages compress it. The drive motor and grease-lubricated ball bearings are located in the fore-vacuum area of the pump thus keeping the high-vacuum space free of grease contaminants (see Figure 6-2).

The rotor is made of aluminum and is dynamically balanced to produce a total vibration velocity of not more than 0.10 mm/second. Thus the rotor should never be altered except at the factory or at one of our service centers. However, customers that have been trained by Leybold can remove the stators and clean the rotor and stator if necessary (see Section 4.3 for this procedure).

The rotor shaft is supported by two ceramic ball-bearing assemblies lubricated with a special grease. The bearings are lifetime lubricated within the sealed spindle assembly. This unique lubricating system allows the pump to be mounted in any desired angular position.

The rotor is directly driven by a 3-phase, AC induction motor (see Figure 6-2). The motor is normally water cooled; however, an air cooling option is also available (see Appendix A.1).

A bi-metal thermal switch shuts down the pump if the temperature near the motor coil exceeds 158°F (70°C). This switch opens and causes the NT150/360 Frequency Converter to shutdown the turbopump if the cooling water or air is inadequate. The turbopump can't be restarted until the thermal switch closes and the converter is reset by pressing the STOP pushbutton.

All turbopumps have a vent port. The TMP151/361C models also have a purge port (see Figure 6-1). The vent port is the 10KF port in the side of the upper pump housing; the purge port is the smaller port (10KF) on the pump's base flange. It's important to vent turbopumps during shutdown to prevent oil vapors from backstreaming from the backing pump into the turbopump. Venting also prevents the rotor from spinning for long periods at critical frequencies which could cause premature bearing failure.

For standard application, the pump is normally vented through the vent port. The purge port is sealed off on the TMP151/361C pump models for standard applications.

However, if the pump is exposed to corrosive or aggressive process gases, or to gases that contain abrasives or metallic dust, venting through the vent port would result in harmful process gases entering the bearing cavity and damaging the grease. Harmful process gas can also be drawn into the bearing area if the inlet pressure becomes higher than the original foreline pressure. Particles as small as 5 microns can cause damage.

Thus, for harmful process gases, you must use a TMP151/361C pump model. Seal the vent port and use dry inert gas to purge and vent the pump through its purge port. A special Purge/Vent Valve is required which allows a constant flow (minimum 12 sccm at 0 psig) during operation for purging, and which automatically increases the flow to 4800 sccm to vent the pump during shutdown (see Appendix A.6). See Table 2-B for purge flow rates at higher pressures.

This purge and venting gas keeps the motor/bearing cavity at higher pressure than the foreline, thus preventing the bearing and grease from being exposed to harmful process gas.

Even though inert gas purging allows you to pump many corrosive and aggressive gases, we don't recommend pumping oxidizers or higher than atmospheric concentrations of oxygen with any pump which uses hydrocarbon grease.

6.2 Summary of Frequency Converter Models and Features

There are currently three USA versions of the NT150/360 frequency converter:

- **P/N 85472-3** — The standard NT150/360 converter is normally used for the TMP151, TMP361, TMP150**V** and TMP360**V** pumps.
- **P/N 85572-1** — The NT150/360 VH converter is used primarily with the TMP150**H** and TMP360**H** pumps but it can also be used with the TMP150V and TMP360V pumps and the TMP 151/361 pumps.
- **P/N 85472-1** — The old NT150/360 converter has been discontinued. This converter can be used with the TMP361 and TMP360**V** but it must be modified for use with the TMP151 or TMP150**V**.

  A modification kit is available (P/N 728-40-005) that includes the 1-ohm board, a cable, and the necessary hardware. This modification can be made by Leybold Service or by a skilled electrical technician.

  If you try to use this converter without modifications with the TMP151 or TMP150 V, it could damage the turbopump or cause the converter to go into failure mode. Once the converter is modified, it can be used with the same pump models as standard **85472-3** converter.

Except where noted otherwise, the information in this section and Sections 6.2 through 6.4.9 applies to all three converters listed above. Section 6.4.10 describes the 1-ohm board which is used only in the standard NT150/360 converter (85472-3).

The frequency converter converts single-phase, 100-240 V AC, 50/60 Hz power into three-phase, variable voltage, variable frequency power as required by the turbopump's induction motor. It accelerates the turbopump's rotor to 50,000 rpm for the TMP151 and 45,000 rpm for the TMP361.

The turbopump is turned "on" and "off" by the converter's front panel START and STOP pushbuttons. The standard NT150/360 converter has a front panel HOURS meter which records the turbopump's total operating time for maintenance purposes. Front panel POWER, ACCELERATION, NORMAL OPERATION, and FAILURE indicators show the status of the converter. A rear panel terminal block provides the means of connecting external control and monitoring devices.
Other features of this frequency converter include:

- **Self Test** - Maintenance is simplified due to the use of large scale integration (LSI) and digital technology. The microprocessor allows the concentration of numerous functions in one package and the flexibility to incorporate self test features aiding in rapid fault isolation in the event of a failure. There are two types of self test: 1) dynamic testing, is run continuously while the turbopump is being controlled; 2) static testings, is implemented only when the converter is turned ON with no turbopump connected. Dynamic tests are limited to verifying the computer's integrity alone. The static tests exercise all the circuitry, one block at a time, in a manner that aids troubleshooting in the event of a component failure. See Section 5.3 for detailed information of the static tests.

- **No Calibration** - No calibration is required to set the frequency, voltage or current setpoints in this unit. All are determined by the software and guaranteed to the accuracy of the internal reference supply and resistance tolerances. This is approximately 5% for voltage and current and 0.02% for frequency. The accuracy of the frequency is guaranteed by a 2 MHz quartz crystal.

- **Long Cable Drive Capability** - The converter is designed to drive a turbopump at distances as far as 328 feet (100 m). The unit automatically establishes the necessary voltage corrections to compensate for the cable losses and maintain maximum output power. No calibration is required.

- **Output Short Circuit Protection** - The converter is designed to withstand short circuiting of the power output stages. Short circuits between any two outputs or between any output and ground will set a hardware latch, leaving the unit in a powered down mode. To reset, AC power must be turned off and on.

- **Annunciation of Four Distinct Failure Conditions** - Four distinct types of faults are detected and flagged by the converter. These are: dynamic self test failure, output short circuiting, turbopump overload, and turbopump overtemperature. All fault types leave the unit latched in a powered down state, with a front panel indicator, designated FAILURE, flashing at one of four fixed rates. The flash rate indicates the type of the failures as described in Table 3-D.

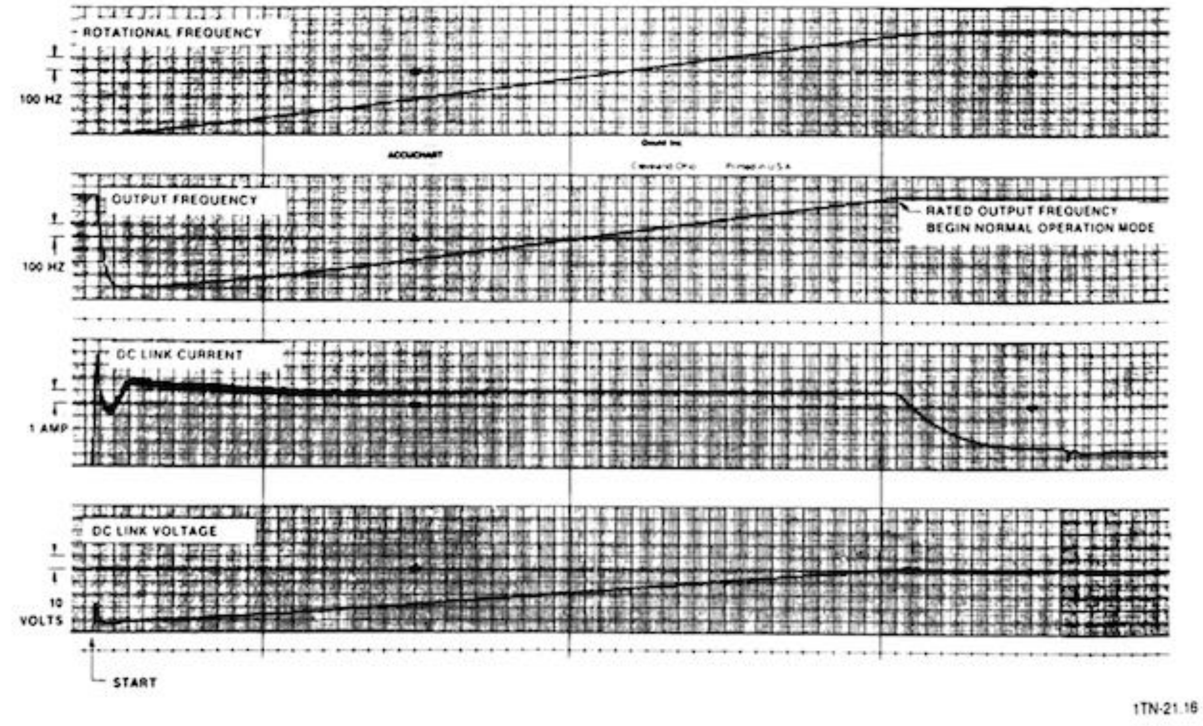


Figure 6-3. Typical TMP151 Start-Up Profile

6.3 Functional Description of the Frequency Converter

The NT150/360 Frequency Converter's primary function is to convert 120/240 V AC, 50/60 Hz, single-phase power, into high-frequency, 3-phase AC power. This power conversion is necessary to operate the AC induction motor of a turbomolecular pump at its rated rotational speed. Induction motors require that their drive frequency be closely related to their actual rotational speed.

For the turbopump to achieve its rated rotational speed as quickly as possible, the frequency converter will start the turbopump's motor from rest with a low drive frequency, and then slowly raise the drive frequency as the turbopump accelerates. This function causes the motor to operate at maximum torque during acceleration. Torque is a function of the motor's slip frequency, which is defined as the difference between the applied drive frequency and the motor's actual rotational frequency. Up to a point, induction motor torque increases as the slip frequency increases; however, as the slip frequency continues to increase, torque ceases to increase, and for a low-slip, high-efficiency motor, torque actually begins to decrease.

In addition to varying the drive frequency, the frequency converter also varies its output voltage level so as to maintain the proper relationship between the motor's drive voltage and drive frequency (known as the "volts per Hertz" ratio). Induction motors require that the drive voltage be proportional to, and closely related to the drive frequency. A drive voltage which is too high or too low with respect to the drive frequency will result in reduced torque.

The torque required to accelerate the turbopump is generally more than that required to maintain normal operating speed once it has been achieved. In order to reduce heating in the motor and in the converter package, the frequency converter lowers the drive power after normal operating speed has been achieved. The power reduction is done by reducing the maximum current allowed to flow through the motor. To aid in the understanding of the above operating principles, a typical start up profile of the TMP151 turbopump is shown in Figure 6-3. This figure illustrates the relationship between output voltage, motor current, output frequency, and rotational frequency of a typical TMP151 as it accelerates from rest.

6.4 Circuit Descriptions

The NT150/360 Frequency Converter uses the variable frequency, variable voltage technique to control the motor speed of a turbomolecular pump. This technique is based on the principle that the speed of an induction motor is determined by the synchronous speed and slip of the rotor. The synchronous speed is related to the motor's drive frequency while slip is proportional to the load or torque demand on the motor.To convert the 120/240 V AC, 50/60 Hz power line into a variable frequency, variable voltage controlled 3-phase power source, the converter uses the DC Link method. This method basically converts AC into a variable DC voltage, and then switches this DC voltage (hereafter called the DC link voltage), onto the converter's three output lines in a sequence which synthesizes an AC output signal. Six power transistors are used to switch the three output lines. Each transistor pair switches its output between the DC link voltage and ground. This type of converter is called a DC Link converter because of the DC link between the input and output of the power transistor switching stage.

The variable DC link voltage is generated through the use of an SCR (silicon controlled rectifier). The DC link voltage level can be varied by controlling the ratio of the SCR's "on-time" to its "off-time".

The DC link voltage is controlled as a function of the converter's output drive frequency. The exact function is determined by the type of turbopump being driven, and the cable resistance (length) between the converter and turbopump.

During acceleration, the converter increases its drive frequency as fast as possible to a predetermined value. This acceleration is consistent with the limiting of the DC link current which, in turn, is proportional to the turbopump's motor current.

The microcomputer, which controls all the above functions, monitors the DC link voltage and current by means of an A/D (analog to digital) converter.

The converter electronics has been divided into the following functional blocks:

A detailed description of each of the converter's functional blocks is presented in the following sections. For easy reference, the first nine functions are outlined on the NT150/360 electrical schematic contained in Section 7, Figure 7-5. The convention used in labeling logic signals on an electrical schematic is that the label is true when the voltage at the signal point is more positive (logic High) than the signal's false state (logic Low). For example, a positive voltage (logic High) at TP7 indicates the presence of a START signal. A bar over the label indicates that the label is true when the voltage at the signal point is less positive (logic Low) than the signal's false state (logic High). Barred signals are denoted by an apostrophe in the following text. For example, RESET' signifies that the microcomputer will be reset when this signal goes to ground (logic Low).

6.4.1 Microcomputer

With the exception of gross overcurrent detection and shut down, all logic and control functions are performed by the single microcomputer chip, U7.

Last resort protection of the power devices is provided by the Output Short Circuit Protection circuitry. It over-rides the microcomputer and thus provides power device protection in the event of a microcomputer failure.

The microcomputer controls the DC link voltage by direct control of the SCR gate. The microcomputer uses its multiplexer and the A/D Converter to measure both DC link voltage and current in order to generate an output signal that adjusts the SCR gate signal as required to obtained the desired output voltage.

The output switching sequence and drive frequency is controlled by the microcomputer directly through the transistor buffers in the Output Drivers block.

The microcomputer uses its 2 MHz quartz crystal (Y1) as its basic time reference.The microcomputer obtains digital values for the link current (ILINK) and the link voltage (VLINK HI) from the A/D converter. The signal to be converted is chosen by means of the MUX ADDR 0 and MUX ADDR 1 lines. Conversion is initiated by the START CONVERSION signal, and data is transferred to the microcomputer over the 8-bit data buss DB0 through DB7.

Five discrete (ON/OFF) status signals, THERMAL SWITCH, 150'/360 PUMP SELECT, START, STOP, AND RESET' provide the microcomputer with the information required to establish its operating mode.

The ZERO CROSS signal informs the microcomputer when the power line voltage is crossing through zero. The microcomputer uses this signal to time the actuation of the SCR GATE' signal.

The microcomputer provides four discrete output signals, ACCELERATION, NORM OPERATION, FAIL, and RELAY to control the front panel indicators and the normal operation relay, K1.

The microcomputer provides pulses on the ELAPSED TIME IND output to drive the elapsed time indicator, M1.

The six output power switching transistors are controlled directly by microcomputer outputs PHASE 1 HI' through PHASE 3 LO'.

6.4.2 Power Supply

The power supply circuitry provides the DC link voltage (VLINK HI), a regulated +5 volts, an unregulated +12 volts, a +5 volt reference, and two AC reference signals as required by the Zero Crossing Detector.

DC link power is provided by the upper secondary of transformer T1 which produces 55 V RMS. This AC voltage is rectified by diode bridge CR1, switched by SCR Q1, and filtered by inductor L1 and capacitors C1, C2, and C3.

Control of VLINK HI is accomplished by means of the GATE input to the SCR. See Figure 6-4. The SCR is turned ON sometime in each half cycle of the AC input voltage, and then turns itself off at the end of each half cycle. If the SCR is turned ON at the beginning of the cycle, then full power is applied to the following rectifier and filter. This results in maximum output voltage. The later the SCR is turned ON in the half cycle, the less power is applied to the rectifier and filter, and the lower is the corresponding output voltage.

The DC link supply circuit may appear unusual at first. Figure 6-5 shows the components placed in a more familiar manner. The circuit used, however, has the advantages of a smaller choke due to the elimination of any DC current, a grounded VLINK HI return, and simple gate drive circuitry.

Resistor R5 is the link current (total motor current) sense resistor, providing a voltage of -50 mV per ampere of link current. The output called ILINK is used by the microcomputer (through the A/D Converter) and the Output Short Circuit Protection circuitry. The "high" side of R5 is grounded so that the high currents resulting from short circuits to ground, in addition to output-to-output short circuits can be detected through this resistor.

