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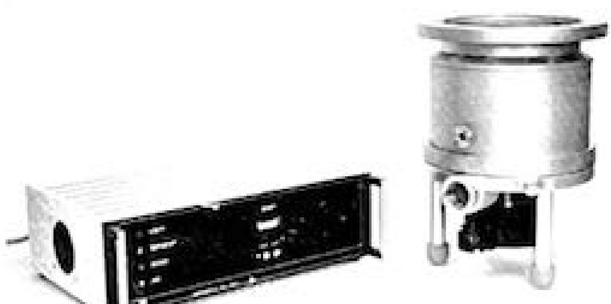
LEYBOLD VACUUM PRODUCTS INC.

Part Number 722-78-018 ■ Edition E

TMP1000 Turbopump & NT1000 VH Converter

MANUAL



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 a 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 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 — TMP1000 TURBOVAC® Specifications

Pumping Speed (Volume Flow Rate — liters/Second)				
High-Vacuum Flange	**160 ISO-K**	***160 CF***	***6-inch ASA 200 CF***	***250 ISO-K***
For Nitrogen	850	850	1100	1150
For Helium	880	880	975	1000
For Hydrogen	900	900	970	1000
Ultimate Pressure	$<10^{-9}$ mbar	$<10^{-10}$ mbar	$<10^{-10}$ mbar	$<10^{-9}$ mbar

Compression Ratio:	
For Nitrogen	$>10^9$
For Helium	5×10^4
For Hydrogen	2×10^3

Starting Pressure (maximum fore-vacuum pressure)	$<1 \times 10^{-1}$ mbar
Maximum Pressure at the High-Vacuum (HV) Flange	1×10^{-2} mbar
Rotational Speed	36,000 rpm
Start-Up Time	4 minutes with NT1000/1500 VH 9 minutes with NT20 converter
Lubrication	Life-long supply of grease
Cooling Water Flow Rate	30 l/hr (8 gal/hr) at 15°C (60°F)
Cooling Water Temperature	60 to 75 °F (15 to 25 °C)
Maximum Cooling Water Pressure	80 psig
Cooling Water Connection, Hose Nozzle	7⁄16 inch (11 mm)
Fore-Vacuum Port Fitting	40 KF or 63 ISO-K
Maximum Bakeout Temperature at High-Vacuum Flange	212°F (100°C)
Bakeout Power Requirements	See Section 3.8
Mounting Position	In Any Desired Position
Vibration Velocity	≤0.15 mm/sec
Weight	55 pounds. (25 kg)
Dimensions	See Table V
Recommended Backing Pump: NOTE:The recommended backing pump can vary widely depending on the gas load, the required pumpdown time, & the conductance of the foreline. Contact Leybold for recommendations for your particular process.	TRIVAC® D40B (28.3 cfm). TRIVAC D65BCS (45.9 cfm) if operating with inert-gas purging

Table II — Specifications of the NT1000/1500 VH Converter

Input Voltages (± 10%)	100,115/120, 220/240 V AC ±10%, single phase, 50/60 Hz
Maximum Power Input	0.9 KVA for TMP1000 (1.2 KVA for TMP1500)
Overload Current Limit	
During start-up	8.5 amps for TMP1000 (11.5 amps for TMP1500)
During operation	3.5 amps for TMP1000 (8.0 amps for TMP1500)
Input Fuses:	
100, 115/120 V AC	10 amps
240 V AC	6.3 amps

Output Voltage (maximum)	42 V AC, 3 phase
Rated Frequency (normal operation):	595 Hz (355 Hz for TMP1500)
Admissible Ambient Temperature	32–110°F (0–45°C)
Maximum Output Relay Load (resistive load)	<250 V AC 1000W AC/4 amps <130 V DC 120W DC/1 amp
Weight	55 pounds (25 kg)
Dimensions	445 x 138 x 372 mm

Table III — Ordering Information for the Turbopump & Converter

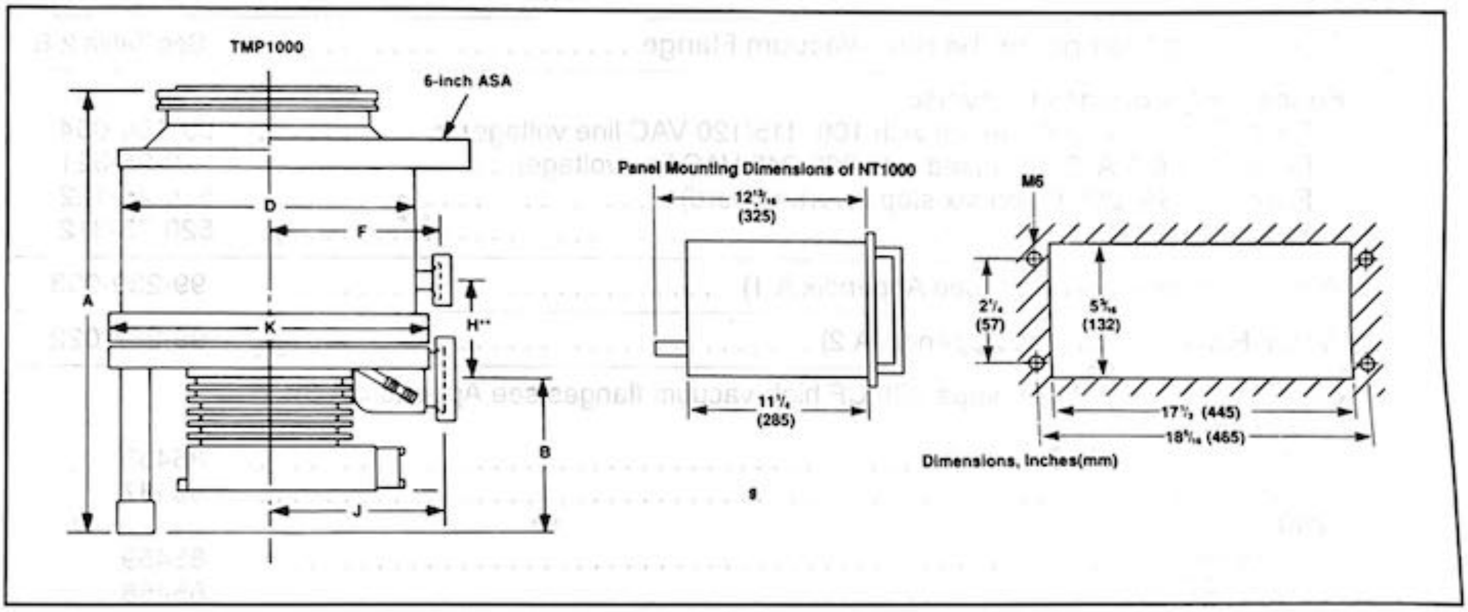
Pump and Converter	Part Numbers
Turbomolecular Pump Models:	
TMP1000C with 6-inch ASA High-Vacuum Flange & 40KF Fore-Vacuum Port	89489
TMP1000C with 6-inch ASA High-Vacuum Flange & 63 ISO-K Fore-Vacuum Port	89499
TMP1000C with 250 ISO-K High-Vacuum Flange & 40KF Fore-Vacuum Port	85536
TMP1000C with 250 ISO-K High-Vacuum Flange & 63 ISO-K Fore-Vacuum Port ..	85539
TMP1000C with 160 ISO-K High-Vacuum Flange & 40KF Fore-Vacuum Port	85535
TMP1000C with 160 ISO-K High-Vacuum Flange & 63 ISO-K Fore-Vacuum Port	85538
TMP1000C with 160 CF High-Vacuum Flange & 40KF Fore-Vacuum Port	899238
TMP1000C with 200 CF High-Vacuum Flange & 40KF Fore-Vacuum Port	899239
NT1000 VH Frequency Converter	
For 115 VAC	85578-1
For 220 VAC	85578
NT20 Frequency Converter (115VAC)	85562-1
Pump/Converter Cable, 16 feet (5 meters)	200-17-045

Table IV — Ordering Information for Accessories

Accessories	
Gaskets and Clamps for the High-Vacuum Flange	See Table 2-B
Fuses for Frequency Converter	
Fuse F1 T 10 A, 250D (used with 100, 115/120 VAC line voltage)	99-180-054
Fuse F1 T 6.3 A, 250D (used with 200-240 VAC line voltage)	520-25-321
Fuse F2 16A, 250 G (on six-step inverter board)	520-25-122
Fuse F3 T 0.5/250	520-25-312
Water Refrigeration Unit (see Appendix A.1)	99-239-003
Water-Flow Switch (see Appendix A.2)	99-287-022
CF Flange Heater (For pumps with CF high-vacuum flanges,see Appendix A.3):	
160 CF	
115V AC	85438
220V AC	85437
200 CF	
115V AC	85459
220V AC	85458
Vibration Damping Bellows (see Appendix A.7)	
For pumps with a 160 ISO-K high-vacuum flange	85344
For pumps with a 160 CF or 200 CF high-vacuum flange	On request
Flange Adapter (Adapts 250 ISO-K Flange to 10" ASA)	98-278-0703
Automatic KF10 Vent Valve (see Appendix A.4)	
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 for Corrosive Applications (see Appendix A.5)	
115 V AC	85528*
220 V AC	85529*
Adsorption Trap (see Appendix A.6)	
40KF Trap	85416
Al_2O_3 Adsorbent, 2-liter can	85410
Air Cooling Unit (see Appendix A.8)	
115V	89445
220V	85498

* If the pump's serial number is smaller than A9113 . . . ., use the 36 sccm purge/vent valve (P/N 85548 for 115VAC, and P/N 85549 for 220 VAC).

Table V — Dimensions



Dimensional Data

Dimensions, Inches (mm)

TMP 1000 Flanges	A	B*	D	F	H**	J	K
160 ISO-K	14 5/8 (371)	4 31/32 (126)	9 3/8 (238)	5 13/32 (137)	3 9/16 (90)	5 1/2 (140)	10 5/32 (258)
CF160	15 3/32 (383)	4 31/32 (126)	9 3/8 (238)	5 13/32 (137)	3 9/16 (90)	5 1/2 (140)	10 5/32 (258)
CF200	14 5/8 (371)	4 31/32 (126)	9 3/8 (238)	5 13/32 (137)	3 9/16 (90)	5 1/2 (140)	10 5/32 (258)
250 ISO-K	13 1/2 (343)	4 31/32 (126)	9 3/8 (238)	5 13/32 (137)	3 9/16 (90)	5 1/2 (140)	10 5/32 (258)
6"ASA	14 5/8 (371)	4 31/32 (126)	9 3/8 (238)	5 13/32 (137)	3 9/16 (90)	5 1/2 (140)	10 5/32 (258)

* Dimension listed is for 63 ISO-K Foreline Port., KF40 Foreline Port "B" Dimension is 5 9/32 (134).

** Dimension listed is for 63 ISO-K Forline Port.. KF40 Foreline Port "H" Dimension is 3 7/32 (82).

1 — Introduction

Contents

This manual contains installation, operation, description, and service information for the TMP1000 Turbomolecular Pump and the NT1000/1500 VH Frequency Converter. The pump and converter function together to produce ultra-clean, hydrocarbon-free high vacuum.

This manual doesn't cover the model TMP600 or TMP1500 turbopumps or the model NT20 converter.

"WARNING" statements are used in this manual to prevent personal injury;
"CAUTION" statements are used to prevent damage to equipment.
The "NT1000/1500 VH" converter is sometimes called the "NT1000 VH" converter in this manual.

NOTE: **ASA Flanges** — We refer to one of our intake-flange options as 6-inch ASA. The bolt pattern of this flange is compatible with a standard 150-pound 6-inch 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.

1.1 Brief Description of Turbopump and Converter

See the front of this manual for important precautions, specifications, and ordering information. See Section 6 for detailed descriptions of the TMP1000 and the NT1000 V/H.

The **TMP1000 Turbomolecular Pump** can produce an ultimate pressure of $<10^{-10}$ mbar and can achieve a pumping speed of 1000 liters/second for air at molecular flow. A turbopump must be backed by a rotary vane pump to avoid overloading the turbopump at higher pressures and to evacuate hydrogen. Other features of the TMP1000 are listed 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.8 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 2-5)** — 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. For standard applications, the purge port is sealed off and the pump is normally vented through the vent port as described in Section 3.6.

  If the pump will be exposed to corrosive or aggressive process gases or gases that contain dirt or abrasives, you must seal off the 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.

  All current TMP1000 models include the purge port; however, older models didn't have this port.

- **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.

The **NT1000/1500 VH Frequency Converter** converts single-phase 50/60 Hz power to the three-phase power pulses required by the turbopump's motor for acceleration and steady running at 36,000 rpm. The NT1000/1500 VH converter can drive the TMP1000, the TMP600, or the TMP1500 turbomolecular pumps.

The pump is started and stopped by the converter's START and STOP pushbuttons. A frequency meter on the front panel indicates the motor's drive frequency as a percentage of its maximum value (100% corresponds to maximum pump speed). Front panel POWER, ACCELERATION, NORMAL OPERATION, and FAILURE indicators show the status of the converter. External control and monitoring devices can be connected to the converter's rear-panel terminal block (see Section 2.2.4).

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 15 days of delivery in accordance with Interstate Commerce Commission regulations.
   - 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 NT1000 VH Frequency Converter and the TMP1000 Turbomolecular Pump. Also included is a procedure which checks the turbopump's direction of rotation (see Section 2.2.7).

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 16 ft. (5 m) from the frequency converter, a longer pump cable will be required.

- A vent valve (see Appendix A.4) is required for standard applications. A source of dry inert gas and a Purge/Vent Valve (see Appendix A.5) are required for the turbopump 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.2), 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.8).

- The turbopump requires a backing pump for proper operation. A TRIVAC D40B is recommended for standard applications. A larger capacity backing pump (TRIVAC D65BCS) 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^{-2} mbar. Otherwise, the foreline pressure will exceed its maximum pressure of 1×10^{-1} mbar. Contact Leybold for recommendations.

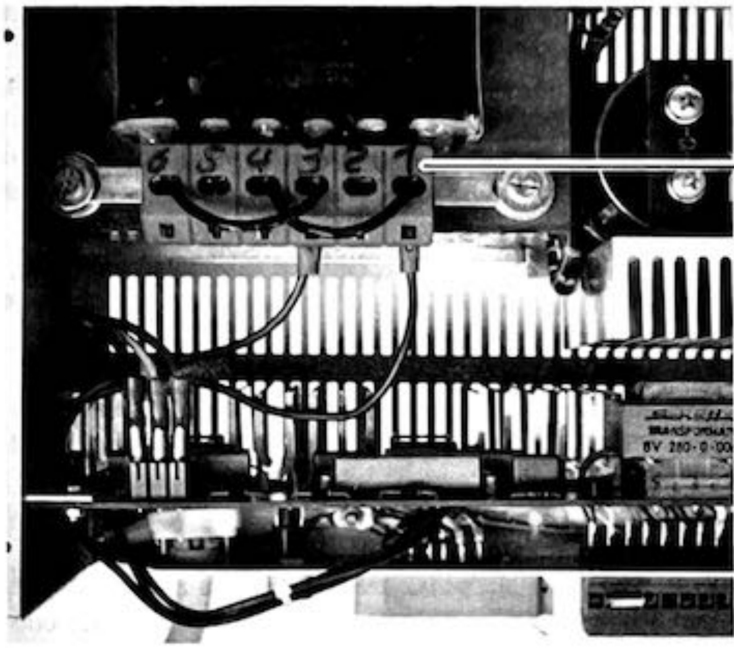
- The turbopump must be protected from external shocks or vibration while its rotor is spinning. Bellows are recommended if the turbopump is connected to any vibrating components. Use bellows to connect the turbopump's fore-vacuum port to the backing pump. Refer to Appendix A.7 for information on bellows 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-B 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 the converter's cooling fan isn't obstructed and that the ambient temperature doesn't exceed 113°F (45°C).

- 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.



Refer to Table 2-A for transformer T1 primary connections. (This photo shows primary connected for 115 VAC.)

1TN-37.22A

Figure 2-1. Power Transformer T1 Primary Connections

Table 2-A —Transformer Connections & Fuse Selection for the Converter

AC Line Voltage	*110*	*115/120*	*200/220*	*240*
AC Line Connection to Terminals	2 & 3	1 & 3	2 & 6	1 & 6
Jumper Connections to Terminals	2 to 5; 3 to 6	1 to 4; 3 to 6	3 to 5	3 to 4
Fuse (F1)	10 A	10 A	6.3 A	6.3 A

2.2 *Frequency Converter Installation*

2.2.1 *AC Voltage and Fuse Selection*

! WARNING — Electrical Shock !

DON'T plug the converter into an AC service outlet during the following procedure.

CAUTION: Failure to ensure that the converter's transformer settings and fuse match your AC power source could result in damage to the converter.

The NT1000 VH converter is supplied ready for connection to a 115 V AC, 50/60 Hz power outlet. If your service is 100, 220, or 240 V AC, you must change the following:

1. **Voltage Selection** — Before plugging into the outlet, remove the NT1000 VH top cover and change the connections to the primary-side terminals of transformer T1 as listed in Table 2-A and shown in Figure 2-1. For additional wiring details, see the electrical schematic (Figure 7-6).

2. **Fuse** —The NT1000 VH is shipped with the 10 amp fuses installed for 100 or 120 V AC operation. If your service is 220 or 240 V 60-Hz, change the input fuse F1 in the back panel fuse holder to 6.3 amps. We inlcude a 6.3 amp fuse in the bag of spare fuses shipped with the converter.

3. **Plug** — If your AC service is 240V 60-Hz, remove the standard 120V plug from the converter's linecord and replace it with a 250V, 20A right-angle plug (P/N 99-122-049).

2.2.2 Converter Cooling

The converter is cooled by an internal fan mounted on the left side of the unit as seen from the front. This fan maintains the converter at an acceptable operating temperature as long as the fan's intake isn't obstructed and the ambient air temperature doesn't exceed 113°F (45°C).

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.

2.2.3 Converter Mounting

The converter is shipped with four rubber feet, allowing it to be placed on any hard surface up to 16.4 feet (5 m) away from the pump. For greater distances, additional pump cable must be ordered.