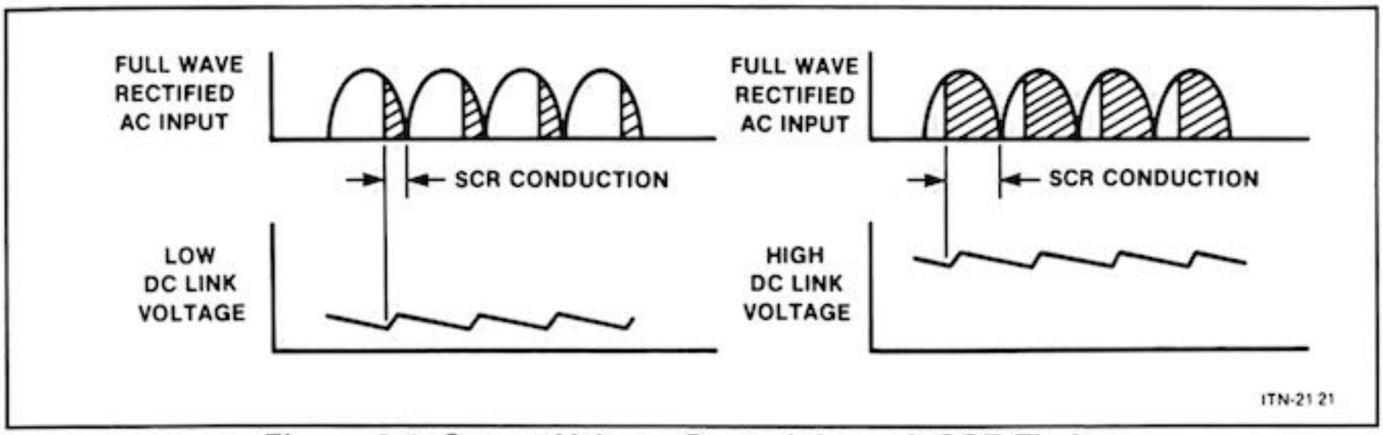


Figure 6-4. Output Voltage Control through SCR Timing

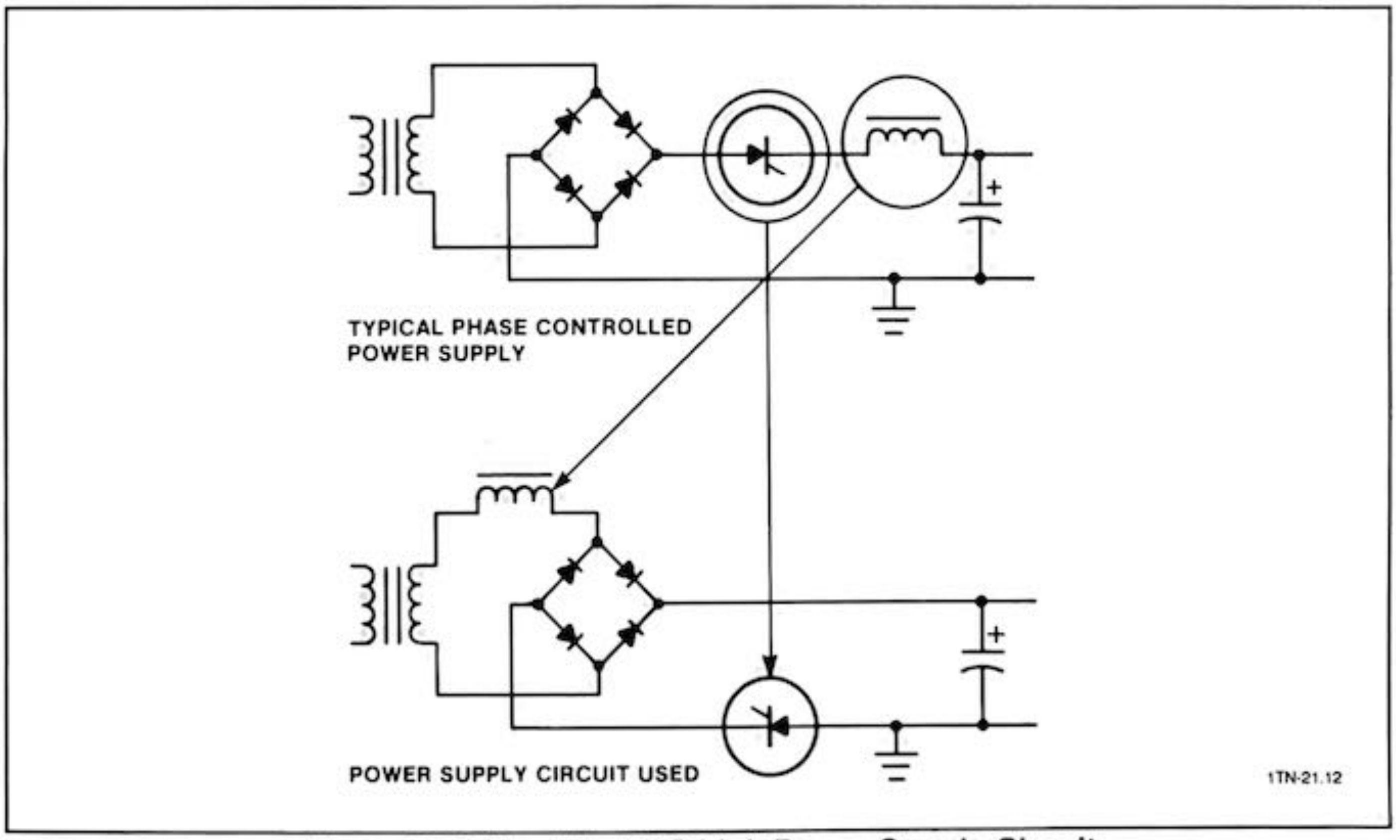


Figure 6-5. Simplified DC Link Power Supply Circuit

6.4.3 A/D Converter

The A/D (Analog to Digital) Converter circuitry consists of two input conditioning circuits, a combined multiplexer and an 8 bit A/D converter contained in IC U4, and a frequency divider circuit. The frequency divider flip-flop, U3A, is used to derive the 1 MHz clocking frequency, required by the A/D converter, from the 2 MHz oscillator of the microcomputer.

The A/D Converter section interfaces the microcomputer to analog signals VLINK HI and ILINK. These inputs are conditioned to span the input range of the A/D converter IC, which is from 0 to +5 volts. One or the other signal is selected at the multiplexer, converted, and then placed onto the data bus (DB0 through DB7). The microcomputer controls conversion over signal lines START CONVERSION, MUX ADDR 0, and MUX ADDR 1.

The A/D Converter block is continuously monitored by the microcomputer for gross failure. The A/D Converter's output is offset such that it shouldn't, under normal circumstances, output a "zero". This is done by adding an offset voltage to the analog inputs of the A/D converter IC, U4. Resistor R17 offsets the ILINK signal, and resistor R18 offsets the VLINK HI signal. If the failure condition, zero output, is detected by the microcomputer, it will enter the failure mode and indicate an internal fault by flashing the front panel FAILURE indicator at a rate of 4 Hz.

6.4.4 Discrete Inputs

The Discrete Input circuitry buffers the external inputs to the microcomputer for protection against radio frequency and transient noise and damage due to mis-wiring. Filtering is provided by the series resistor and shunt capacitor on each input. The inputs are protected from going below ground or above +5 volts by the combination of the series resistors and the diode clamps. The PUMP SELECT input is unique in that it is pulled up to and clamped to +12 volts.This is done to allow an external measurement of the +12 volt power supply at the pump connector; it doesn't modify the basic function of the circuit.

6.4.5 Discrete Outputs

The Discrete Outputs circuit includes the front panel indicators, the elapsed time meter, the normal operation relay, and the circuitry to drive these devices. IC U5 contains high current, open collector drivers which buffer the microcomputer's low power MOS outputs to the voltage and current levels required by the output devices. In the event of a failure, the normal operation relay must be de-energized.This is implemented in hardware by FET Q17 and its associated components; thus, even in the event of a microcomputer failure, the relay will be de-energized.The filtering at the gate of Q17 (provided by capacitor C31, diode CR29, and resistor R44) is needed to keep Q17 off even when the failure type leads to a flashing FAILURE indicator.

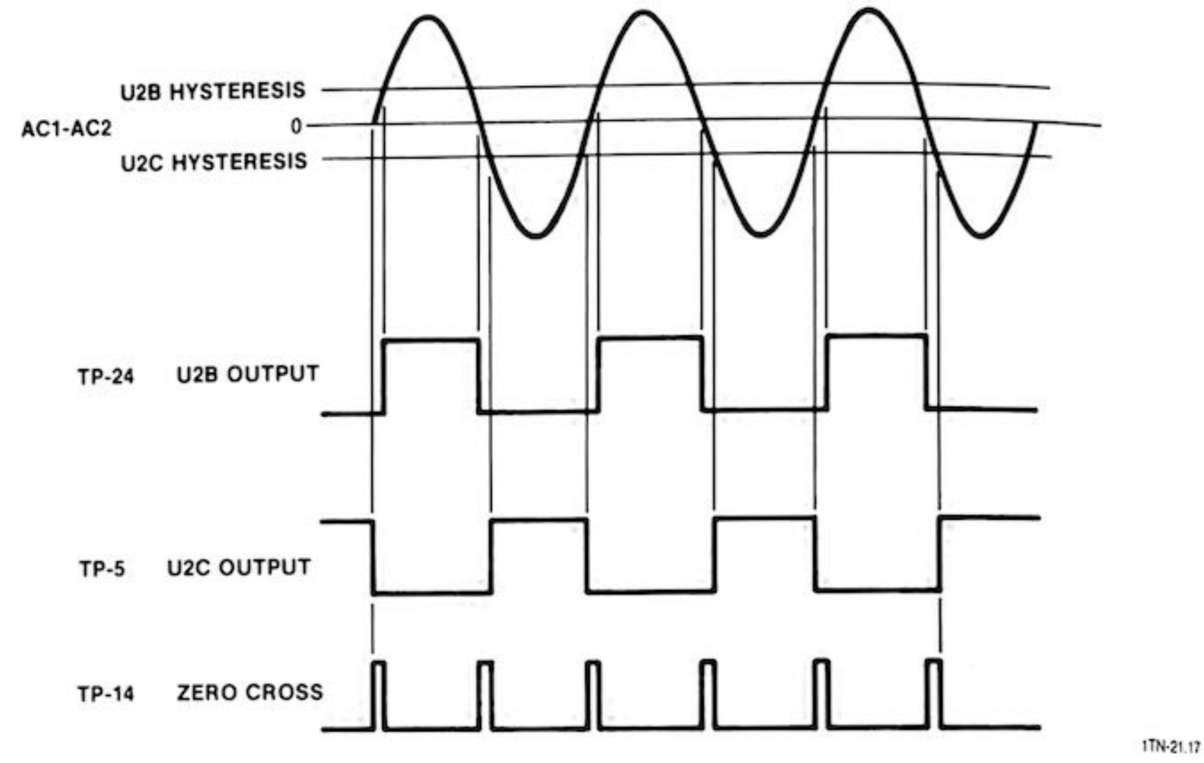


Figure 6-6. Zero Crossing Detector Timing Diagram

6.4.6 *Zero Crossing Detector*

The Zero Crossing Detector outputs a pulse each time the AC line voltage crosses through zero volts. Signals AC1 and AC2 from the power supply are the input signals. The detector consists of two comparators and a NOR gate.

Refer to Figure 6-6. Each comparator detects one of the two zero crossings per cycle of the AC line. One, when the transition of AC1 with respect to AC2 is from negative to positive and two, when the transition is from positive to negative. The output pulse widths are controlled by setting the hysteresis of the comparators with resistors R6, R7, R9, and R10. The pulses are then OR'd and inverted, resulting in a train of trigger pulses that have a pulse duration time of about 1 millisecond.

6.4.7 SCR Buffer

The SCR Buffer circuitry buffers the SCR GATE' signal and produces the pulsed current GATE signal which turns on the SCR. The buffer utilizes three signals: RESET', OUTPUT INHIBIT and ZERO CROSS, in addition to the SCR GATE' signal. RESET' enables the GATE output. OUTPUT INHIBIT and ZERO CROSS inhibit the GATE output.

RESET' ensures that, following power up, the GATE output isn't enabled until the microcomputer is no longer being Reset. Flip-flop U3B performs the function of a two input NOR gate and inverter.

The ZERO CROSS inhibit ensures that a GATE signal occurring late in the previous half line cycle doesn't spill over into the present half cycle by inhibiting the GATE output in the region of zero cross.

OUTPUT INHIBIT also inhibits the GATE signal and ensures that DC link power is shut off independently of the microcomputer in the event that excessively high link current is detected by the Output Short Circuit Protection circuitry.

6.4.8 Output Drivers

The Output Drivers circuit includes six switching transistors and their buffers which convert the output signals of the microcomputer, PHASE 1 HI' through PHASE 3 LO', to the levels necessary to drive the switching transistors. The HI and LO output of each switching transistor pair are connected together in the pump cable, leaving the converter's three output lines connected to the delta configured pump motor.

Figure 6-7 shows a simplified schematic of the Output Drivers circuit, along with its output voltage and current waveforms for a resistive load (connected in place of a motor). Note that the resultant current waveform of each output line resembles an AC signal, with each cycle consisting of six discrete steps.

The OUTPUT INHIBIT signal from the Output Short Circuit Protection circuitry inhibits pull-up transistors Q7, Q8, and Q9 independently of the microcomputer outputs by removing current from their driver transistors, Q4, Q5 and Q6.

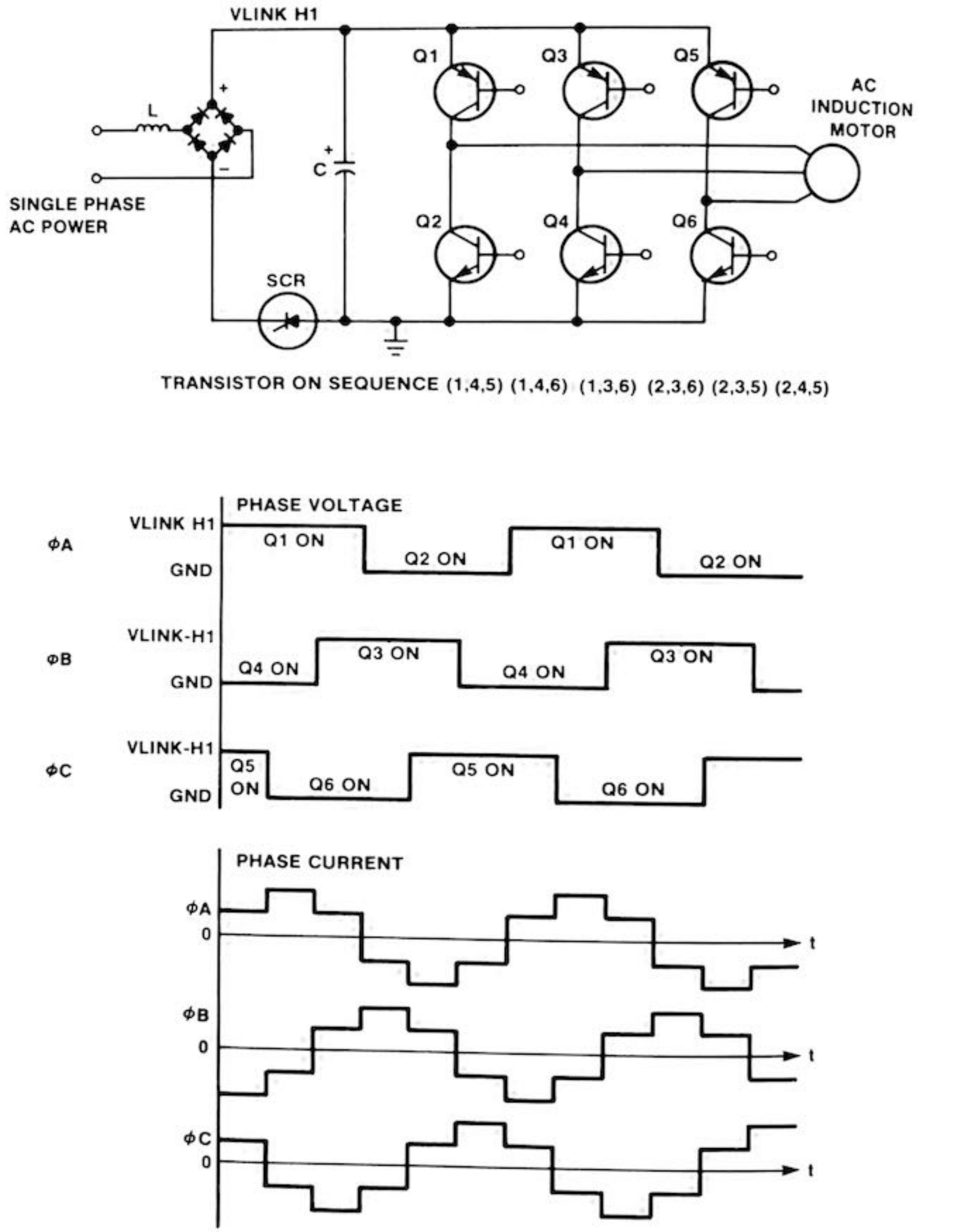


Figure 6-7. Output Drivers, Simplified Schmetic with Voltage and Current Waveforms

6.4.9 Output Short Circuit Protection

The Output Short Circuit Protection circuitry provides two outputs. OUTPUT INHIBIT inhibits switching transistors Q7, Q8 and Q9 and the DC link power supply SCR, Q1. EXCESS CURRENT FAIL turns on the front panel FAIL indicator, DS3. The two outputs are logically the same.

Two inputs are utilized by this circuitry. The ILINK input provides very fast response to link currents greater than 20 amperes. The BUFFERED ILINK signal from the ILINK signal conditioner, U2A, provides a slower response to link currents greater than 16 amperes.

The operation of the circuit is as follows. Transistor Q2 and FET Q3 form a bi-stable flip-flop. When power comes up, the gate of Q3 is pulled up by resistor RP3, thus turning it ON. With no link current, the source of Q3 is near ground, and with Q3 conducting, its drain is also near ground. With the cathode of diode CR26 near ground and no buffered ILINK signal, there is no base drive for Q2, thus turning it off. The above state is a stable state for Q2 and Q3. The circuit remains in the above state pending a signal on the ILINK or BUFFERED ILINK inputs.

Consider first a signal on ILINK. The ILINK signal is a negative going signal. Note that the base of Q2 is held near ground by resistors R25 and R26. If ILINK goes sufficiently negative, Q2 will be turned ON, turning off Q3. With Q3 turned off, the clamp on diode CR26 is removed so that pull-up resistor RP3 now provides base current to Q2 through Zener diode VR2 and diodes CR27 and CR28, thus keeping Q2 turned ON even after the removal of the ILINK signal. The OUTPUT INHIBIT and EXCESS CURRENT FAIL signals are now at a logic High, thus inhibiting the converter's output and lighting the FAIL indicator continuously. The BUFFERED ILINK signal provides the same function by turning ON Q2 directly through Zener diode VR3.

Table 6-A — Turbopump Coding Resistance and Motor Specifications

Pump Model	Coding Resistance	Rotational Speed	Output Frequency	Motor Volts	Motor Coil Resistance
TMP151	2,740 Ω	50,000 rpm	840 Hz	40 VAC	1 Ω
TMP361	412.0 Ω	45,000 rpm	760 Hz	40 VAC	1 Ω

6.4.10 1-Ohm Board (Standard NT150/360 model only)

This board (P/N 721-78-011) is included only on the standard NT150/360 converter (P/N 85472-3). Its electrical schematic (Figure 7-7), board layout drawing (Figure 7-6), and parts list (Table 7-D) are located in the back of this manual.

The 1-ohm board detects a coding resistance in the turbopump to identify which turbopump model is connected to the converter and adjusts the output and voltage accordingly. The coding resistance and rotational speed for each pump is listed in Table 6-A.

It is important to use this board with the TMP151 and TMP150V pumps because the board prevents the motor voltage from dropping to 20 VAC after reaching normal operation. This lower voltage (20 VAC) was sufficient to drive the grease-lubricated TMP150 during normal operation; however, the more powerful motor on the TMP151 and TMP150V requires 40 VAC to operate at full pumping speed at higher inlet pressures. If the motor voltage isn't maintained at 40 VAC, the motor won't be able to provide full power and the converter may go into failure at higher inlet pressures.

7 — Parts Lists and Diagrams

This section includes the part numbers for replacement parts for the TMP151/361 and TMP151/361C turbopumps and the NT150/360 converter. Electrical schematics and waveform diagrams for the NT150/360 frequency converter are also included. The part numbers for ordering the turbopump, the converters, and accessories are listed in Tables III and IV in the front of this manual.

Use the Figures to help identify the parts you need. The numbers called out on the TURBOVAC drawings correspond to the item numbers listed for each part in the first column of the corresponding parts table. For example, the first column on Page 115 lists "1" for the "Half stator disk". On Figure 7-1, the number "1" is pointing to a drawing of this stator disk. For the converter components, the item number in the table corresponds to the device number listed on the board layout drawing and on the electrical schematics.

Tables 7-C and 7-D list the parts for the NT150/360 frequency converter models. Table 7-E lists the components for the 1-Ohm board which is found in the standard NT150/360 converter model (P/N 85472-3).

Contents

Parts

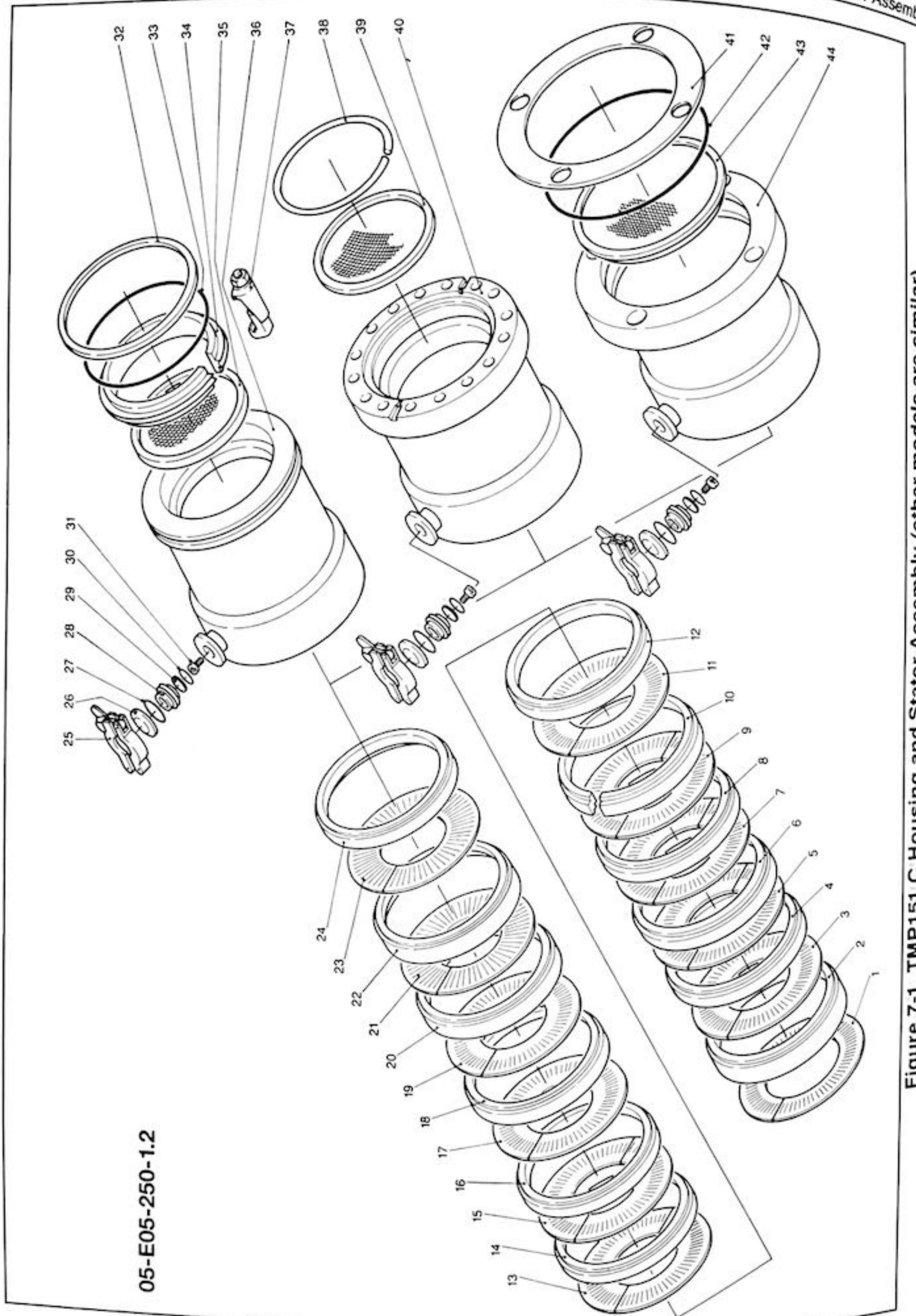


Figure 7-1. TMP151 C Housing and Stator Assembly (other models are *similar*)

Table 7-A — TMP151/361 Housing and Stator Parts List (see Figure 7-1)

Item No.	Quantity TMP 151/151C	Quantity TMP 361/361C	Description	Dimensions (mm)	Material	Part Number	Remarks
1	2		Half stator disk	107 x .06 15°	Aluminum	223 80 130	For pump S/N A 9101 .....
	2		Half stator disk (locking type)	108.3 x 1.5, 15°	Aluminum	200 18 098	For pump S/N A 9111 .....
		2	Half stator disk	143 x 0.6, 22°	Aluminum	238 80 140	For pump S/N A 9101 .....
		2	Half stator disk (locking type)	108.3 x 1.5, 15°	Aluminum	200 18 090	For pump S/N A 9111 .....
2	1		Spacer ring	110 x 10.5	Aluminum	233 81 155	For pump S/N A 9101 .....
	1		Spacer ring	109.9 x 10.4	Aluminum	200 18 092	For pump S/N A 9111 .....
		1	Spacer ring	147/131 x 9.9	Aluminum	200 18 135	For pump S/N A 9101 .....
		1	Spacer ring	149.9 x 10.4	Aluminum	200 18 086	For pump S/N A 9111 .....
3	2		Half stator disk	107 x 0.6, 15°	Aluminum	223 80 131	For pump S/N A 9101 .....
	2		Half stator disk (locking type)	108.3 x 1.5, 15°	Aluminum	200 18 099	For pump S/N A 9111 .....
		2	Half stator disk	143 x 0.6, 22°	Aluminum	223 80 140	For pump S/N A 9101 .....
		2	Half stator disk (locking type)	143.7 x 1.99, 22°	Aluminum	200 18 090	For pump S/N A 9111 .....
4	1		Spacer ring	110 x 7.6	Aluminum	223 81 156	For pump S/N A 9101 .....
	1		Spacer ring	109.9 x 8	Aluminum	200 18 094	For pump S/N A 9111 .....
		1	Spacer ring	147 x 9.4	Aluminum	233 81 168	For pump S/N A 9101 .....
		1	Spacer ring	146.9 x 10.4	Aluminum	200 18 086	For pump S/N A 9111 .....
5	2		Half stator disk	107 x 0.6, 15°	Aluminum	223 80 131	For pump S/N A 9101 .....
	2		Half stator disk (locking type)	108.3 x 1.5, 15°	Aluminum	200 18 099	For pump S/N A 9111 .....
		2	Half stator disk	143 x 0.6, 22°	Aluminum	223 80 140	For pump S/N A 9101 .....
		2	Half stator disk (locking type)	143.7 x 1.99, 22°	Aluminum	200 18 090	For pump S/N A 9111 .....
6	1		Spacer ring	110 x 7.6	Aluminum	233 81 156	For pump S/N A 9101 .....
	1		Spacer ring	109.9 x 8	Aluminum	200 18 094	For pump S/N A 9111 .....
		1	Spacer ring	147 x 9.4	Aluminum	233 81 168	For pump S/N A 9101 .....
		1	Spacer ring	146.9 x 10.4	Aluminum	200 18 086	For pump S/N A 9111 .....
7	2		Half stator disk	107 x 0.6, 15°	Aluminum	223 80 131	For pump S/N A 9101 .....
	2		Half stator disk (locking type)	108.3 x 1.5, 15°	Aluminum	200 18 099	For pump S/N A 9111 .....
		2	Half stator disk	143 x 0.6, 22°	Aluminum	223 80 140	For pump S/N A 9101 .....
		2	Half stator disk (locking type)	143.7 x 1.99, 22°	Aluminum	200 18 090	For pump S/N A 9111 .....
8	1		Spacer ring	110 x 7.6	Aluminum	233 81 156	For pump S/N A 9101 .....
	1		Spacer ring	109.9 x 8	Aluminum	200 18 094	For pump S/N A 9111 .....
		1	Spacer ring	147 x 9.4	Aluminum	233 81 168	For pump S/N A 9101 .....
		1	Spacer ring	146.9 x 10.4	Aluminum	200 18 086	For pump S/N A 9111 .....

Parts

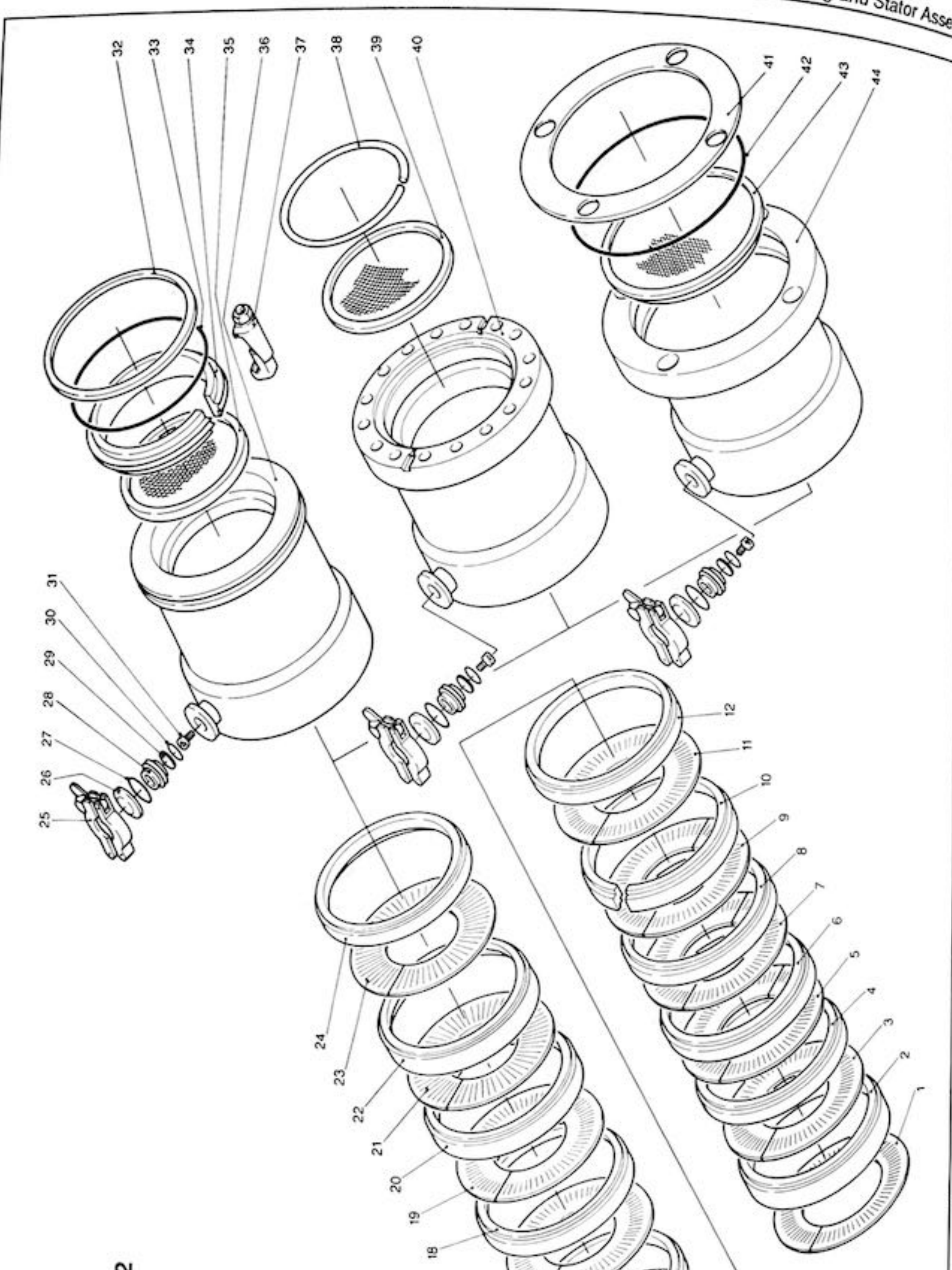


Figure 7-1. TMP151 C Housing and Stator Assembly (other models are similar)

Table 7-A — TMP151/361 Housing and Stator Parts List (see Figure 7-1)