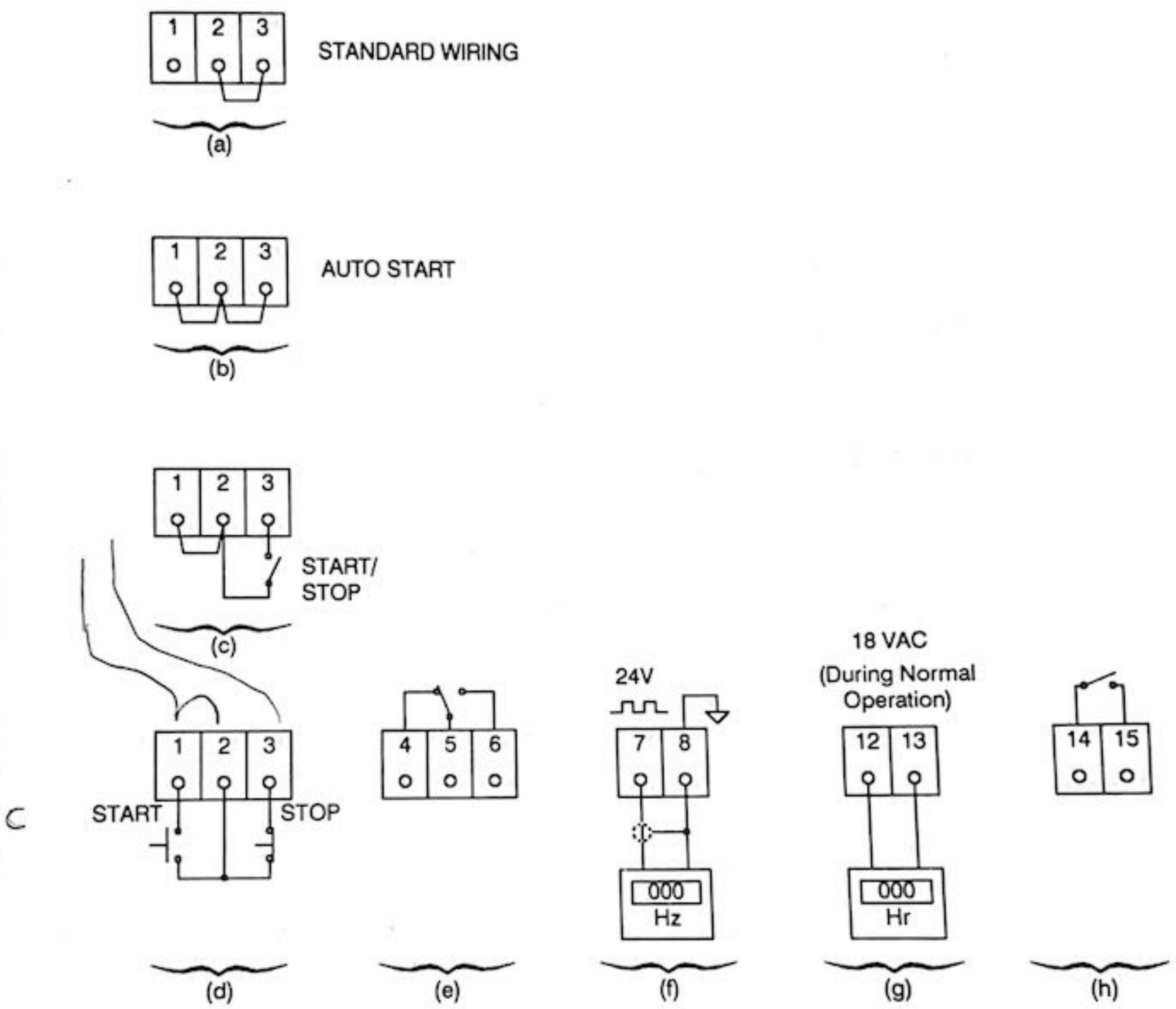
To mount the converter in a 19-inch rack, first remove the converter's rubber feet, and then install Extender Ears (supplied with the converter) behind its front-panel handles. The Extender Ears consist of two rectangular metal plates, each having two slotted screw holes and two round screw holes. To install the Extender Ears, proceed as follows:

1. Using a small flat-blade screwdriver, pry out the plastic cover located in the front of each handle.

2. Loosen the two screws that secure the handles to the front panel; then remove the spacer plate behind each handle.

3. Insert the Extender Ears in place of the spacer plates with their slotted screw holes positioned behind the handle screws; then tighten the handle screws.

4. Reinstall each handle's front-plastic cover.



(a) Standard front-panel START/STOP control of turbopump; no remote control.

(b) Automatic START of turbopump when AC power is applied to converter.

(c) Remote START/STOP using a single toggle switch.

(d) Remote START/STOP using two momentary pushbuttons.

(e) NORMAL operation relay outputs; Terminals 5 & 6 close and 4 & 5 open when converter switches to NORMAL operation.

(f) Frequency Counter.

(g) Elapsed Time Meter; 18 VAC is applied to Terminals 12 & 13 when converter switches to NORMAL operation.

(h) FAILURE relay output; Terminals 14 & 15 close when converter goes into FAILURE.

Figure 2-2. NT1000/1500 VH Rear-Panel Wiring

Installation

2.2.4 Wiring the Converter's Rear Panel Terminal Block (X1)

Figure 2-2 shows the various wiring configurations possible at the converter's rear-panel terminal strip. Detailed wiring information is included in Sections 2.2.4.1 thru 2.2.4.7

2.2.4.1 Standard Wiring

We connected a jumper between terminals 2 and 3 as shown in Figure 2-2a to allow you to control the converter using its front panel start/stop pushbuttons.

2.2.4.2 Auto Start

To automatically start the pump whenever AC power is applied to the converter, connect jumpers to Terminals 1, 2, and 3 as shown in Figure 2-2(b).

2.2.4.3 Remote Starting and Stopping

Terminals 1, 2, and 3 are inputs to be used for starting and stopping the pump from a remote location. Two wiring methods for remotely controlling the converter are described below:

- Figure 2-2(c) shows how a single toggle switch can be used to turn the pump on and off. With this wiring configuration, the pump starts when the switch is closed, and stops when the switch is opened. An advantage of this wiring method is that the pump will automatically restart without operator intervention following a short-term-AC-power failure.
- Figure 2-2(d) shows two momentary pushbutton switches that function the same way as the converter's front-panel START/STOP pushbuttons. This wiring arrangement uses a momentary-switch closure to start the pump, and a momentary-switch open to stop the pump. **Note that a short-term-AC-power failure will reset the converter and stop the pump.**

2.2.4.4 Remote Normal-Operation Sensing

Relay contacts connected to Terminals 4 (N.C.), 5 (Common), and 6 (N.O.) indicate when the converter achieves normal operation. These relay contacts are rated 4 A @ 250 VAC, and 120 W @ 30 VDC. See Figure 2-2(e).

For example, an external lamp or control device can be activated when the converter's NORMAL OPERATION indicator lights by connecting the external device along with its power source in series with Terminals 5 and 6.

2.2.4.5 *External Converter Frequency Indication*

A frequency counter connected to Terminals 7 & 8 will provide a quantitative indication of the converter's output frequency. See Figure 2-2(f).

The output signal at Terminals 7 & 8 is a +24V square wave. The following frequencies represent the pump's maximum rotational speed:

- TMP1000 turbopump model . . . . 595 Hz — 35,700 rpm
- TMP1500 turbopump model . . . . 355 Hz — 21,300 rpm

2.2.4.6 *External Elapsed Time Meter*

Terminals 12 & 13 provide an output of 18 VAC whenever the converter achieves normal operation. An elapsed time meter can be connected to these terminals to indicate total normal operating time of the pump. See Figure 2-2(g).

2.2.4.7 *Remote Failure Sensing*

Relay contacts connected to Terminals 14 & 15 provide an indication of converter failure. These relay contacts are rated 4A @ 250 VAC, and 120 W @ 30 VDC. See Figure 2-2(h).

For example: An external lamp or control device can be activated when the converter's FAILURE indicator lights by connecting the external device along with its power source in series with Terminals 14 and 15.

2.2.5 Grounding

To reduce the possibility of electrical shock, and to prevent a malfunction of the converter due to electrical noise, ground the converter chassis to the enclosure in which it is installed, or to a nearby earth ground. Use the grounding screw at the converter's rear, lower right-hand corner. This ground connection is in addition to the ground wire contained in the converter's AC power cord.

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

2.2.6 Pump and Converter Interconnection

The pump's motor and the converter are interconnected by a standard 16.4 foot (5 m), 7-conductor pump cable that is supplied with the converter. Connect this pump cable between the pump's octal socket and the converter's rear-panel TURBOVAC connector.

Note that the pump cable is marked at both ends by heat-shrink tubing. If the older 6-conductor unmarked pump cable is mistakenly used with the TMP1000, the pump will run at the slower rotational speed of the TMP1500 (21,300 rpm).

CAUTION: When plugging the octal pump-cable connector into the pump's electrical connector, ensure that the key and keyway of these connectors are properly mated. Otherwise, the converter may be damaged due to improper connections.

Important: If you use a pump cable that is longer than the standard cable, you must readjust the Pump Cable Length Compensation control, R71, as described in Section 4.4.1.

2.2.7 Checking the Turbopump's Direction of Rotation

Before installing the pump, check the direction of rotation as follows:

! WARNING — Electrical Shock !

This equipment employs voltages that are dangerous and may be fatal if contacted. Use extreme caution when any of its protective covers are removed. To prevent electrical shock, always connect its chassis to a low-impedance ground.

CAUTION: Before plugging the converter into an AC service outlet, ensure that its power transformer, T1, is wired for the correct AC line voltage, and that the correct chassis fuse, F1, is installed. Refer to Section 2.2.1.

1. Install the cable between the pump and converter as described in Section 2.2.6.

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

3. Press START; observe the direction of rotor rotation through the pump's high-vacuum inlet port; then press STOP.

4. The rotor should be turning clockwise (as see through the high-vacuum flange). If rotation is correct, unplug the converter and skip to Step 5; if the rotor is turning counterclockwise, proceed as follows to correct the rotation:

   a. Unplug the converter from the AC service outlet.

   b. Remove the converter's top cover.

   c. See Figure 2-3, and interchange any two of the three-phase output wires connected to Terminals X6 on the Six-Step Inverter board.

   d. Replace the top cover; then redo Steps 2, 3, and 4 to ensure that the pump's rotation is correct.

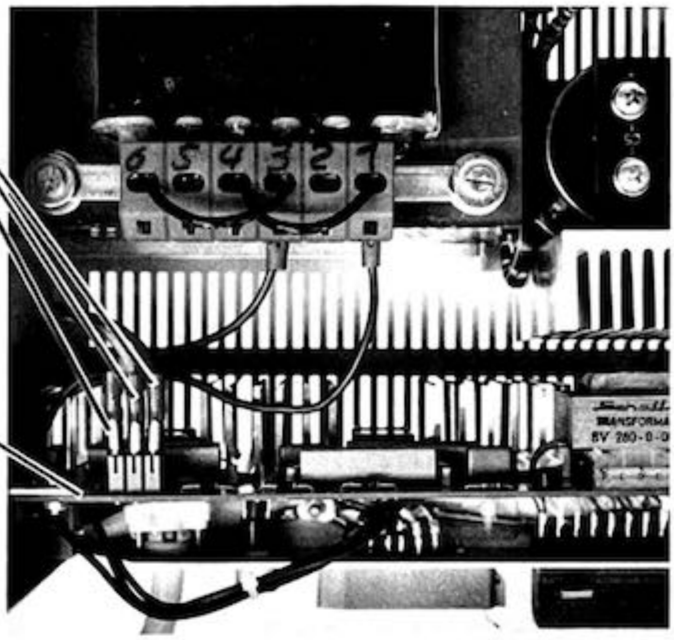


Figure 2-3. Changing the Wiring to Correct the Pump Rotation

2.3 *Turbopump Installation*

Figure 2-4 is a diagram of a typical pumping system containing a turbopump.

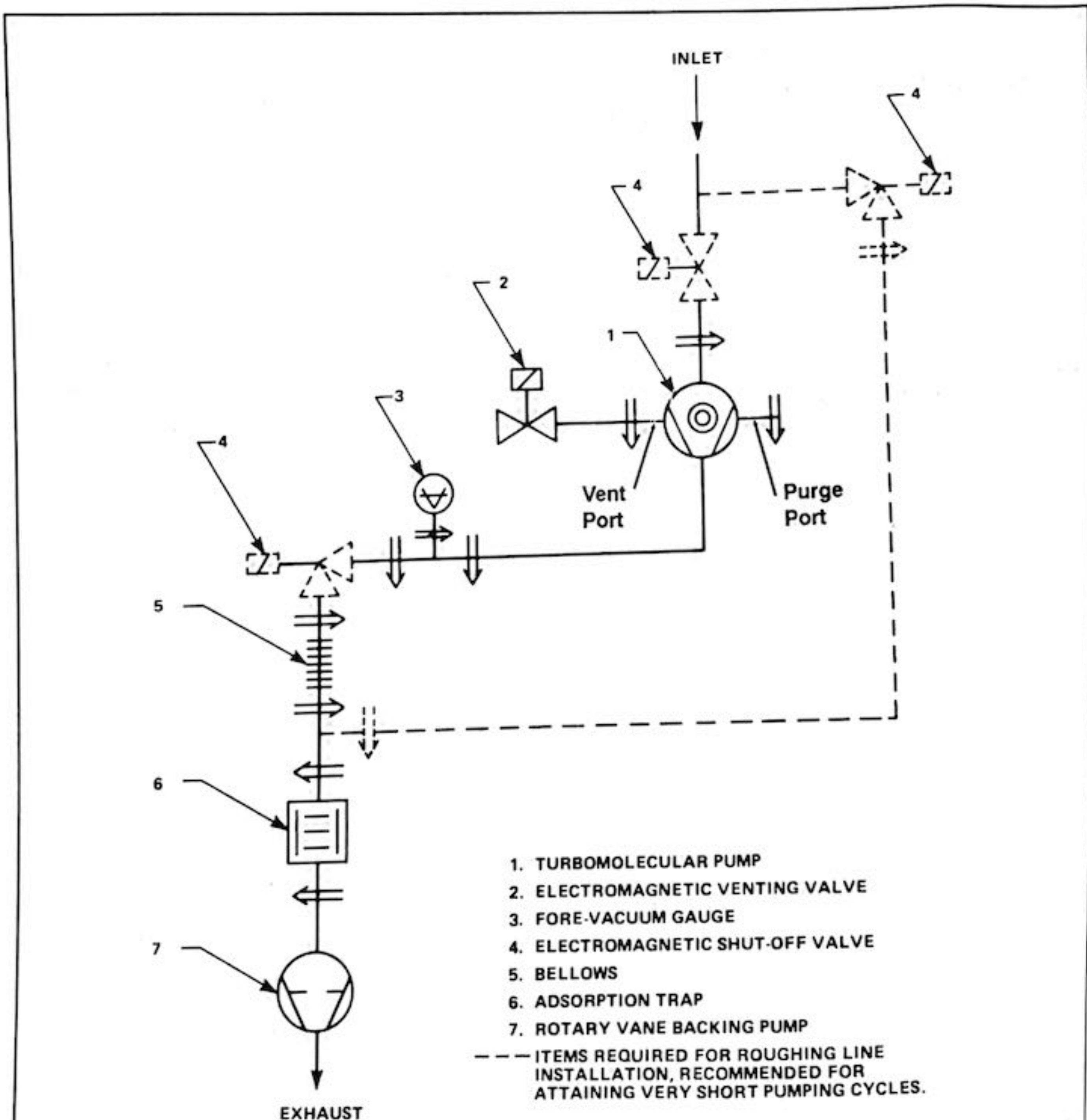


Figure 2-4. Typical Installation Schematic

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 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

The TMP1000 can be mounted and operated in any position.

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-B for the part number of the required sealing disc.

NOTE: The bolt pattern of our ASA flange is compatible with a standard 150-pound 6-inch 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.3) 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-B for the part number of the required copper gasket.

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

6-inch ASA Sealing Discs	ISO-K Clamps (set of 4)	CF 250 Copper Gaskets	CF 200 Copper Gaskets	CF 160 Copper Gasket
910-181-618	26701	83948-M	83947-1	83946-1

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 pump models with a 160 ISO-K or 160 CF high-vacuum flange (see Appendix A.7). If you use the 160 CF bellows for connecting the high-vacuum flange, you don't need to provide structural support for the pump.

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

If the turbopump has a 40 KF fore-vacuum port, a KF40 clamp and centering ring with O-ring are included with the pump.

If the turbopump has a 63 ISO-K fore-vacuum port, a centering ring, an O-ring, an outer ring, and two of the four flange clamps (P/N 26701) required for the fore-vacuum connection are included with the pump. See the Leybold catalog for assembly information for this and other types of vacuum fittings.

If you want to change the fore-vacuum port from 63 ISO-K to 40 KF, unscrew the ISO-K fore-vacuum port and replace it with a 40 KF port (P/N 200-170-655).

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. A TRIVAC D40B is a suitable backing pump for most applications.

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 the TRIVAC D65BCS. It is constructed to withstand corrosive gases and has an optional inert-gas purge system.

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.6 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 2-5). 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 75 °F. The maximum ambient temperature for a pump being baked out with air cooling is 86°F (30°C) while the ambient temperature for unheated air-cooled pumps at operating pressures lower than 10^{-4} 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 2-5). The minimum cooling water consumption is about 30 l/hr (8 gal/hr). The tap water temperature should be about 60°F (15°C). The higher the cooling-water temperature, the higher the required cooling-water flow. The maximum water pressure is 80 psig. Use 7/16 inch (11 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.

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.

Note that the turbopump is protected by a thermal switch which automatically switches off the NT1000 VH converter when the pump overheats because of a water failure.

2.3.4.2 Installing the Optional Air Cooler

If water cooling isn't possible, use the Air Cooling Unit to cool the pump (see Appendix A.8). This air cooler is mounted around the motor housing and is secured to the pump base using three screws supplied with the unit.

When installing the air cooler, ensure that its intake air ports aren't obstructed and aren't near the heated air flowing from the backing pump.

Connect the Air Cooler to a source of either 115 or 220 V AC (depending on the model ordered), single-phase power that is switched on and off simultaneously with the pump . See the electrical specification label on the air cooler for the required voltage. It requires 24 watts.

Note that the maximum ambient temperature for a pump being baked out with air cooling is 86°F (30°C) while the ambient temperature for unheated air-cooled pumps at operating pressures lower than 10^{-4} mbar is 113°F (45°C).

2.3.4.3 Installing the Water Refrigeration Unit

Where tap water cooling isn't possible, the Water Refrigeration Unit (see Appendix A.1) can be used to cool the turbopump. Connect the water lines of the Water Refrigeration Unit to the water nozzles of the turbopump using $\frac{7}{16}$-inch (11 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. These connections are ¼-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 shutdown the turbopump at a minimum water flow rate of 0.13 gal/min (0.5 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 0.13 gal/min (0.5 l/min), this switch opens and causes the converter to shutdown the turbopump.