Item No.	Quantity TMP 151/151C	Quantity TMP 361/361C	Description	Dimensions (mm)	Material	Part Number	Remarks
9	2		Half stator disk	107 x 0.6, 15°	Aluminum	223 80 131	For pump S/N A 9101 .....
	2		Half stator disk (locking type)	108.3 x 1.5, 15°	Aluminum	200 18 099	For pump S/N A 9111 .....
		2	Half stator disk	143 x 0.6, 22°	Aluminum	223 80 140	For pump S/N A 9101 .....
		2	Half stator disk (locking type)	143.7 x 1.99, 22°	Aluminum	200 18 090	For pump S/N A 9111 .....
10	2		Half spacer ring	110 x 7.6	Aluminum	233 81 157	For pump S/N A 9101 .....
	2		Half spacer ring	109.9 x 8	Aluminum	200 18 095	For pump S/N A 9111 .....
		2	Half spacer ring	147 x 9.4	Aluminum	233 81 171	For pump S/N A 9101 .....
		2	Half spacer ring	146.9 x 10.4	Aluminum	200 18 089	For pump S/N A 9111 .....
11	2		Half stator disk	107 x 0.6, 15°	Aluminum	223 80 131	For pump S/N A 9101 .....
	2		Half stator disk (locking type)	108.3 x 1.5, 15°	Aluminum	200 18 099	For pump S/N A 9111 .....
		2	Half stator disk	143 x 0.6, 22°	Aluminum	223 80 140	For pump S/N A 9101 .....
		2	Half stator disk (locking type)	143.7 x 1.99, 22°	Aluminum	200 18 090	For pump S/N A 9111 .....
12	1		Spacer ring	110 x 7.6	Aluminum	233 81 156	For pump S/N A 9101 .....
	1		Spacer ring	109.9 x 8	Aluminum	200 18 094	For pump S/N A 9111 .....
		1	Spacer ring	147 x 9.4	Aluminum	233 81 168	For pump S/N A 9101 .....
		1	Spacer ring	146.9 x 10.4	Aluminum	200 18 086	For pump S/N A 9111 .....
13	2		Half stator disk	107 x 0.6, 15°	Aluminum	223 80 131	For pump S/N A 9101 .....
	2		Half stator disk (locking type)	108.3 x 1.5, 15°	Aluminum	200 18 099	For pump S/N A 9111 .....
		2	Half stator disk	143 x 0.6, 22°	Aluminum	223 80 140	For pump S/N A 9101 .....
		2	Half stator disk (locking type)	143.7 x 1.99, 22°	Aluminum	200 18 090	For pump S/N A 9111 .....
14	1		Spacer ring	110 x 7.6	Aluminum	233 81 156	For pump S/N A 9101 .....
	1		Spacer ring	109.9 x 8	Aluminum	200 18 094	For pump S/N A 9111 .....
		1	Spacer ring	147 x 9.4	Aluminum	233 81 168	For pump S/N A 9101 .....
		1	Spacer ring	146.9 x 10.4	Aluminum	200 18 086	For pump S/N A 9111 .....
15	2		Half stator disk	107 x 0.6, 15°	Aluminum	223 80 125	For pump S/N A 9101 .....
	2		Half stator disk (locking type)	108.3 x 1.5, 15°	Aluminum	200 18 099	For pump S/N A 9111 .....
		2	Half stator disk	143 x 0.6, 22°	Aluminum	223 80 140	For pump S/N A 9101 .....
		2	Half stator disk (locking type)	143.7 x 1.99, 22°	Aluminum	200 18 090	For pump S/N A 9111 .....
16	1		Spacer ring	110 x 7.6	Aluminum	233 81 156	For pump S/N A 9101 .....
	1		Spacer ring	109.9 x 8	Aluminum	200 18 094	For pump S/N A 9111 .....
		1	Spacer ring	147 x 9.4	Aluminum	233 81 168	For pump S/N A 9101 .....
		1	Spacer ring	146.9 x 10.4	Aluminum	200 18 086	For pump S/N A 9111 .....

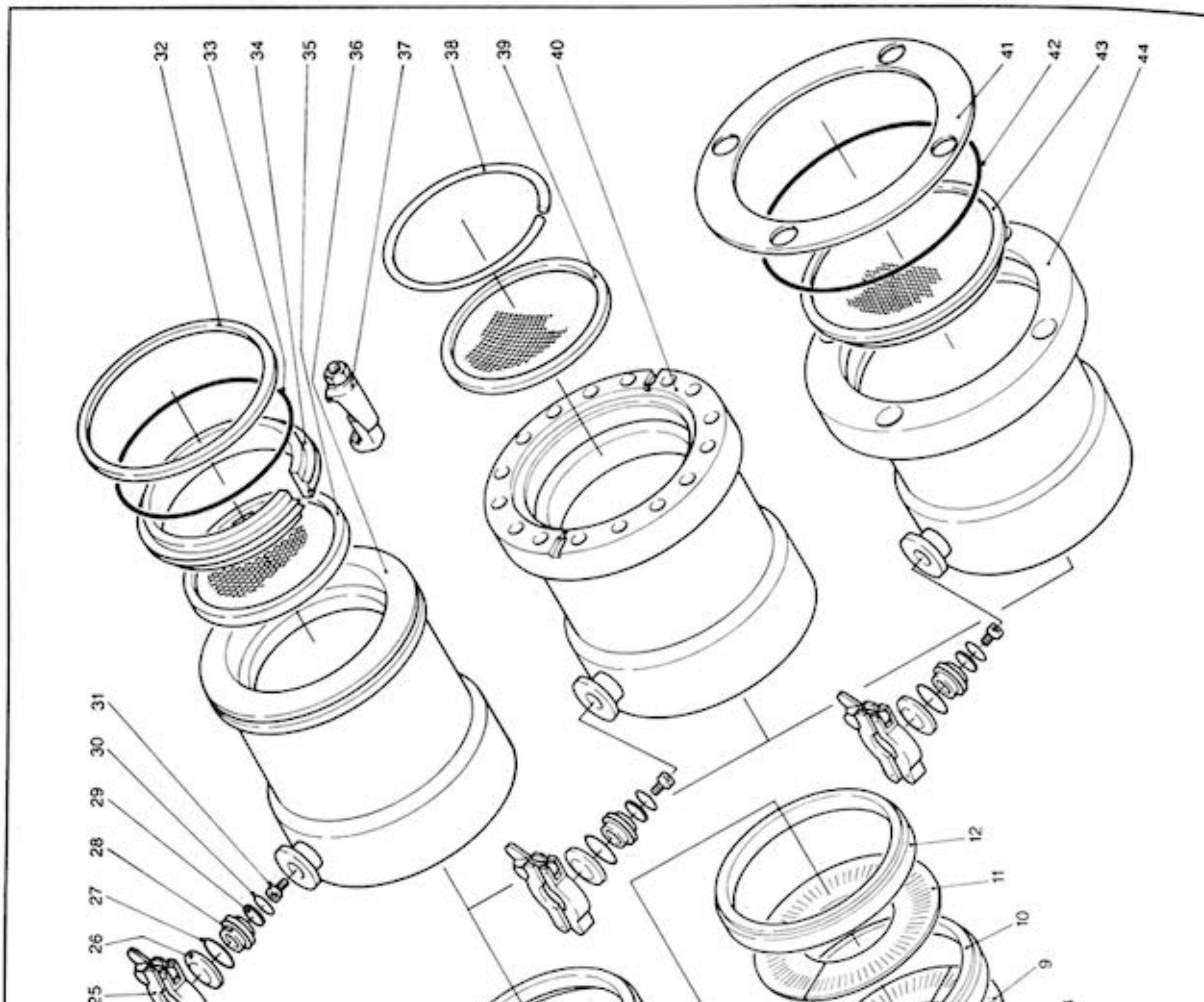


Figure 7-1. TMP151 C Housing and Stator Assembly (other models are similar)

Table 7-A — TMP151/361 Housing and Stator Parts List (see Figure 7-1)

Item No.	Quantity TMP 151/151C	Quantity TMP 361/361C	Description	Dimensions (mm)	Material	Part Number	Remarks
17	2		Half stator disk	107 x 0.6, 15°	Aluminum	223 80 125	For pump S/N A 9101 .....
	2		Half stator disk (locking type)	108.3 x 1.5, 15°	Aluminum	200 18 099	For pump S/N A 9111 .....
		2	Half stator disk	143 x 0.6, 22°	Aluminum	223 80 140	For pump S/N A 9101 .....
		2	Half stator disk (locking type)	143.7 x 1.99, 22°	Aluminum	200 18 090	For pump S/N A 9111 .....
18	1		Spacer ring	110 x 7.6	Aluminum	233 81 156	For pump S/N A 9101 .....
	1		Spacer ring	109.9 x 8	Aluminum	200 18 094	For pump S/N A 9111 .....
		1	Spacer ring	147 x 11.6	Aluminum	233 81 169	For pump S/N A 9101 .....
		1	Spacer ring	146.9 x 12	Aluminum	200 18 087	For pump S/N A 9111 .....
19	2		Half stator disk	107 x 0.6, 15°	Aluminum	223 80 125	For pump S/N A 9101 .....
	2		Half stator disk (locking type)	108.3 x 1.5, 15°	Aluminum	200 18 099	For pump S/N A 9111 .....
		2	Half stator disk	143 x 0.6, 35°	Aluminum	223 80 141	For pump S/N A 9101 .....
		2	Half stator disk (locking type)	143.7 x 3.2, 35°	Aluminum	200 18 091	For pump S/N A 9111 .....
20	1		Spacer ring	110 x 9	Aluminum	233 81 154	For pump S/N A 9101 .....
	1		Spacer ring	109.9 x 8	Aluminum	200 18 094	For pump S/N A 9111 .....
		1	Spacer ring	147 x 13	Aluminum	233 81 170	For pump S/N A 9101 .....
		1	Spacer ring	146.9 x 14	Aluminum	200 18 088	For pump S/N A 9111 .....
21	2		Half stator disk	107 x 0.6, 37°	Aluminum	223 80 126	For pump S/N A 9101 .....
	2		Half stator disk (locking type)	108.3 x 3.44, 37°	Aluminum	200 18 097	For pump S/N A 9111 .....
		2	Half stator disk	143 x 0.6, 35°	Aluminum	223 80 141	For pump S/N A 9101 .....
		2	Half stator disk (locking type)	143.7 x 3.2, 35°	Aluminum	200 18 091	For pump S/N A 9111 .....
22	1		Spacer ring	110 x 10.5	Aluminum	233 81 155	For pump S/N A 9101 .....
	1		Spacer ring	109.9 x 11	Aluminum	200 18 093	For pump S/N A 9111 .....
		1	Spacer ring	147 x 11.6	Aluminum	233 81 169	For pump S/N A 9101 .....
		1	Spacer ring	146.9 x 14	Aluminum	200 18 088	For pump S/N A 9111 .....
23	2		Half stator disk	107 x 0.6, 37°	Aluminum	223 80 126	For pump S/N A 9101 .....
	2		Half stator disk (locking type)	108.3 x 3.44, 37°	Aluminum	200 18 097	For pump S/N A 9111 .....
24	1		Spacer ring	110 x 9	Aluminum	233 81 154	For pump S/N A 9101 .....
	1		Spacer ring	109.9 x 10.4	Aluminum	200 18 092	For pump S/N A 9111 .....
25	1	1	KF Clamp ring	DN 10/16	Aluminum	230 60 101	

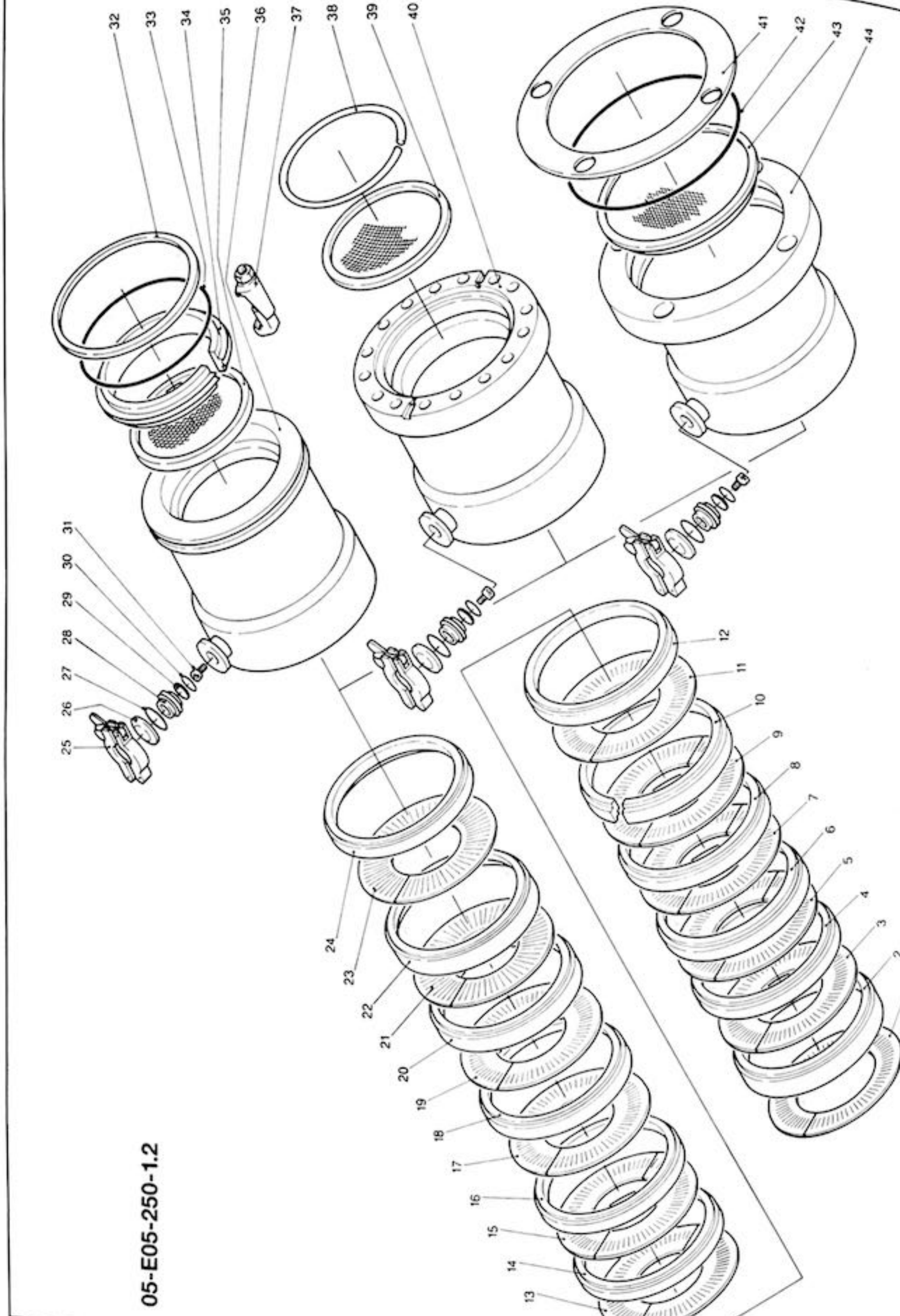


Figure 7-1. TMP151 C Housing and Stator Assembly (other models are *similar*)

Table 7-A — TMP151/361 Housing and Stator Parts List (see Figure 7-1)

Item No.	Quantity TMP 151/151C	Quantity TMP 361/361C	Description	Dimensions (mm)	Material	Part Number	Remarks
26	1	1	Blank flange	DN 10	Aluminum	18441	For pumps with ISO-K high-vacuum flanges.
	1	1	Blank flange	DN 10	Stainless Stl	88441	For pumps with ASA or CF high-vacuum flanges
27	1	1	O-ring	15 x 5	Buna	239 50 193	
28	1	1	Centering ring	DN 10 KF	Stainless Stl	88321	Includes Viton O-ring
29	1	1	Filter disk	10 x 3	Sintered metal	224 03 141	
30	1	1	O-ring	9 x 1.5	Viton	239 70 101	
31	1	1	Nozzle	0.44		392 25 206	
32	1	1	Outer supporting ring	DN100	Aluminum	200 07 329	Items 32 through 37 are for pumps with an ISO-K high-vacuum flange.
	1		Outer supporting ring	DN63	Aluminum	233 93 201	
		1	Outer supporting ring	DIN160	Aluminum	200 07 330	
33	1	1	O-ring	100 x 5	Viton	239 70 139	
	1		O-ring	70 x 5	Viton	239 70 509	
		1	O-ring	151.77 x 5.33	Viton	239 70 512	
34	1	1	Center ring	DN100	Aluminum	200 07 327	
	1		Center ring	DN63	Aluminum	231 93 305	
		1	Center ring	DN 160	Aluminum	200 07 328	
35	1	1	Inlet screen	DN100		200 17 195	
	1		Inlet screen	DN63		200 17 170	
		1	Inlet screen	DN160		200 17 247	
36	1		Housing for a DN100 ISO-K flanged pump	DN100 ISO-K	Aluminum	200 18 050	
	1		Housing for a DN63 ISO-K flanged pump	DN63 ISO-K	Aluminum	200 18 049	
		1	Housing for a DN100 ISO-K flanged pump	DN100 ISO-K	Aluminum	200 18 053	
		1	Housing for a DN160 ISO-K flanged pump	DN 160 ISO-K	Aluminum	200 18 066	
37	2	2	ISO-K Clamp	M 10 x 24	Steel	26701	