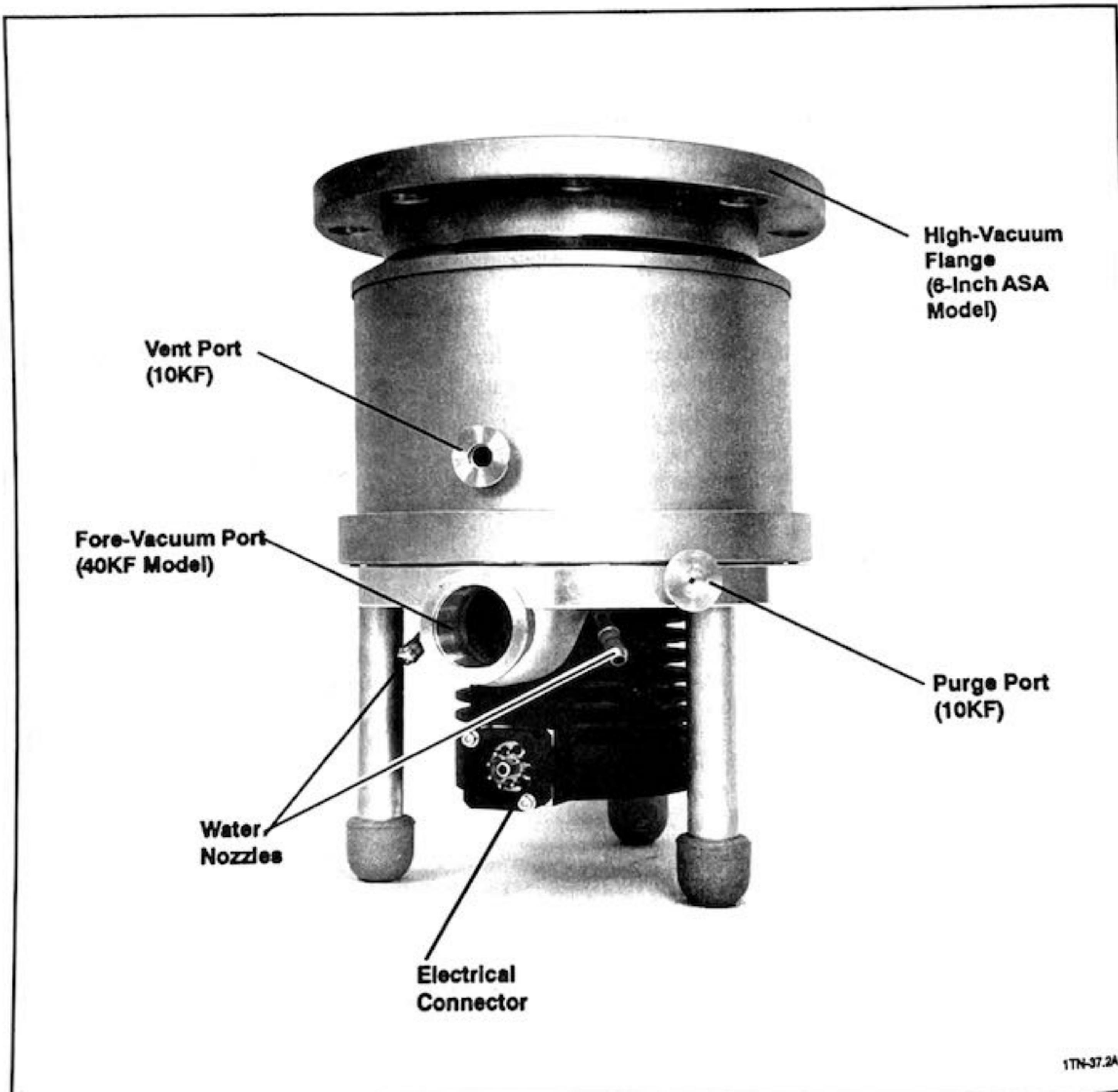


Figure 2-5. TMP1000 Turbopump

2.3.6 Installing Vent and Purge Devices

There are two 10KF ports on the turbopump. The upper 10KF port on the pump housing is the vent port; the lower 10KF port on the base housing is the purge port (see Figure 2-5).

If your pump will be used in standard applications, we recommend sealing the purge port with a blank flange and installing a vent valve onto the vent port as described in Section 2.3.6.1. Venting prevents oil from backstreaming from the foreline into the high-vacuum sections of the system during shutdown.

If your pump will be exposed to corrosive or aggressive process gases or to process gases containing abrasives or dirt, you must 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

Install the optional vent valve as follows:

1. Ensure that the purge port is sealed with its blank flange (see Figure 2-5).
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 2-5).
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

If your pump will be exposed to corrosive, toxic, or aggressive gases or to gas containing abrasives or dirt, then you must 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.

Install the optional Purge/Vent valve as follows (see Figures 2-5):

1. Ensure that the vent port is sealed with its blank flange (see Figure 2-5).

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.

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.

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 24 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-C. 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.

Table 2-C — Purge Gas Pressures & Flow Rates for the TMP1000

Purge Gas Inlet Pressure (psig)	Purge Gas Flow
0.0 psig	24.0 sccm
2.0 psig	27.3 sccm
5.0 psig	32.2 sccm
7.5 (max. recommended)*	36.2 sccm

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

Installation

2.3.7 Installing the CF Flange Heater

The CF flange heater is used only when operational pressures of 10^{-8} mbar are required (see Figure A-3). 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 for the flange heaters are listed below:

160CF Flange Heater . . . . . 150 watts

200CF Flange Heater . . . . . 250 watts

3 — Operation

WARNING!

Death or serious injury can result from improper use or application of this turbopump. Aggressive gases could have a dangerous reaction with the hydrocarbon grease in the TMP1000. 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 safety precautions and specific recommendations.

This section contains information on how to start, operate, and shutdown the TMP1000 vacuum pumping system. Information on turbopump operating temperatures, purging, venting, and bakeout is also included.

Contents

3.1 Operating Temperature and Pressures

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

Table 3-A — Temperatures

Maximum Temperature at High-Vacuum Flange*	212°F (100°C)
Maximum Temperature at Rotor*	175°F (80°C)
Maximum Temperature at the Fore-vacuum Port	175°F (80°C)
Maximum Ambient Temperature for an air-cooled TMP1000 that is being baked out	95°F (35°C)
Maximum Ambient Temperature for an air-cooled TMP1000 that is continuously operating below 10^{-4} mbar	113°F (45°C)
Ambient Temperature Range for Frequency Converter	32° to 113°F (0° to 45°C)

*Use shields to avoid heat radiation from the vacuum chamber if necessary.

There is a thermal switch inside the turbopump's base housing near the motor coil that shuts down the turbopump if the temperature exceeds 133°F (56°C).

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

Table 3-B summarizes the pressure characteristics of the TMP1000 pump model. To achieve an inlet pressure of $<10^{-10}$ mbar, you must use the TMP1000 pump model that has a CF high-vacuum flange 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	1×10^{-3} mbar
Starting Pressure (maximum pressure at the fore-vacuum port)	$<1 \times 10^{-1}$ mbar
Maximum Pressure at the High-Vacuum Flange	1×10^{-2} mbar