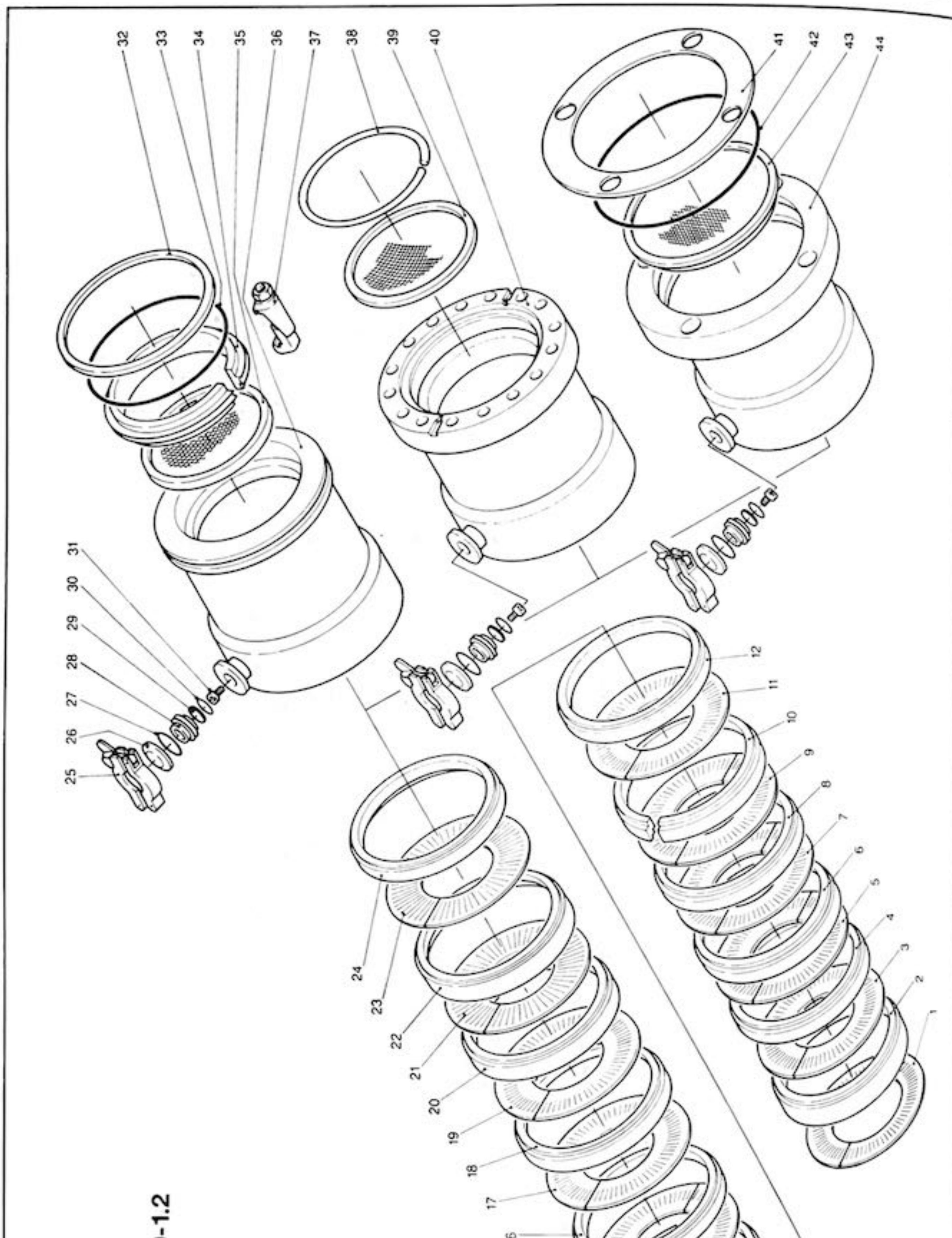


Figure 7-1. TMP151 C Housing and Stator Assembly (other models are similar)

Table 7-A — TMP151/361 Housing and Stator Parts List (see Figure 7-1)

Item No.	Quantity TMP 151/151C	Quantity TMP 361/361C	Description	Dimensions (mm)	Material	Part Number	Remarks
38	1	1	Circlip	DN100	Steel	200 17 402	Items 38, 39, & 40 are for pumps with a CF high-vacuum flange.
		1	Circlip	DN160	Steel	231 02 418	
39	1	1	Inlet screen	DN100 CF	Stainless Stl	200 17 195	
		1	Inlet screen	DN160 CF	Stainless Stl	200 17 247	
40	1		Housing for a DN100 CF flanged pump	DN100 CF	Stainless Stl	200 18 051	
		1	Housing for a DN100 CF flanged pump	DN100 CF	Stainless Stl	200 18 054	
		1	Housing for a DN160 CF flanged pump	DN160 CF	Stainless Stl	200 18 055	
41	1		Outer support ring	152 x 98 x 4	Aluminum	223 78 137	Items 41 through 44 are for pumps with an ASA high-vacuum flange.
		1	Outer support ring	229 x 4	Aluminum	233 93 403	
42	1		O-ring	85 x 5	Viton	239 70 135	
		1	O-ring	151.77 x 5.33	Viton	239 70 512	
43	1		Inlet screen	2" ASA		411 70 143	
		1	Inlet screen	4" ASA		411 70 135	
44	1		Housing for a 2" ASA flanged pump	DN 2" ASA	Stainless Stl	200 18 052	
		1	Housing for a 4" ASA flanged pump	DN 4" ASA	Stainless Stl	200 18 056	

Parts

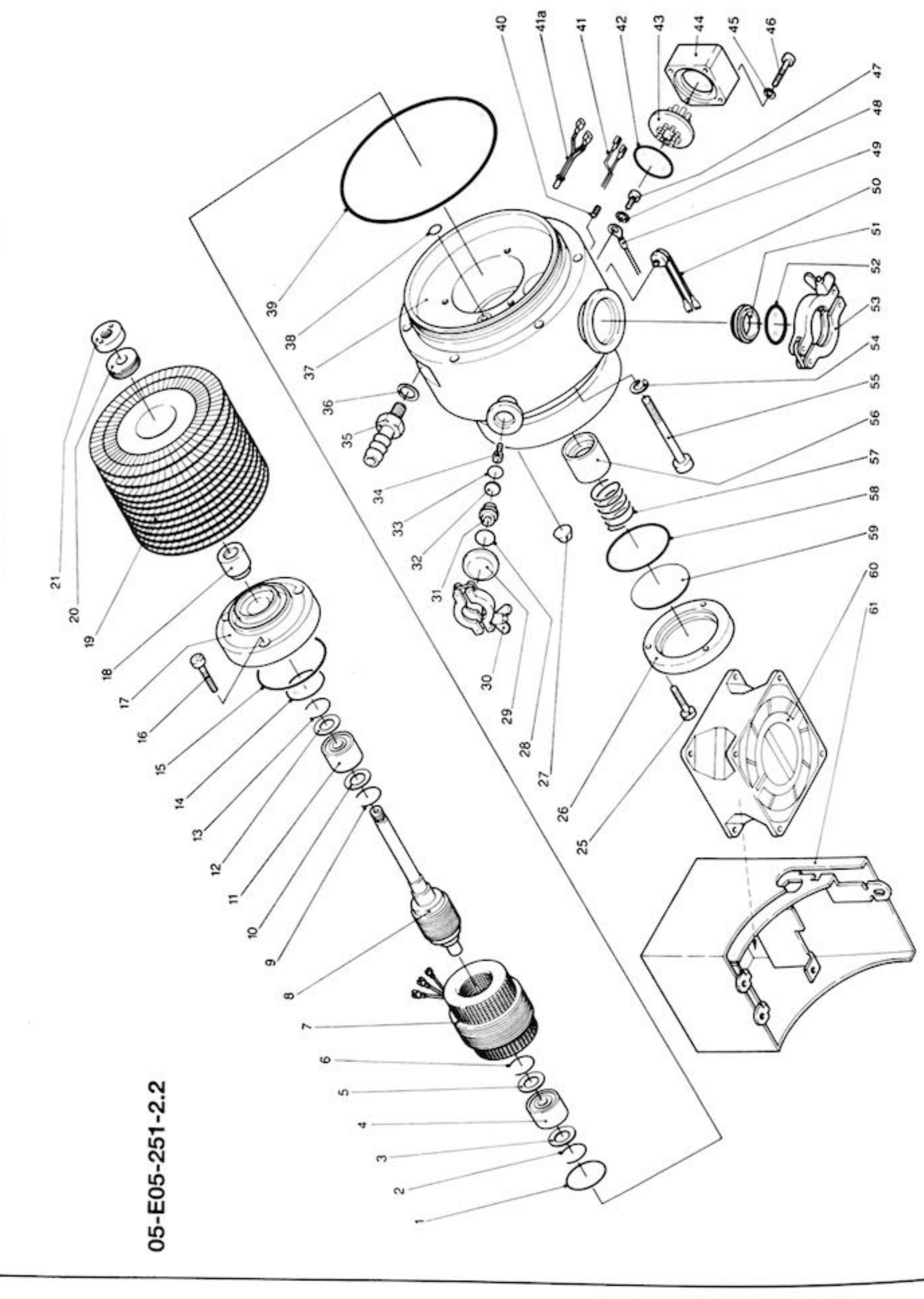


Figure 7-2. TMP151/361 Rotor/Base Assembly

Table 7-B — TMP151/361 Rotor/Base Parts List (see Figure 7-2)

Item No.	Quantity TMP 151	TMP 151C	TMP 360	TMP 361C	Description	Dimensions (mm)	Material	Part Number	Remarks
1–21					Rotor Assembly				The part numbers for Items 1 thru 21 aren't listed here because replacing these parts requires special tools and techniques. These repairs must be done by Leybold.
22	3	3	3	3	Foot	13.5 x 6	PVC	200 17 309	For pump S/N A 9101 . . . . . Not shown in Figure 7-2. However, all of the photogrpahs in this manual show the pump model that has the stand assembly
23	3	3	3	3	Capscrew	M 15 x 16	DIN 912	20017 965	
24	3	3	3	3	Washer	5.3	DIN 433	200 17 610	
	1	1	1	1	Stand	135.5 x 65		200 18 048	
25	3	3	3	3	Capscrew	M 4 x 14	DIN 7991	200 18 074	
26	1	1	1	1	Holder	60 x 7	Aluminum	200 18 044	
27	1	1	1	1	Foot	12	PVC	200 18 193	For pump S/N A 9111 . . . . . only
28		1		1	O-ring	15 x 5	Buna	239 50 193	Items 28 through 34 apply to the TMP151C and TMP361C models only.
29		1		1	Blank flange	DN 10	Aluminum	18441	
30		1		1	KF clamp ring	DN 10/16	Aluminum	230 60 101	
31		1		1	Center ring w O-ring	DN 10 KF	Stainless Stl	88321	
32		1		1	Disk	10 x 3	Sintered metal	224 03 141	
33		1		1	O-ring	9 x 1.5	Viton	239 70 101	
34		1		1	Nozzle	0.44		392 25 206	
35	2	2	2	2	Hose nipple	10 x 42	Ultramid	200 18 117	
36	2	2	2	2	USIT-gasket	U 10.7 x 16 x 1.5	Steel/Buna	230 02 106	
37	1				Base flange	132 x 106.9	Aluminum	200 18 038	For pump S/N A 9101 . . . . . .
		1			Base flange	132 x 106.9	Aluminum	200 18 039	
			1		Base flange	172 x 112.8	Aluminum	200 18 040	
				1	Base flange	172 x 112.8	Aluminum	200 18 041	
37	1				Base flange	132 x 106.9	Aluminum	200 18 187	For pump S/N A 9111 . . . . . .
		1			Base flange	132 x 106.9	Aluminum	200 18 188	
			1		Base flange	172 x 112.8	Aluminum	200 18 189	
				1	Base flange	172 x 112.8	Aluminum	200 18 190	
38		1		1	O-ring	1.42 x 1.52	Viton	239 70 013	
39	1	1			O-ring	105 x 3	Viton	239 50 224	
			1	1	O-ring	139.5 x 3	Viton	239 70 327	

Parts

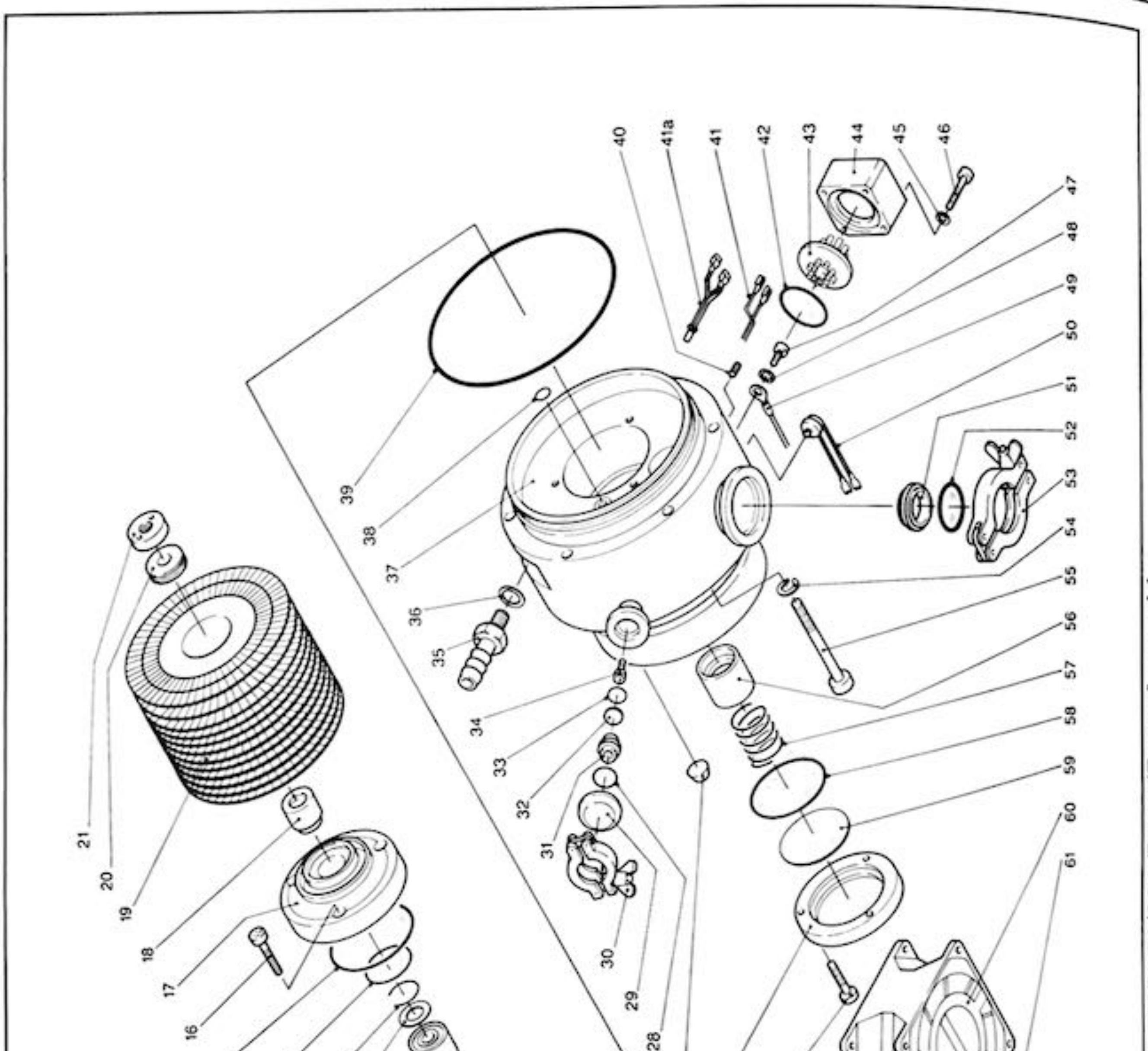


Figure 7-2. TMP151/361 Rotor/Base Assembly

Table 7-B — TMP151/361 Rotor/Base Parts List (see Figure 7-2)

Item No.	Quantity TMP 151	TMP 151C	TMP 360	TMP 361C	Description	Dimensions (mm)	Material	Part Number	Remarks
40	1	1	1	1	Threaded pin	M 4 x 6	DIN 916	241 17 119	
41	1	1			Codification			200 18 078	
			1	1	Codification			200 18 079	
41a	1	1	1	1	Temperature sensor			200 18 192	
42	1	1	1	1	O-ring	28 x 3.5	Buna	200 17 414	
43	1	1	1	1	Socket	35.4, 8 pol.		200 17 399	
44	1	1	1	1	Current leadthrough	38 x 38 x 22.8	Pocan	200 17 386	
45	4	4	4	4	Washer	A 4.3	DIN 125	221 01 201	
46	4	4	4	4	Capscrew	M 4 x 30	DIN 912	200 17 492	
47	1	1	1	1	Capscrew	M 4 x 8	DIN 912	201 03 008	
48	1	1	1	1	Fan-type washer	A 4.3, DIN 6798		221 09 107	
49	1	1	1	1	Ground wire	1 x 0.75 Ge/Gr		200 17 663	
50	1	1	1	1	Temperature controller	16.3, 12 V	C 172/Z 800	200 18 186	
51	1	1	1	1	Centering ring	DN 25 KF		231 94 206	
52	1	1	1	1	O-ring	28 x 5		239 50 113	
53	1	1	1	1	Clamping ring	DN25		230 60 102	
54	6	6			Washer	5	DIN 7980	200 18 076	
			6	6	Washer	6	DIN 7980	200 17 509	
55	6	6			Capscrew	M 5 x 55, DIN912		200 17 960	
			6	6	Capscrew	M 6 x 60, DIN912		200 17 162	
56	1	1	1	1	Guide sleeve	22 x 23.5	1.4305	200 18 082	
57	1	1	1	1	Split spring	1.5 x 16 x 43.6	Steel	200 17 469	
58	1	1	1	1	O-ring	40 x 1.5	Viton	239 70 015	
59	3	3	3	3	Shim	0.1	1.4310	200 18 042	For pump S/N A 9101 . . . . .
	3	3	3	3	Shim	0.05	1.4310	200 18 058	
	1	1	1	1	Distance clip	40.5 x 0.1, 1.4310		200 18 199	For pump S/N A 9111 . . . . .
60	1	1	1	1	Optional fan	115V		200 17 037	
	1	1	1	1	Optional fan	220V		380 91 106	
61	1	1	1	1	Optional air cooler	115 V		894 08	
	1	1	1	1	Optional air cooler	220 V		855 31	

Parts

*Table 7-C — NT150/360 Chassis Parts List**

Item	*Part Number*	*Description*
—	722 91 000	Motherboard (Refer to Table 7-D for component part numbers.)
—	721 78 011	1-Ohm Board (Refer to Table 7-E for component part numbers)
—	99 700 1001	Pump Cable, 15 feet (4.5 meters)
—	99 276 513	AC Power Cord
—	721 38 006	AC Connector, Fuse Holder, & Voltage Selection Card
—	99 122 049	250V/20A Right-Angle Plug
CR1	723 03 001	Bridge Rectifier, 100 Volts, 25 Amps
DS1	722 51 001	LED - Green
DS2	722 51 002	LED - Yellow
DS3	722 51 000	LED - Red
DS4	722 51 002	LED - Yellow
F1	721 95 000	Fuse, 120 Volts, 10 Amps
	721 95 001	Fuse, 240 Volts, 5 Amps
L1	721 54 001	Choke, 3.5 MHz
M1	721 57 000	Hours Meter (NT150/360 model only)
S1 & S2	723-22-000	Switch, Pushbutton
T1	723 34 003	Power Transformer

**See the electrical schematics (Figures 7-5 & 7-7) for component type numbers not listed in this table.*

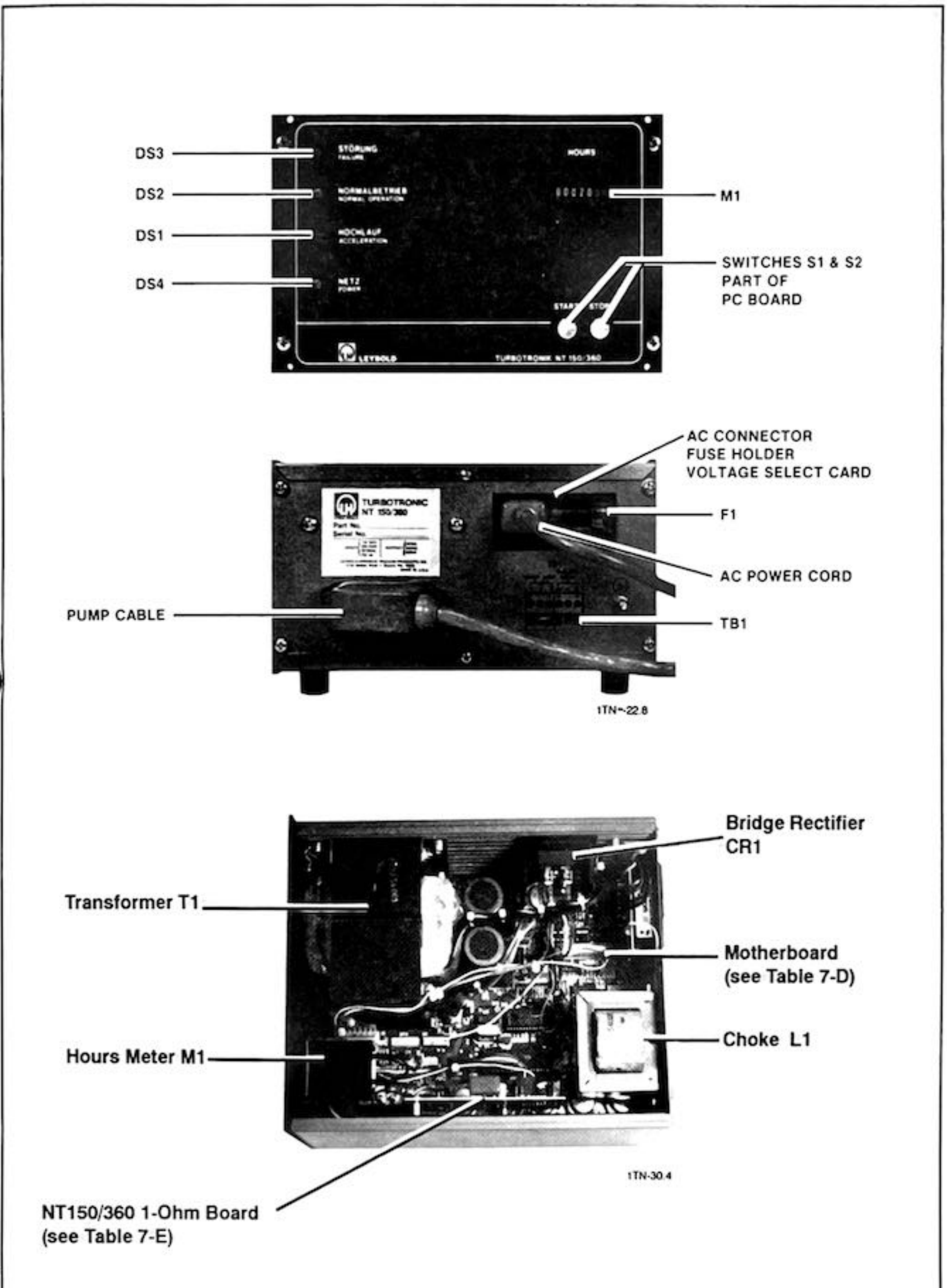


Figure 7-3. NT150/360 Chassis Part Locations

*** Not applicable to 200 V AC Version P/N 85472-5 see fig. 7-3A**

Parts

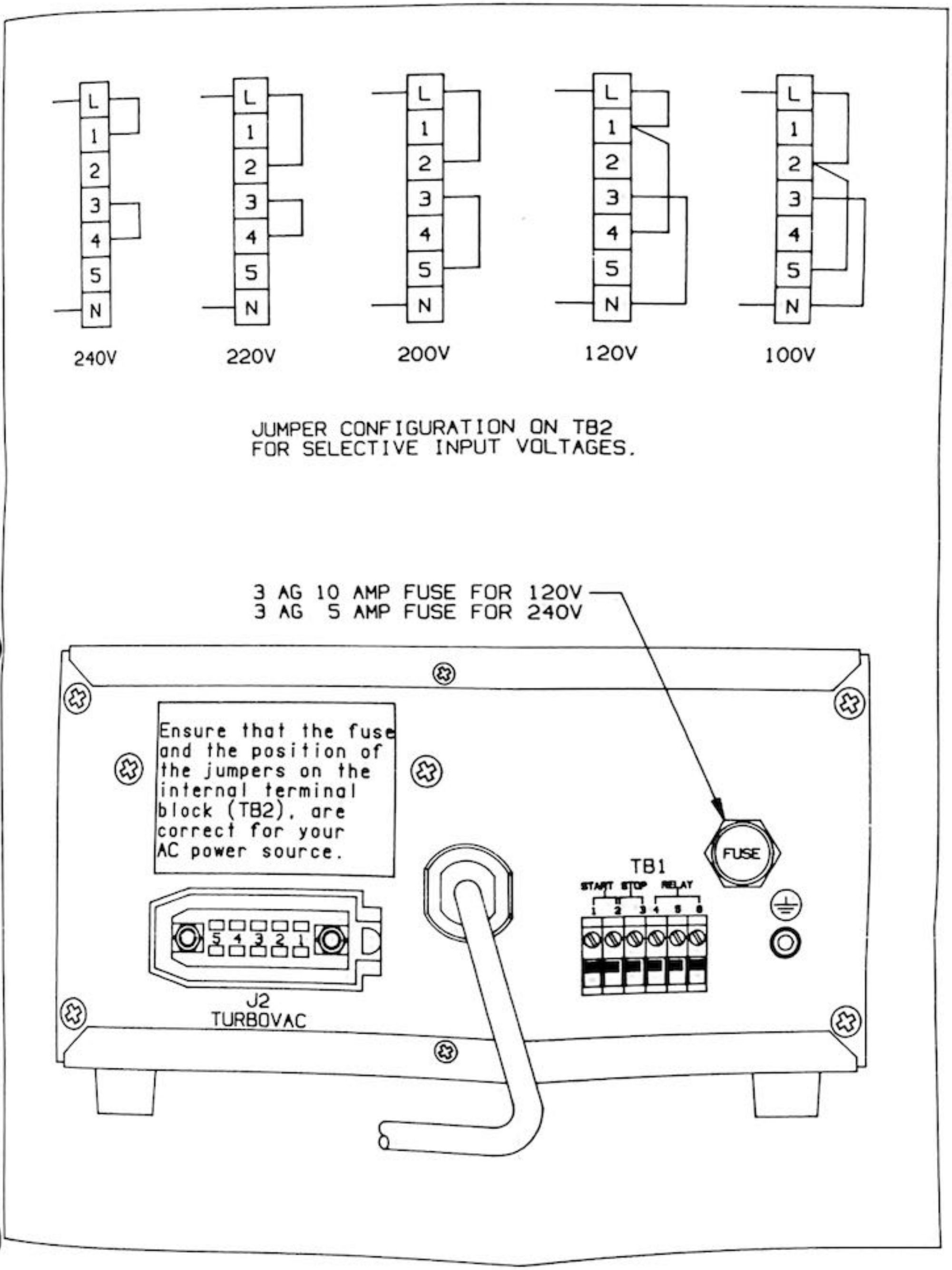

L
1
2
3
4
5
N
240V
220V
200V
120V
100V
JUMPER CONFIGURATION ON TB2
FOR SELECTIVE INPUT VOLTAGES.
3 AG 10 AMP FUSE FOR 120V
3 AG 5 AMP FUSE FOR 240V
Ensure that the fuse and the position of the jumpers on the internal terminal block (TB2), are correct for your AC power source.
FUSE
TB1
START
STOP
RELAY
J2
TURBOVAC

Figure 7-3A

Table 7-D — Converter Motherboard Component Parts List*

Item	Part Number	Description
—	722-91-000	Motherboard, complete
C1 & C2	721-28-914	Capacitor, 3300 MFD, 80 VCC, Radial Lead
CR2, CR3, CR4, & CR5	721-69-001	Diode, MR501
CR6 thru CR19	721-69-000	Diode, 1N914
CR20 thru CR25	721-69-001	MR501
CR26, CR27, & CR28	721-69-000	Diode, 1N914
CR29	721-69-281	Diode, 1N4002
CR30	721-69-001	Diode, MR501
K1	723-04-000	Relay, 12 V DC, SPDT
L2	721-54-000	Choke, 3uH, 7 A
Q1	723-03-000	SCR, MCR649AP-3 — Old Style
Q1**	723-03-004	SCR, MCR225 4FP — New Style Fig. 7-4A
Q2	723-35-000	Transistor, NPN, 2N3904
Q3	723-35-281	FET, N-Channel, VN10KM
Q4, Q5, & Q6	723-35-002	Transistor, NPN, 2N6553
Q7, Q8, & Q9	723-35-141	Transistor, PNP, 2N6287
Q10, Q11, & Q12	723-35-001	Transistor, NPN, 2N6284
Q13	723-35-142	Transistor, PNP, 2N6730
Q14 thru Q17	723-35-281	FET, N-Channel, VN10KM
S1 & S2	723-22-000	Switch, Pushbutton
U1	722-39-142	IC, Triple 3-Input Nor Gate, CD4025
U2	722-39-281	IC, Quad Op-Amp, LM324
U3	722-39-141	IC, Dual Flip-Flop, CD4013
U4	722-39-000	IC, A/D Converter, ADC0809
U5	722-39-421	IC, Darlington Array, ULN2004A
U6	722-39-143	IC, Hex Inverter, CD4049AE
U7	722-39-001	IC, Microcomputer, R6500/1AP
VR1	722-39-561	IC, 5 V Regulator, MC7805CT
VR2	721-69-141	Zener Diode, 5.1 V, 1N4625
VR3	721-69-142	Zener Diode, 6.8 V, 1N4099
Y1	721-55-000	Crystal, 2 MHz

**See the NT150/360 electrical schematic (Figure 7-5) for component type numbers not listed in this table.*

***Old style SCR P/N 723-03-000 is now obsolete. This part number has been replaced by a kit (P/N 720-24-046). This kit contains the new style SCR (P/N 723-03-004), several mounting parts, a 150 ohm Resistor to replace R1 and a drawing with instructions.*

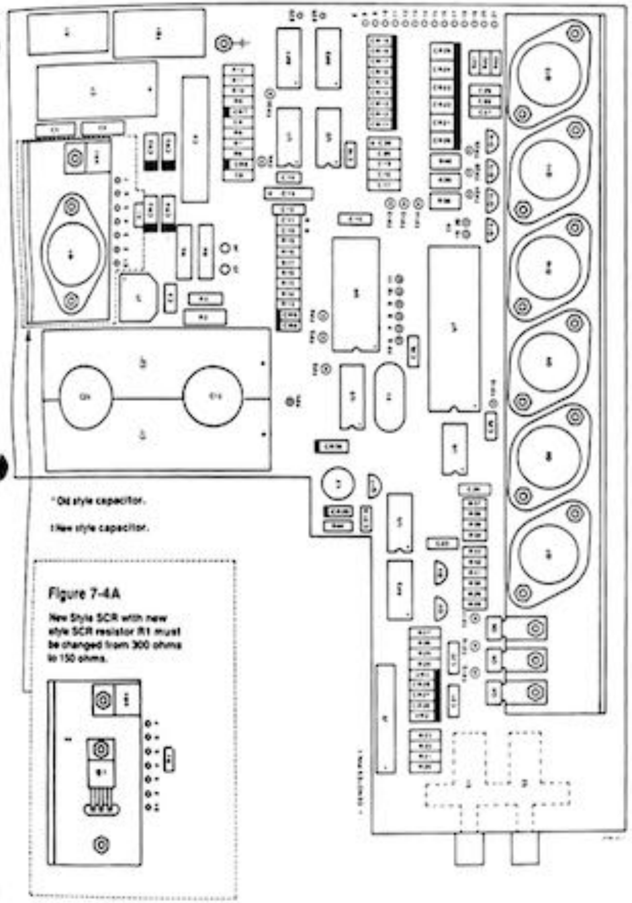
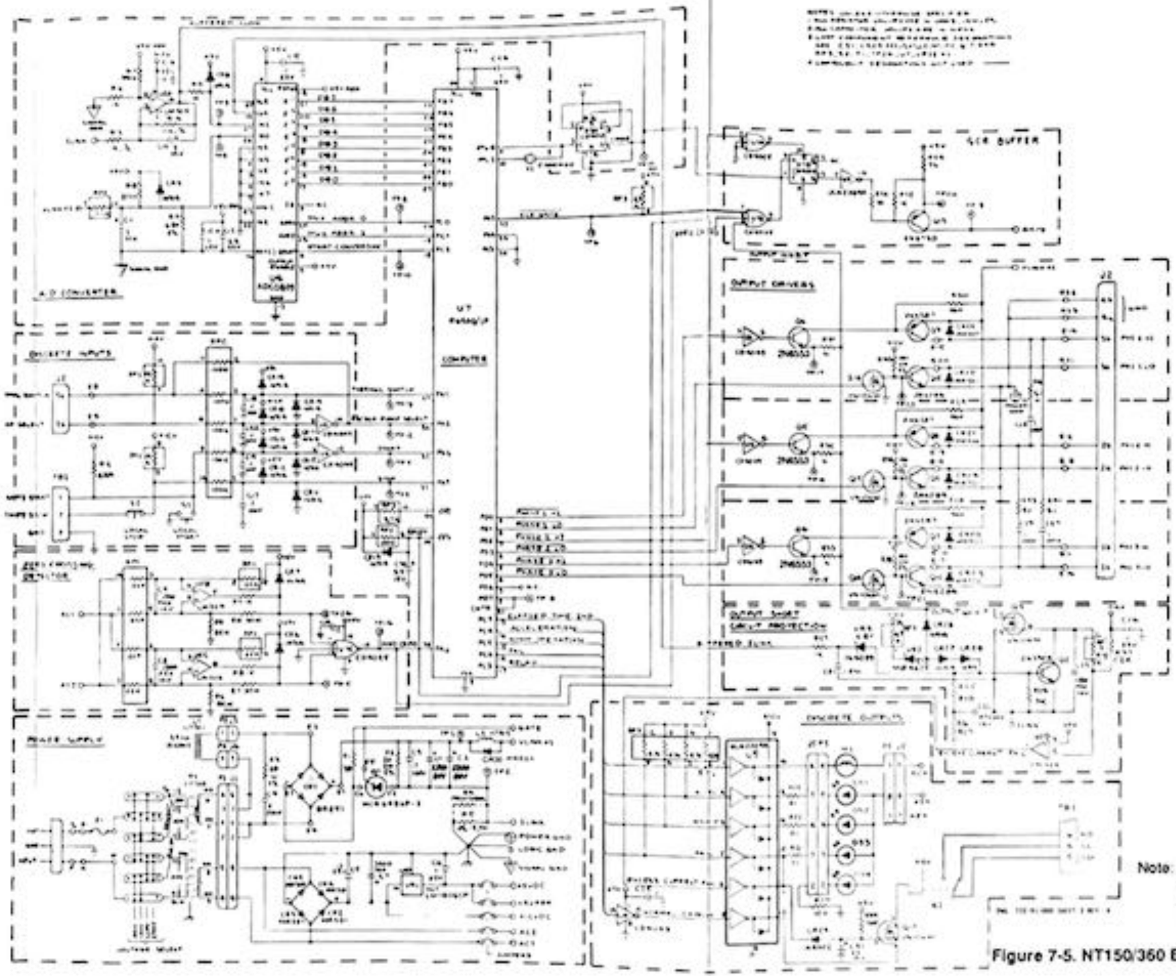


Figure 7-4. NT150/360 Motherboard Layout



Note: See Figure 7-7 for the NT150/360 1-Ohm board schematic.