Operation

3.2 NT1000/1500 VH Front Panel Controls and Indicators

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

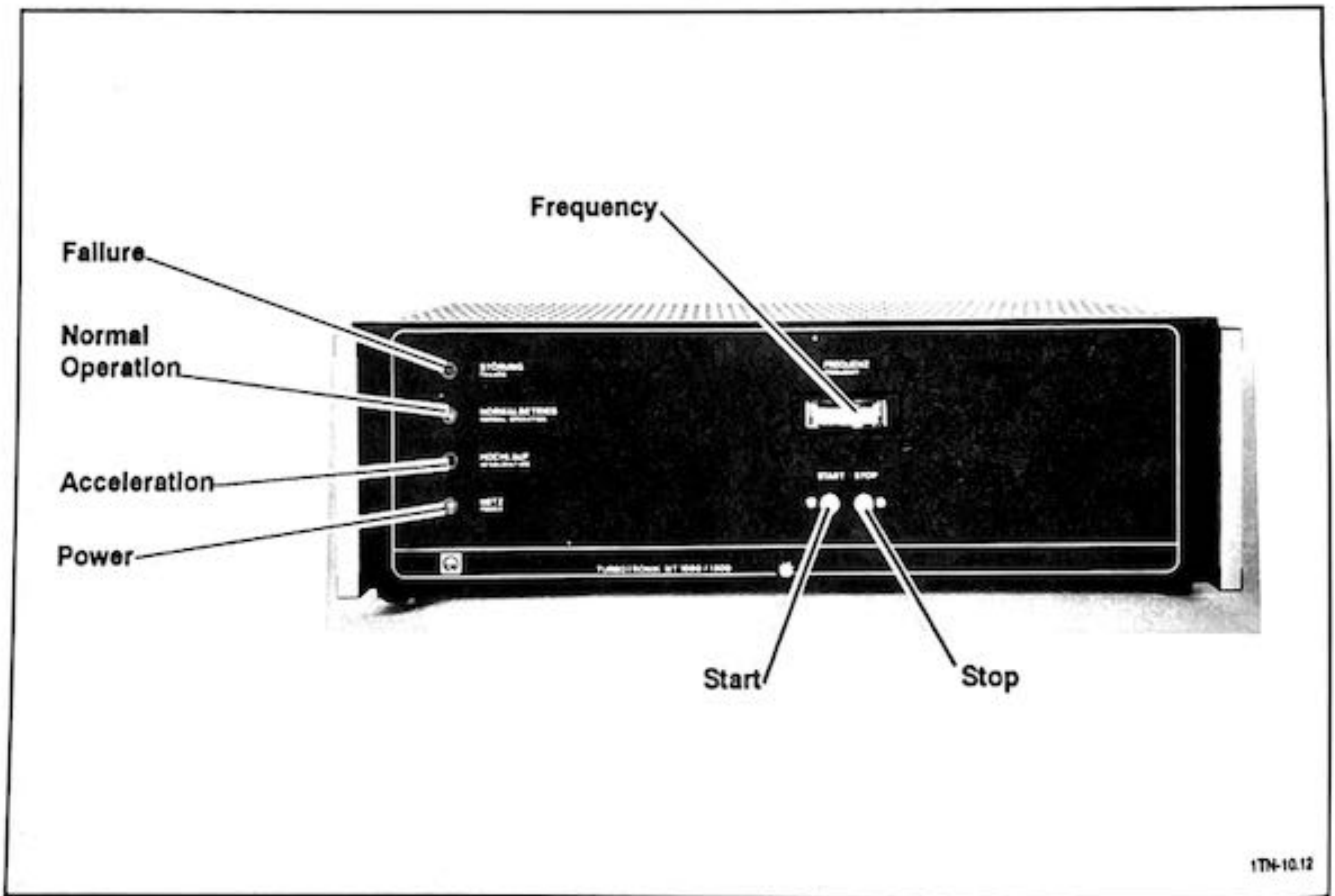


Figure 3-1. NT1000/1500 VH Converter Front Panel

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.
Indicators	***Function***
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. The pump motor current level during acceleration must be about 30% higher than is normally permissible during normal operation. Acceleration time may vary anywhere from a few seconds to a maximum of 15 minutes depending on the initial rotational speed and load of the turbopump.
NORMAL OPERATION LED (yellow)	Indicates when the turbopump has attained the desired rotational speed.This indicator remains ON as long as the pump's rotational speed doesn't drop below about 12,000 rpm.
FAILURE LED (Red)	Indicates that the pump has been stopped due to: o The pump's failure to accelerate to at least ⅓ of its rated rotational speed within an acceleration time of 15 minutes, o An overload which caused the pump's rotational speed to drop below about 12,000 rpm (corresponds to a frequency meter indication of about 33%), o A pump overtemperature condition, o A defective or misadjusted converter. The failure mode is a latched mode; after the fault condition is remedied, you must reset the converter by pressing the STOP button.
FREQUENCY Meter	Indicates the motor's drive frequency as a percentage of its maximum value (100% corresponds to the maximum pumping speed).

3.3 Start-up

Proceed as follows to start the vacuum 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; its POWER LED will light.

3. Ensure that the optional venting valve is closed.
   If the pump will be exposed to corrosive or aggressive process gases or gases that contain dirt or abrasives, ensure that the optional purge/vent valve is connected to a source of inert gas; open the purge-gas line, and ensure that the purge/vent valve is energized.

4. Turn ON the turbopump's cooling-water flow or 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 until the frequency meter indicates about 15%; then, press the converters STOP button and wait for about 5 minutes before proceeding to Step b.

      Note that the FREQUENCY meter indication should first swing to 100%, then drop to about 5%, and then slowly rise as the pump accelerates.

   b. Press the converter's START button and allow the turbopump to accelerate until the FREQUENCY meter indicates about 30%; then, press the converters 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 until the frequency meter indicates about 40%; then, press the converters STOP button and wait for about 5 minutes before proceeding to Step 7.

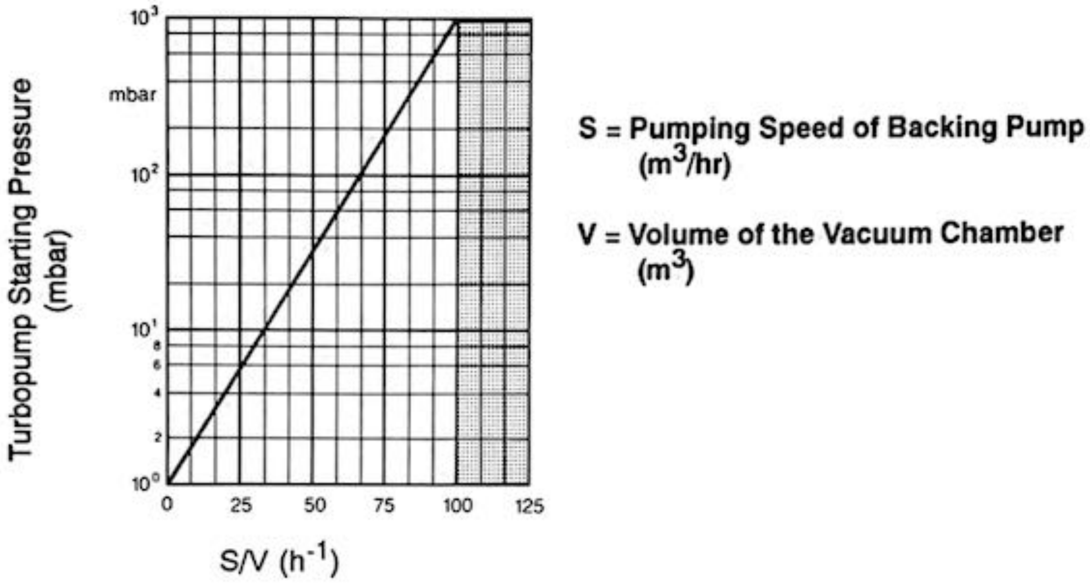


Figure 3-2. Estimating Turbopump Starting Pressure for Large Chambers

7. Determine when to start the turbopump as follows:

The turbopump can normally be started after the foreline pressure reaches 1×10^{-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 1×10^{-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 START button on the converter. The converter's ACCELERATION indicator should light and the FREQUENCY meter indication should first swing to 100%, then drop to about 5%, and then slowly rise as the pump accelerates. The turbopump can also be remotely started as described in Section 2.2.4.3.

9. If operational pressures of 10^{-8} mbar are required, bakeout the vacuum chamber and use the optional CF flange heater to bakeout the turbopump as described in Section 3.8.

10. After the turbopump accelerates to the desired operating speed, the NORMAL OPERATION indicator lights, and the ACCELERATION indicator turns off.

3.4 Operation and Failures

WARNINGS!

DON'T pump oxidizers or higher than atmospheric concentrations of oxygen with the TMP1000. Oxygen can react with the hydrocarbon bearing grease in the TMP1000 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 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 is slowed down becuase of an overload, the NORMAL OPERATION LED remains lit as long as the pump's rotational speed doesn't drop below about 12,000 rpm which is about 33% on the FREQUENCY meter. Any drop below 12,000 rpm causes the converter to shutdown and the FAILURE indicator to light.

If the turbopump doesn't reach 12,000 rpm after accelerating for 15 minutes, the converter shuts down and lights its FAILURE LED. If this happens, reset the converter by pressing the STOP button and then the START button. The START button may be pressed before the rotor has coasted to a stop. If the system fails to accelerate again, or if it fails to reach NORMAL OPERATION, press the STOP button and refer to the troubleshooting section (Section 5).

The converter also enters the failure mode if the turbopumps motor temperature becomes excessive as detected by the thermal switch mounted within the motor housing.

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 2.2.4.3.

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 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.

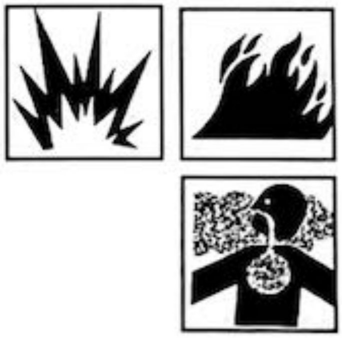
   If a Leybold SECUVAC valve is installed in the fore-vacuum line, this valve automatically closes when the backing pump is switched off.

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

4. Vent the turbopump immediately after shutting down the backing pump. For standard processes, the pump is vented through its vent port. If you have the optional Purge/Vent Valve, de-energize it to vent the pump through the pump's purge port. Refer to Section 3.6 for additional venting information.

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 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 its vent, purge, and fore-vacuum ports with blank flanges to avoid contamination or corrosion. When storing the turbopump for prolonged periods, also place the turbopump into its polyethylene shipping bag with moisture adsorbent and store in a dry location.

3.6 Venting

Venting prevents the backstreaming 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.

Although venting directly from the atmosphere is possible, venting form 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.

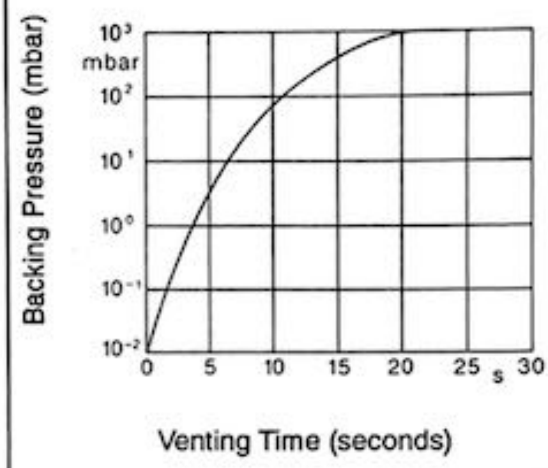


Figure 3-3. Recommended Venting Pressure Rise

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. 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, the turbopump must be vented with dry inert gas through its purge port using the optional Purge/Vent Valve (see Section 3.7). The purge port 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, the turbopump must be purged and vented 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-C 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 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, 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.

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^{-4} mbar and the ambient air temperature doesn't exceed 113°F (45°C). The ambient temperature for an air-cooled turbopump during bake-out must not exceed 95°F (35°C). If the ambient temperature is 95 to 104°F (35 to 40°C) with an air-cooled pump, reduce the heating power of the bake-out jacket or flange heater.

Power consumption for the flange heaters are listed below:

160CF Flange Heater . . . . .150 watts

200CF Flange Heater . . . . .250 watts

4 — Maintenance, Adjustments, & Repairs

This section contains information on cleaning and disassembly/reassembly of the TMP1000 turbopump and adjustments of the NT1000/1500 VH converter.