Figure 7-5. NT150/360 Electrical Schematic

Table 7-E — 1-Ohm Board Component Parts List

Item	Part Number	Description
—	721-78-011	1-Ohm Board, complete
U1	722-39-281	IC, Quad Op-Amp, LM324
U2	533-20-186	IC, Quad Schmidt Nangate, MC4093
V1, V5, & V6	721-69-002	Diode, IN4148
V2 & V3	721-69-143	Diode, Zener, IN4733A
V4	723-35-284	Transistor, FET "N" Channel Motorola BS107
C1 & C4	721-28-917	Capacitor, Electrolytic 100 MFD, 16V
C2	721-28-916	Capacitor, Metallized 1 MFD, 250V
C3	721-28-007	Capacitor, Ceramic, 0.1 MFD, 50V
R1	723-05-152	Resistor, 6.34K Ohm, 1%, 1/8W MMF
R2	723-05-156	Resistor, 511 Ohms, 1%, 1/8W MMF
R3	723-05-155	Resistor, 4.32K Ohm, 1%, 1/8W MMF
R4 & R5	723-05-017	Resistor, 10M, 1/4W
R6, R12, R13, R14, R15, & R16	723-05-016	Resistor, 1/4W, 10K Ohm
R7	723-05-157	Resistor, 7.5K, 1/8W, 1% MMF
R8	723-05-003	Resistor, 2,2K, 1/4W
R9	723-05-154	Resistor, 4.75K, 1/8W, 1% MMF
R10	723-05-153	Resistor, 33.2K, 1/8W, 1% MMF
R11	723-05-010	Resistor, 1M, 1/4W
X1	721-78-014	6-Pin Shrouded Header Assembly, AMP 102202-3
	721-27-725	6-Conductor Cable Assembly
X2 & X3	721-78-013	3-Pin Shrouded Header Assembly
	721-78-018	Housing Contact, 3 position, AMP #102241-1, 2 required
Contacts for X1, X2, & X3	721-38-071	#26-22 AWG, AMP 87165-1, 12 required

Notes:

- 1/8W, 1% Resistors-R1-3,7,9,10
  All others are 1/4W.
- V1,5,6- are 1N4148 Diodes.
  V2,3-1N4733A Zener
- C3-100NFD
- X1- 6pin amp HDR 102202-3
  X2,3-3 Pin amp HDR 3-102202-4

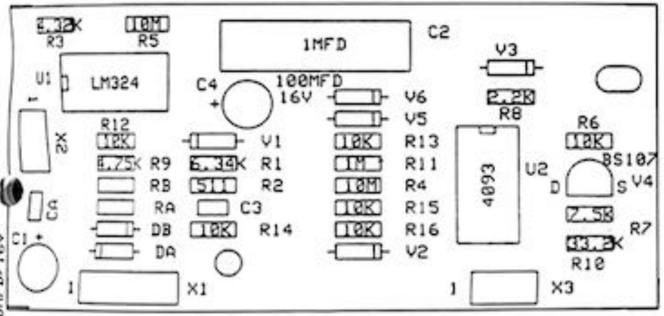


Figure 7-6. 1-Ohm Board Layout (Board P/N 721-78-011)

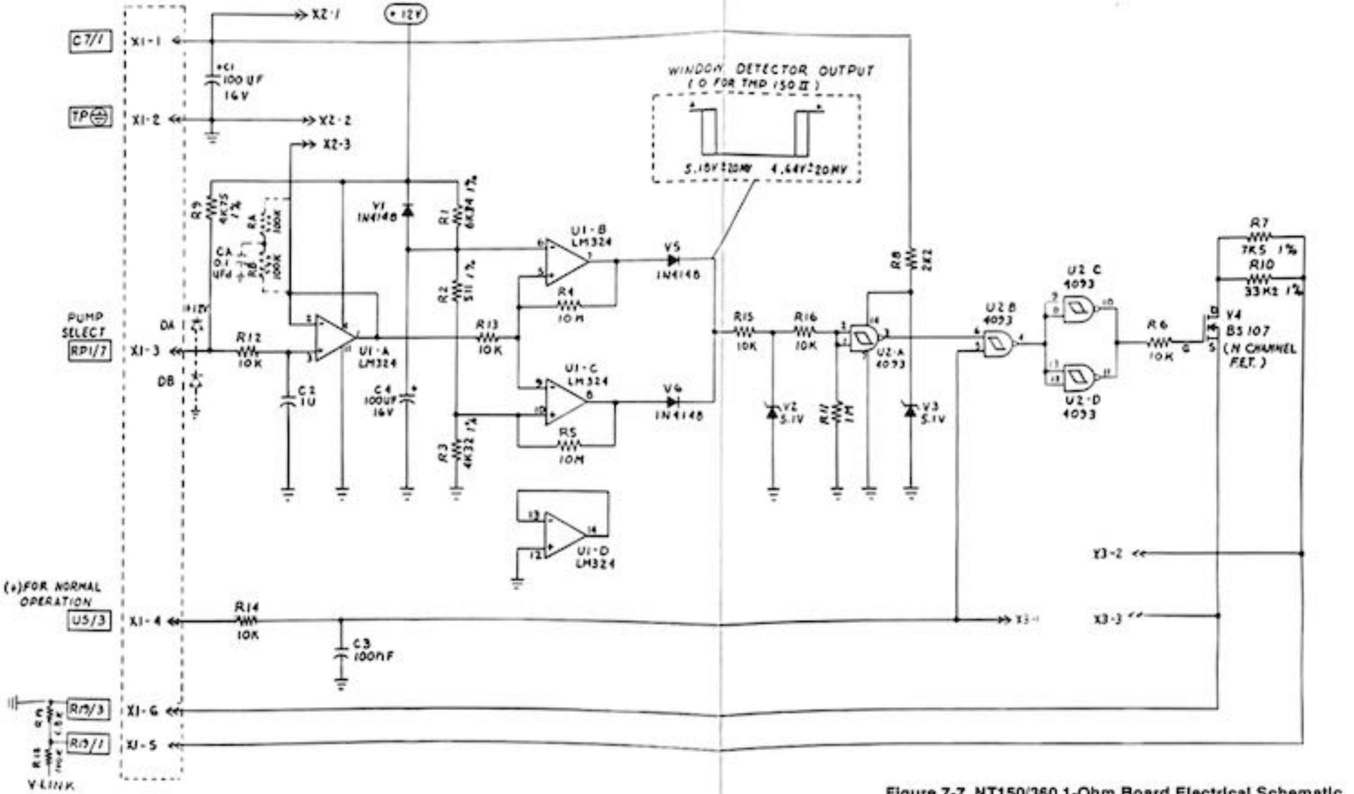


Figure 7-7. NT150/360 1-Ohm Board Electrical Schematic

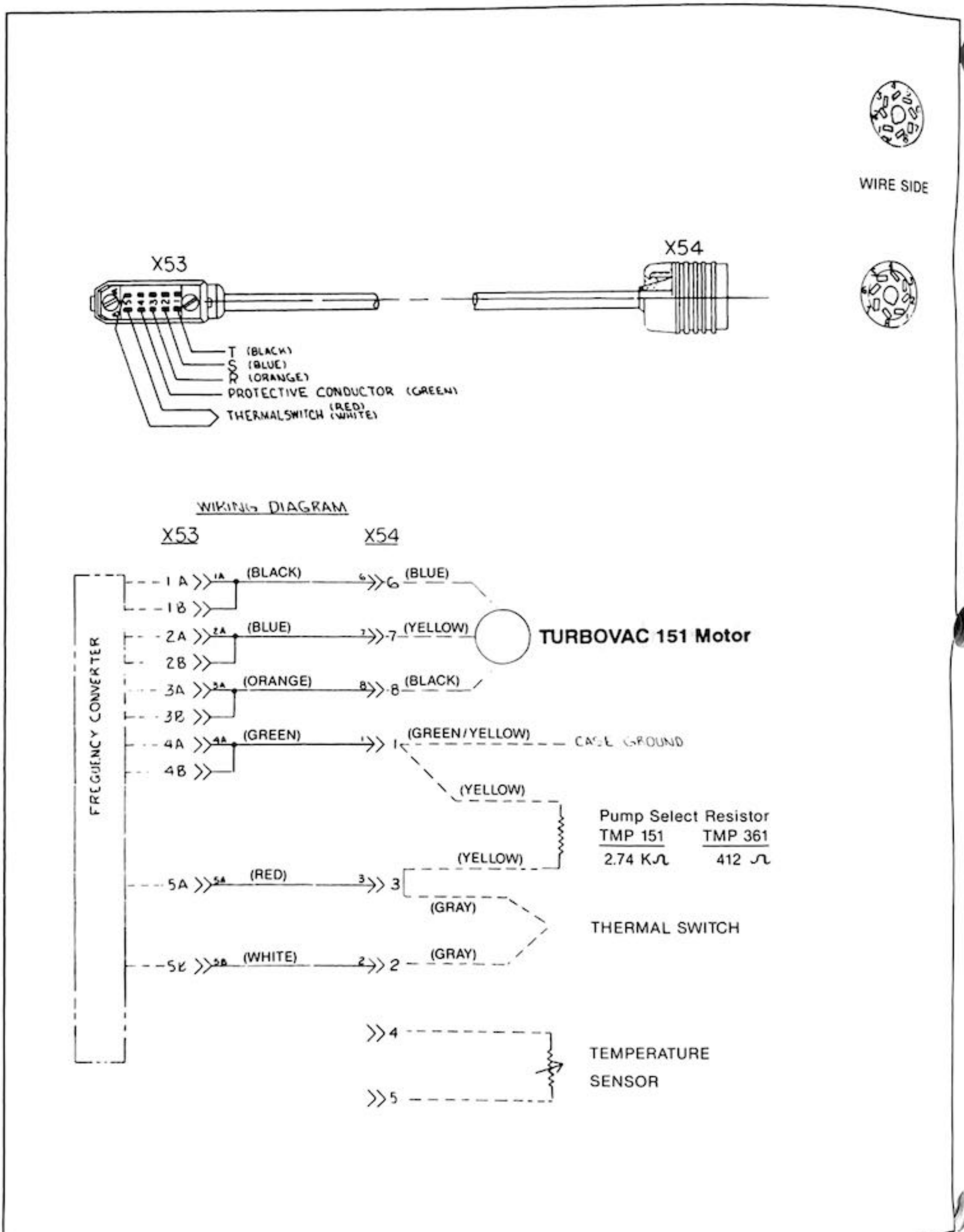


Figure 7-8. TMP/NT-Cable Wiring Diagram

TP1 - V LINK HI

24 +/-10V during test no. 1
30 +/-1.5 V during test no. 2
60.5 +/-3 V during test no. 3

TP2 - I LINK

-50 mV/Ampere
-0.35 V corresponds to a maximum current of approx. 7.2 A
-0.07 V corresponds to a normal operation current of approx. 1.5 A

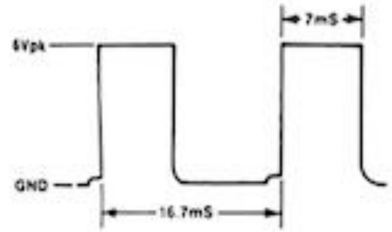
TP3 - BUFFERED I LINK

Should never measure less than 0.035 V
0.5 V/Ampere
+3.6 V corresponds to a maximum current of approx. 7.2 A
+0.7 V corresponds to a normal operation current of approx. 1.5 A

TP4 - BUFFERED V LINK HI

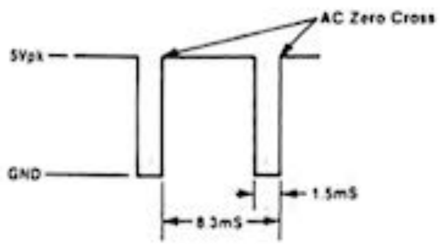
Should never measure less than 0.035 V
+0.85 V corresponds to a link voltage of approx. 13 V during startup
+4.00 V corresponds to a maximum link voltage of approx. 60 V

TP5 & TP24 - AC ZERO CROSSING DETECTOR ENABLE INPUTS

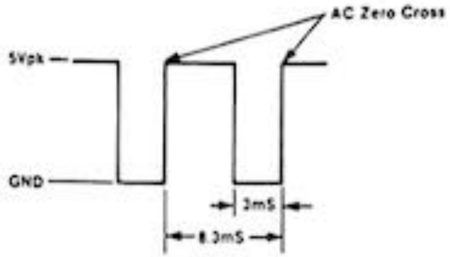


TP6 - COMPUTER SCR GATE OUTPUT

VLink HI ≈ 30V during test no. 2



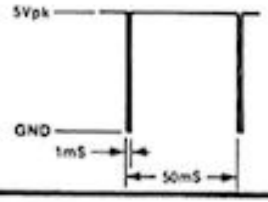
VLink HI ≈ 60V during test no. 3



TP7 - START

+5 V when START button is pressed

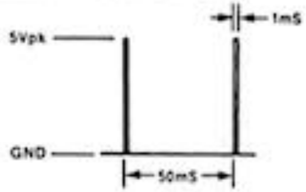
TP8 - MUX ADDR 0



TP9 - STOP

+5 V when STOP button is pressed

TP10 - START CONVERSION



TP11 - CLOCK

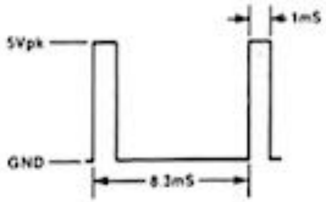
TP12 - PUMP SELECT

0 V when a TMP-150 is connected to converter
+5 V when a TMP-360 is connected to converter

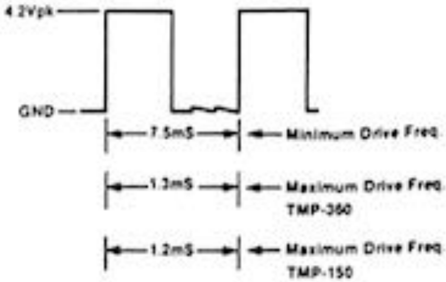
TP13 - THERMAL SWITCH

+5 V when an overtemperature condition exists

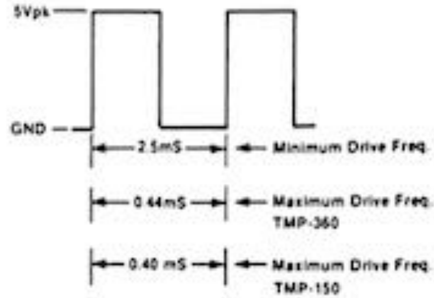
TP14 - ZERO CROSS OUTPUT



TP15, 16, 17 - OUTPUT DRIVERS HI

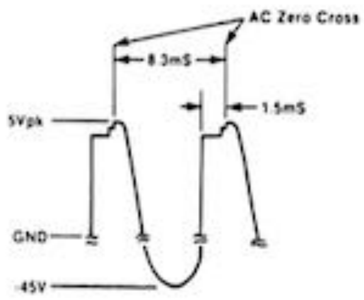


TP18 - COMPUTER OUTPUT SWITCHING SEQUENCE RESTART

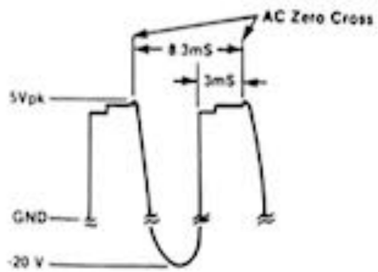


TP19 - SCR GATE OUTPUT

VLink HI ≈ 30V during test no. 2

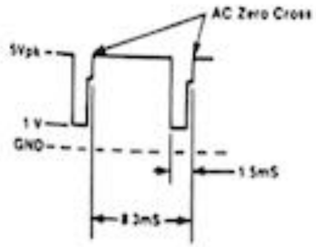


VLink HI ≈ 60V during test no. 3

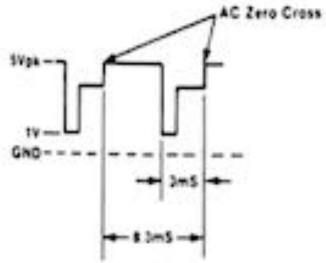


TP20 - SCR BUFFER

VLink HI ≈ 30V during test no. 2



VLink HI ≈ 60V during test no. 3



TP21, 22, 23 - OUTPUT DRIVER LO

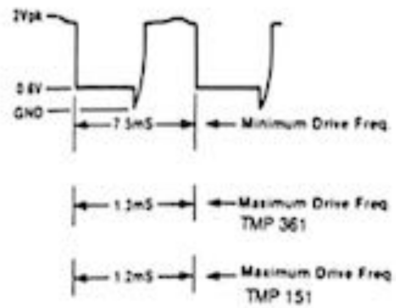


Figure 7-9. NT150/360 Voltages and Waveforms

Maintenance Record

Date	Hours-Meter Reading	Maintenance

Appendix A — Turbopump Accessories

The following are accessory items available for the turbopump. Catalog numbers for these items are listed in Table IV (Ordering Information) located at the front of this manual.