Figure 4-2 shows an exploded view of the turbopump. Refer to this figure as necessary in the following sections.

Contents

Maintenance

4.1 Preventive Maintenance

The TMP1000 turbopump is maintenance free. It contains 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 NT1000/1500 VH converter is also maintenance free. It is an all solid-state unit which doesn't require any further attention once it has been adjusted for proper operation.


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.6 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.5 for more information on the optional Purge/Vent valve.

4.2 TMP1000 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 4.3.2 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.

WARNING!

If the pump has been exposed to toxic or hazardous gases, it could be contaminated with dangerous chemicals. Use the proper precautions to prevent inhaling or coming in contact with these chemicals when disassembling the pump.

CAUTION: DON'T apply cleaning solvent to any of the O-rings. Some solvents dissolve or cause swelling and cracking of the O-ring material. Also, DON'T allow the cleaning solvent to enter the spindle assembly which contains the greased ball bearings.

Proceed as follows to clean the pump without disassembly, :

1. Disconnect the turbopump from the system and then remove its inlet screen and inlet O-ring or copper seal.

! WARNING: !

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

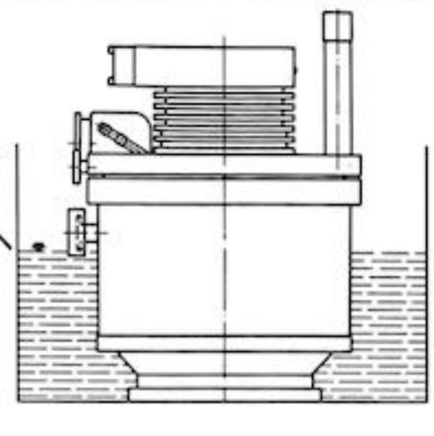


Figure 4-1. TMP1000 Cleaning without Disassembly

CAUTION: In the following step, DO NOT allow the vent port to be submerged in the cleaning solvent; the cleaning solvent level must be below the rim of the vent port as shown in Figure 4-1. This prevents cleaning solvent from entering into the greased ball-bearing assembly.

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

3. Allow the cleaning solvent to react for 10 to 15 minutes. During this period, GENTLY lift and lower the turbopump several times to flush the rotor & stator components.

4. Repeat steps 2 and 3 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 pump right-side up until all cleaning solvent has been removed as described in Step 5. This prevents cleaning solvent from entering into the greased ball-bearing assembly.

5. After cleaning, place the turbopump, with its high-vacuum flange 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 on its side for a short time , and roll it around its axis to allow the solvent to drain from between the stator package and pump housing.

6. When the turbopump is completely dry, replace the inlet screen and O-ring and remount the pump onto your system.

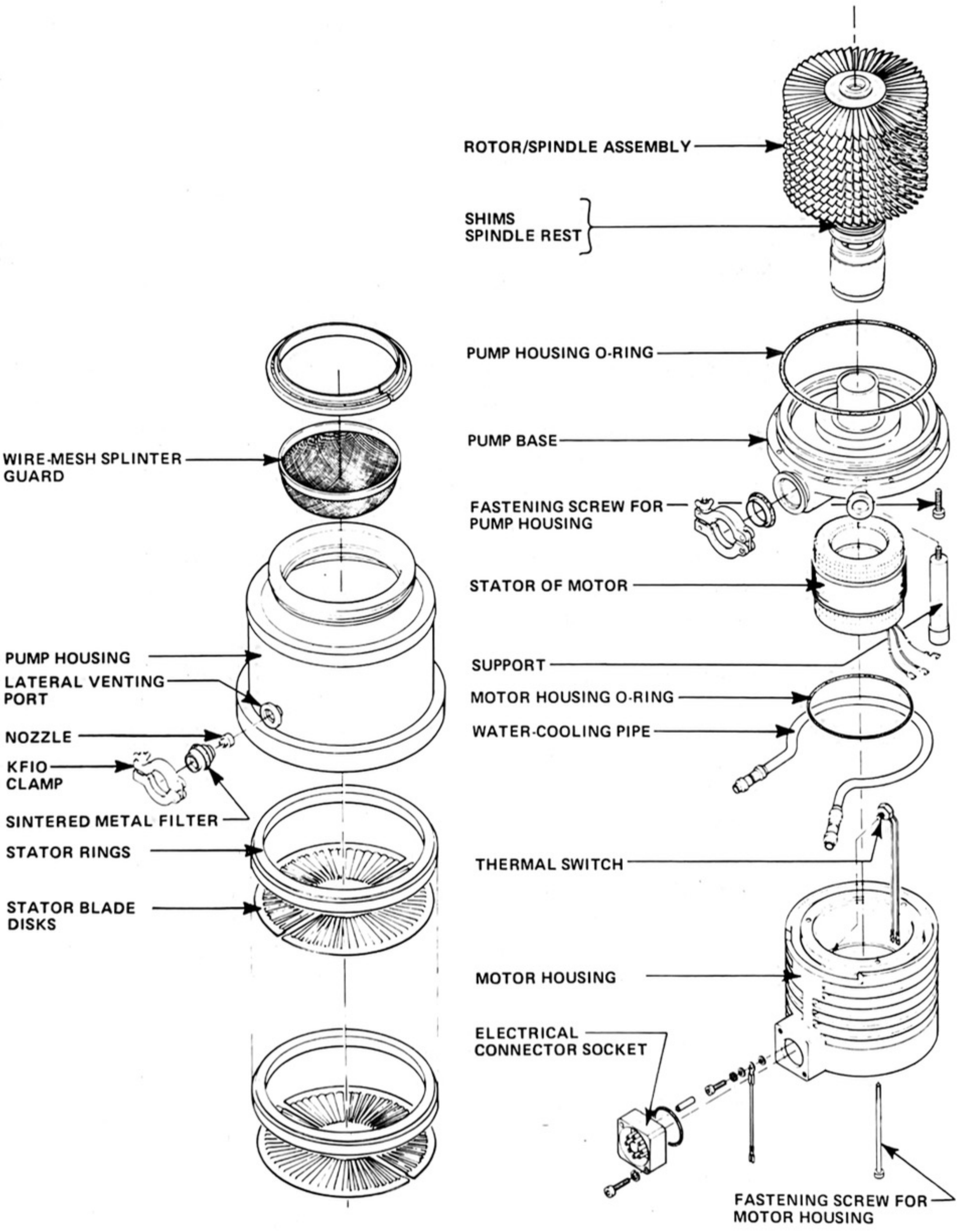


Figure 4-2. TMP1000 Exploded View

4.3 TMP 1000 Turbopump Disassembly/Reassembly


! WARNING — Hazardous Gas !

If the pump has been exposed to toxic or hazardous gases, it could be contaminated with dangerous chemicals. In such cases, use the proper precautions to prevent inhaling or coming in contact with these chemicals when disassembling the pump.

Complete disassembly of the TMP1000 is necessary only if it is heavily contaminated and requires cleaning.

4.3.1 Tools and Materials Required

The following tools and materials are required to disassemble/reassemble the TMP1000:

- 3-mm, 4-mm, and 5-mm Allen Wrenches
- Allen Torque Wrench, 1 to 15 Nm (0.7 to 11 ft-lb)
- Small Flat Blade Screwdriver
- Small Phillips Screwdriver
- Flat Pliers
- Feeler Gauges 0.1 to 1 mm (0.004 to 0.040 inch)
- Ohmmeter (ohm and megohm range)
- Felt-Tip Pen (erasable)
- Emery Cloth, 120 grain

4.3.2 Disassembling the Stator Package

1. Disconnect the pump from your vacuum system and remove its inlet screen.

2. If the turbopump uses the optional air-cooler assembly, remove the air cooler as follows; otherwise, proceed to Step 3.

   a. Carefully set the turbopump upside down on its inlet flange.

   b. Using a phillips screwdriver, remove the three screws which secure the air-cooler assembly to the turbopump.

   c. Pull the air-cooler assembly up from the pump base; it may be necessary to remove the turbopump's rubber feet.

   d. Place the turbopump back on its support legs.