Contents

A.1 Air Cooling Unit

An air cooling unit is available that can be used on the TMP151/361 pump models. It mounts on the tapped holes in the pump's base flange on the opposite side from the fore-vacuum port. Both 110 VAC (P/N 89408) and 220 VAC (P/N 85531) versions are available. The air cooler must be wired so that it is always running when the turbopump is operating.

Figure A-1. Air Cooler Mounted on a TMP150V

Ensure that there is at least 8 inches (20 cm) between the fan and the nearest air-flow restriction. When using the this standard air cooler, avoid air temperatures in excess of 95°F (35°C) at the air-cooler intake. Also ensure that the air cooler doesn't draw in air that is heated by the backing pump. A baffle, heat shield, or cooling-air channels are sometimes necessary to avoid drawing in heated air from the backing pump.

To ensure that the cooling air is adequate, check the pump's operating temperature at the small port just below the purge port; if this temperature exceeds 130°F (55°C), you must use water cooling to avoid premature pump failure.

A variable speed DC drive air cooler for use in high temperature processes is also available. This option requires a separate power supply. Contact our factory for more information.

A.2 Water Refrigeration Unit

The optional Water Refrigeration Unit (see Figure A-2) is used where the ambient temperature is too high for air cooling, where normal tap water isn't available for water-cooling, or where water supply would deposit calcium or dirt in the turbopump's cooling line. The water in this device is contained in a separate reservoir, where it is kept at the required temperature by refrigeration. The cooling water is circulated through the turbopump by the Water Refrigeration Unit's internal water pumping system.

See Section 2.3.4.3 for installation information for the Water Refrigeration Unit. See Appendix A.1 for information on the optional Air Cooler.

Figure A-2. Water Refridgeration Unit

A.3 Water-Flow Switch

The optional Water-Flow Switch (Figure A-3) is used to check that the required quantity of cooling water is flowing through the turbopump. This switch's normally-open contacts are connected to the remote STOP input of the frequency converter. As long as there is sufficient water flowing through the turbopump, these contacts will close and allow the turbopump to operate normally. However, if the water flow should decrease to an insufficient level, these contacts open and turn off the turbopump. See Section 2.3.5 for installation and adjustment information for the Water-Flow Switch.

Figure A-3. Water-Flow Switch

Accessories

A.4 CF Flange Heater

The optional CF flange heater (see Figure A-4) allows automatically controlled bakeout of the turbopump's CF flange and your system's mating flange. It has a thermal switch which keeps the CF flange temperature within the acceptable temperature range. Either 115 VAC or 220 VAC models can be ordered.

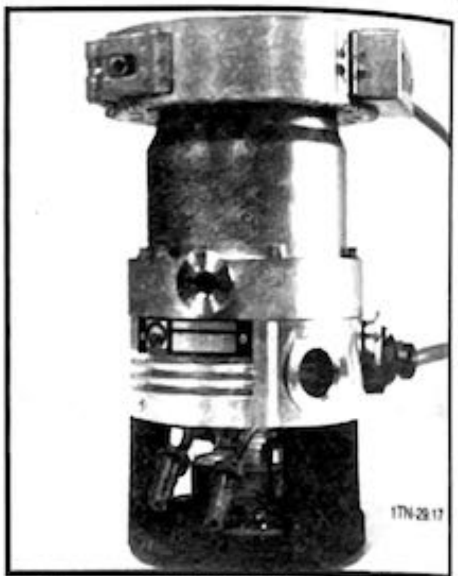


Figure A-4. CF Flange Heater Installed on a TMP150V Pump

Power consumption is as follows:

100CF flange heater 100watts
160CF flange heater ..... 150 watts

Bakeout of the turbopump and vacuum chamber is only necessary when operational pressures of 10^{-8} mbar or lower are required. Normally a bake-out time of 5–6 hours is sufficient for the turbopump. Longer baking times won't, as a rule, significantly improve the ultimate pressure.

A.5 Automatic Vent Valve

An automatic vent valve (see Figure A-5) is used in standard applications to vent the pump during shutdown. See Appendix A.6 for information on venting and purging for process gases that are corrosive, aggressive, or that contain abrasives.

Figure A-5. Automatic Vent Valve

The valve is wired to the pumping system so that it opens immediately after the pump is shutdown allowing gas to enter the pump while it is still rotating rapidly. This prevent backstreaming of oil from the foreline into the pumping system's high-vacuum space.

The vent valve mounts on the turbopump's 10KF vent port and is electromagnetically-actuated. Normally-open and normally-closed valves are available. See Section 2.3.6.1 for information on vent-valve installation and Section 3.6 for information on operation.

A.6 Purge/Vent Valve

WARNING!

It is essential that the Purge/Vent Valve is connected to a source of inert gas or is sealed when pumping toxic or reactive process gas. The Purge/Vent Valve isn't a shutoff device. If its inlet port is left open, toxic process gas could escape after shutdown or air could enter the pump and have a dangerous reaction with aggressive process gas.

The optional Purge/Vent Valve (Figure A-6) is required for a TMP151/361**C** pump model when pumping corrosive or aggressive gases or when pumping gases containing dirt or abrasive substances.

The Purge/Vent Valve is connected to the turbopump's purge port. Its nozzle is always open allowing a constant flow (12 sccm at 0 psig) of purge gas into the pump. The flow rate can be increased by increasing the pressure up to a maximum of 7.5 psig as shown in Table 2-B. A larger capacity Purge/Vent Valve is required if the process gas contains oxygen or chlorine (see Table 2-B).

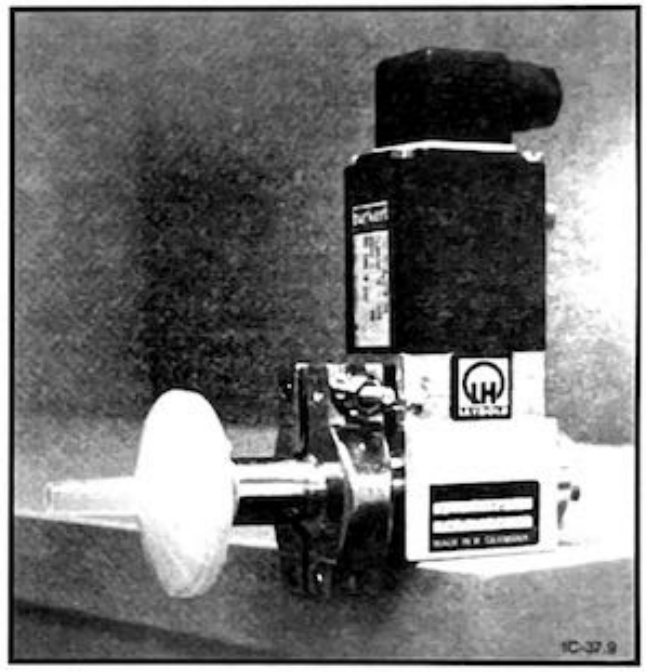


Figure A-6. Purge/Vent Valve

When the power is switched off, a bypass valve opens that increases the flow to 4800 sccm to vent the pump.

The Purge/Vent Valve must be checked periodically to ensure that its filter isn't clogged. The filter element (P/N 200 17-876) should be replaced before the purge-gas flow drops below 90% of its throughput. If you have an older model without the filter, order the retrofit kit (P/N 200-17-980) to install the filter assembly.

The Purge/Vent Valve isn't a shutoff device; thus, you will need an isolation valve if you want to shutoff the purge-gas flow.

If you plan to use your own valve for purging and venting, ensure that it has the correct capacity (minimum 12 sccm purge/4800 sccm vent) and that it can perform both purging and venting at the pump's purge port.

See Section 2.3.6 or GA 05.296 for installation information for the Purge/Vent Valve.

A.7 Adsorption Trap

Figure A-7. Adsorption Trap

Oil can't backstream through an operating turbopump; however, oil can backstream from the backing pump into the foreline during operation and it can backstream through the turbopump when its rotation begins to slow during shutdown. Purging and venting the turbopump greatly reduces this backstreaming.

An adsorption trap (see Figure A-7) should be installed on the backing pump's inlet port to provide an additional degree of protection against backstreaming oil contaminating the turbopump. The activated alumina (Al_2O_3) adsorbs oil vapors and must be replaced about every 3 months depending on operating conditions. If there is any dust in the new Al_2O_3, use dry air or nitrogen to blow it away. The part number of a 2-liter can of Al_2O_3 is 85410.

When you must achieve very low pressures, ensure that the Al_2O_3 doesn't become saturated with water vapor from the vacuum chamber or from the venting air. To prevent the Al_2O_3 from becoming saturated with water, use a roughing line to pump down the chamber to approximately 1 mbar before pumping through the adsorption trap. In these applications, the Al_2O_3 should be replaced or regenerated when you observe a noticeable pressure rise from the adsorbed water vapor.

Although the conductance of the adsorption trap is very good, it does results in some decrease in the pumping speed. See the manual (GA 04.197) that comes with the adsorption trap for more information.

A.8 Vibration Damping Bellows

The optional Vibration Damping Bellows assembly (Figure A-8) is a flexible duct which is connected between the turbopump's high-vacuum flange and the outlet of the system's vacuum chamber. It is available for the turbopump models with CF or ISO-K high-vacuum flanges. See Table IV in the front of this manual for the part numbers.

Figure A-8. Vibration Damping Bellows

Vibration Damping Bellows should be used whenever the turbopump is connected to instruments highly sensitive to vibration, or to prevent external vibrations from being transmitted to the turbopump.

In addition to absorbing vibration, the bellows listed in Table IV are strong enough to support the weight of the turbopump when mounted vertically. However, additional structural support is required for other mounting positions. Don't use bellows that can't support the weight of your turbopump model.

Note that the turbopump is normally used without bellows because of its precision dynamic balance which produces a total vibration velocity of not more than 0.10 mm/second.

A.9 NT150/360 Conversion Kit (P/N 728-40-005)

This kit is used to convert an old style converter (P/N 85472-1) that was used with a grease-lubricated TMP150/360 pump into a NT150/360 converter (P/N 85472-3) to drive a TMP151/361, TMP151/361C, or TMP150/360 V pump. The conversion can be done by Leybold or by customer technicians. Conversion instructions are included with the kit.

Maintenance Record

Date	*Hours-Meter Reading*	*Maintenance*

Index

Index

O

P

R

S

T

U

V

W

Z

DECLARATION OF CONTAMINATION

LEYBOLD

Fax this form to the number below and include a copy with each unit.

Fax Number:	Date:	RMA#:
Region:		

	Bill to Address	Ship to Address
Company		
Line 2		
Line 3		
Line 4		

PO #: ____________________ Not to exceed: $ ____________________

The units ID tag information (P/N and S/N)

If **Turbo**, cooled by?

Air _____ Water ____

If applicable check oil type to return in unit:

Hydrocarbon _____ PFPE _____

UNIT WAS EXPOSED TO THE FOLLOWING CHEMISTRY

__ Air(if no chemistry, check here.)
__ Ammonia (NH3)
__ Argon (Ar)
__ Arsenic (As)
__ Arsine (AsH3)
__ Boron Trichloride (BCl3)
__ Boron Trifluoride (BF3)
__ Carbon Tetrachloride (CCl4)
__ Carbon Tetrafluoride (CF4)
__ Chlorine (Cl2)
__ Dichlorosilane (SiH2Cl2) (DCS)
__ Hexafluoroethane (C2F6)(Freon 116)
__ Hydrogen Bromide (HBr)
__ Hydochloric Acid (HCl)
__ Hydroflouric Acid (HF)
__ Nitrogen (N2)
__ Nitrogen Triflouride (NF3)
__ Nitrous Oxide (N2O)
__ Oxygen (O2)
__ Ozone (O3)
__ Phosphine (PH3)
__ Silane (SiH4)
__ Sulfur Hexaflouride (SF6)
__ Tetraethylorthosilicate (C2H2O4Si)(TEOS)
__ Tetrafluoromethane (CF4)(Freon 14)
__ Trifluoromethane(CHF3)(Freon 23)
__ Trimethylboron (B(CH3)3)
__ Trimethylphosphite (C3H9O3P) (TMP)
__ Tungsten Heaxaflouride (WF6)

Write in Chemicals if not listed: (Chemicals not listed should include CAS#)

Semi-conductor only: Process/Tool Information

Implantation	Deposition:	PVD	TEOS-CVD	MCVD		
Etch:	Polysilicone	Metal	Deep	Trench	Silicide	Oxide

Reason for return: (be specific)

End User Signature:	Phone #:

SVCF-004:1/29/97

LIMITED WARRANTY

Seller warrants to the original purchaser that the equipment to be delivered pursuant to this Agreement will be as described herein and will be free from defects in material or workmanship. Minor deviations which do not affect the performance of the equipment shall not be deemed to constitute either a failure to conform to the specifications or a defect in material or workmanship.

This warranty shall extend for a period of twelve (12) months from the initial date of shipment. Should any failure of conformity to this warranty appear within twelve (12) months from the initial date of shipment, Seller shall, upon immediate nofitication of such alleged failure and substantiation that the equipment has been operated and maintained in accordance with Seller's recommendations and standard industry practices, correct such defects by suitable repair or replacement at its own expense.

Seller's liability under this warranty shall cease if any major repairs to or any replacement or modification of the equipment is made by any person other than Seller's personnel or persons working under the supervision of Seller's personnel, unless authorized by Seller in writing. Further, the warranty shall cease unless the Buyer has operated the equipment in strict compliance with operating instructions and manuals, if any, provided for the equipment, and unless Buyer operates the equipment in normal use and with proper maintenance.

If the equipment contains components from another manufacturer and are subject to the manufacturer's warranty, then Seller's liability shall be limited to the extent of the warranty which Seller received from the manufacturer or supplier of the equipment conponent parts. Seller's liability shall be no greater than the liability of the manufacturer or supplier as determined by a final judgment by the Buyer against the manufactuerer or supplier of such components. Seller will cooperate with Buyer in such legal action but at Buyer's expense.

THIS WARRANTY IS EXPRESSLY IN LIEU OF ANY AND ALL REPRESENTATIONS AND WARRANTIES, EXPRESS OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR OTHER WARRANTY OF QUALITY, EXCEPT THE WARRANTY OF TITLE. THIS WARRANTY CONSTITUTES THE EXCLUSIVE REMEDY, and shall not be deemed to have failed of its essential purpose so long as Seller is willing and able to correct defects covered by the warranty in the manner prescribed. The sole purpose of the exclusive remedy shall be to provide Buyer with free repair and/or replacement in the manner and for the time period provided herein.

The entire agreement between the parties is embodied in this writing, which constitutes the final expression of the parties, and it is the complete and exclusive statement of the terms of the agreement. No other warranties are given beyond those set out in this writing.

LIMITATION OF LIABILITY. SELLER SHALL NOT, UNDER ANY CIRCUMSTANCES, BE LIABLE FOR DIRECT OR INDIRECT, SPECIAL DAMAGES, INCIDENTAL OR CONSEQUENTIAL, such as but not limited to, loss of profits, damage to or loss of other property, downtime costs of the equipment, delay expenses, overhead or capital costs, claims of Buyer's customers or activities dependent upon the equipment.

Except to the extent provided in the LIMITED WARRANTY, Seller shall not be liable for any claim or loss arising out of or related to this agreement or the equipment provided pursuant thereto, whether such claim allegedly arises or is based on contract, warranty, tort (including negligence), strict liability in tort or otherwise. Liability shall not in any event exceed the cost of the equipment upon which such liability is based.

SEVERABILITY. If any portion or clause of this agreement is held invalid or unenforceable as to any person or under any circumstances, the invalidity or lack of application shall not impair or affect the other provisions and the application of those provisions which can be given effect without the invalid or unenforceable provision or application. With this intention, the provisions of this agreement are declared to be severable.

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