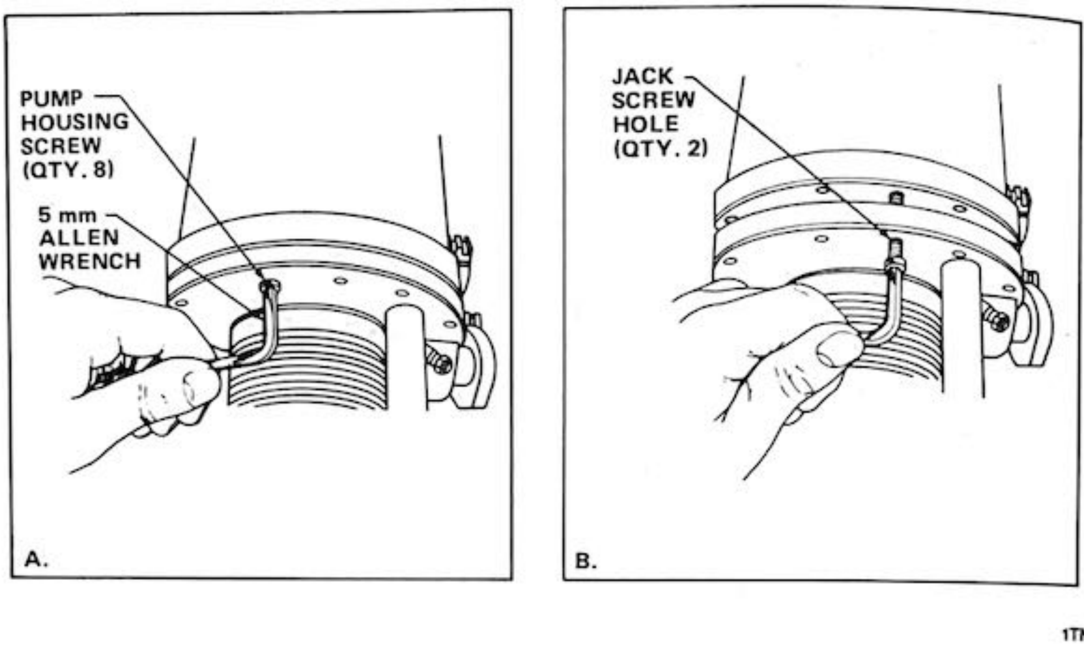


Figure 4-3. Removing the Pump Housing

3. Remove the pump housing as follows (see Figure 4-3):

   a. Using a 5-mm allen wrench, loosen the eight pump-housing screws from the pump base (see Figure 4-3A).

   b. Insert two of the pump-housing screws removed in Step 3a into the two jack-screw holes (see Figure 4-3B). Tighten these two screws uniformly until the pump housing lifts off the pump base by approximately ⅛ inch (5 mm). Then remove these jack screws.

   c. 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 (see Figure 4-3B).

4. Disassemble the stator as follows:

   a. Using a felt-tip pen, number the stator rings from top to bottom (see Figure 4-4A).

   b. Lift off the first stator ring (see Figure 4-4B) and place it upside down next to the turbopump. If the stator rings cling together, use a flat blade screwdriver and 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. DON'T remove any part by force.

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

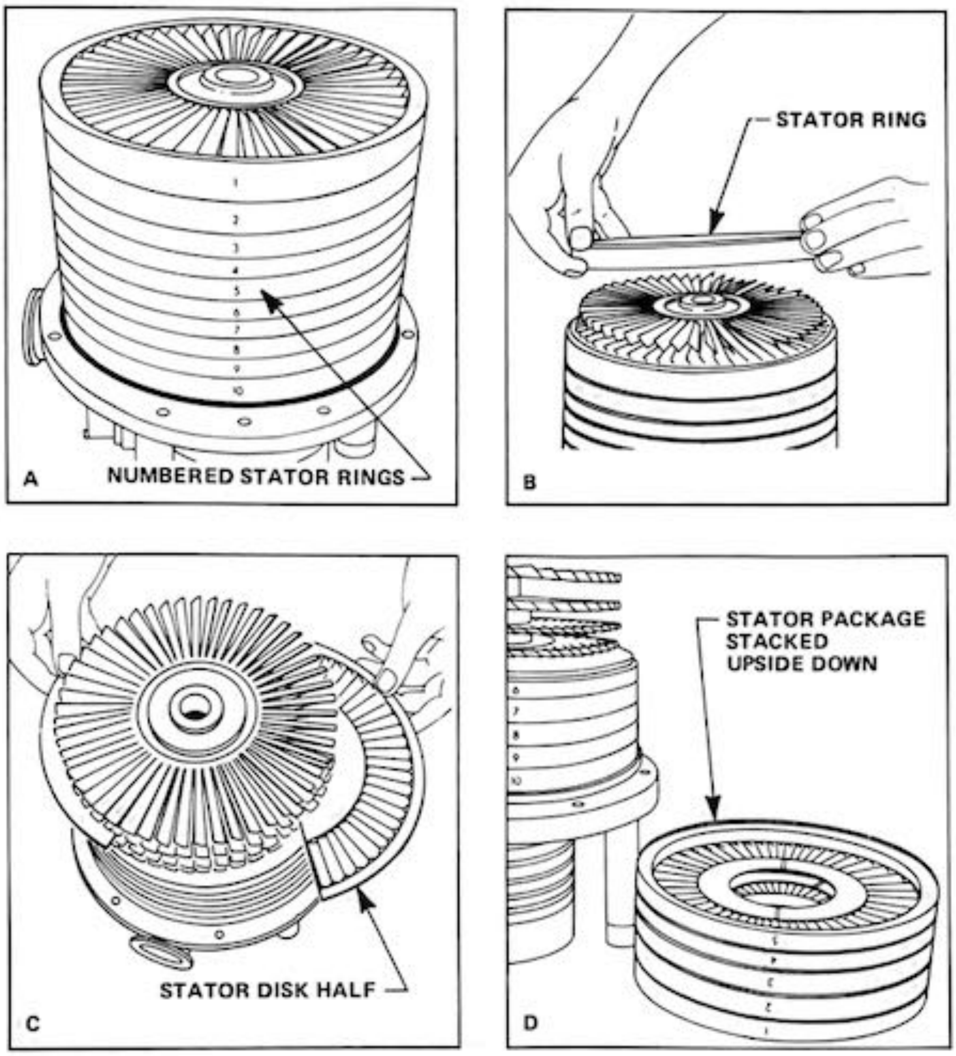


Figure 4-4. Disassembling the Stator Package

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. Inspect both ends on the straight edge of each stator disk to ensure they aren't bent or elongated. If the end is flattened and elongated, file it square. If the stator disk doesn't lie flat, carefully straighten it. 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.

d. 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 (see Figure 4-4D). If you continue to stack them upside down on the previously removed rings and disks as you remove them, they will be stacked in the correct order for reassembly.

Proceed to Section 4.3.5 to reassemble the stator package, or to Section 4.3.3 if you need to remove the motor housing or replace the rotor/spindle assembly.

Maintenance

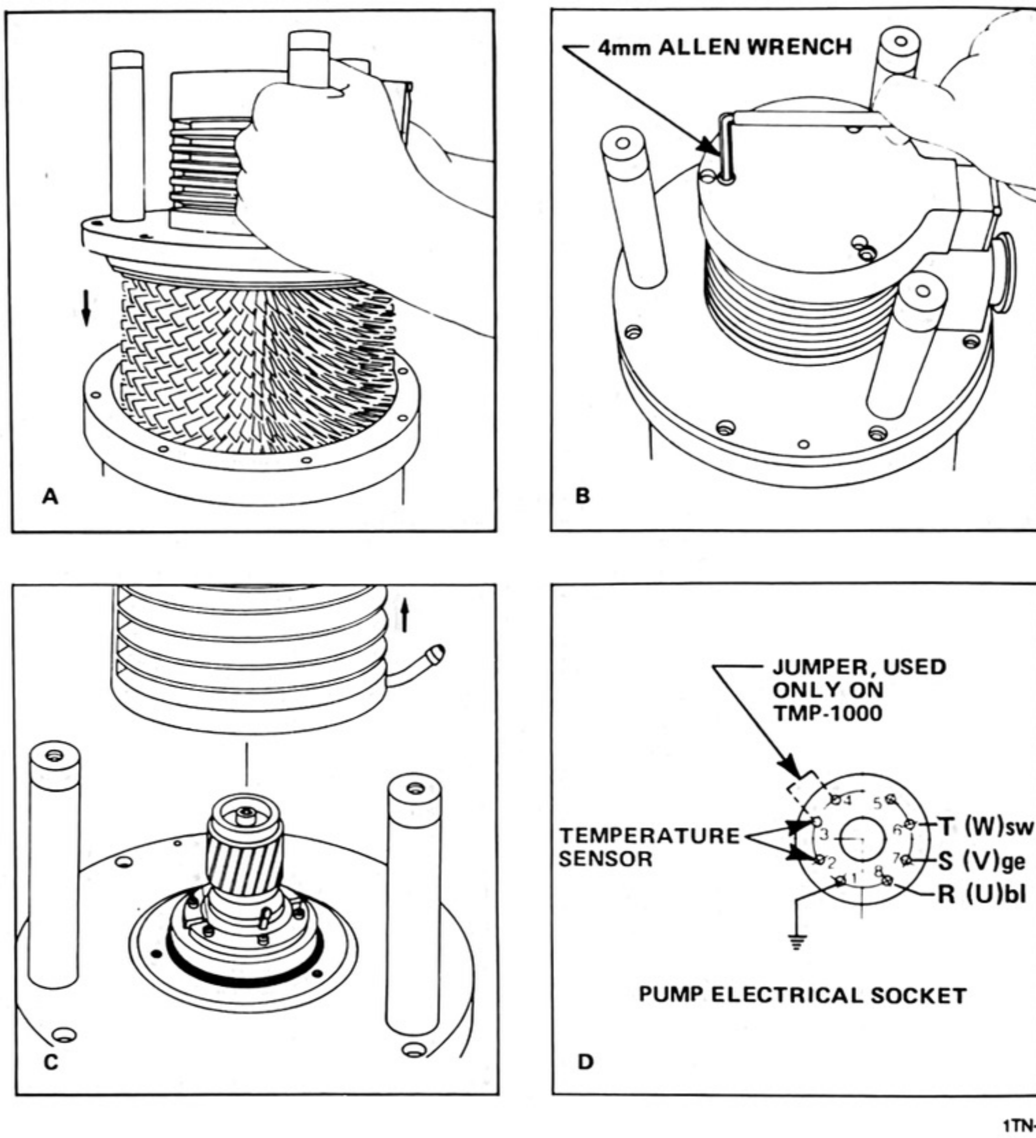


Figure 4-5. Removing the Motor Housing

4.3.3 Removing the Motor Housing & Checking the Motor Stator

This procedure describes how to remove the turbopump's motor housing and check the motor stator for signs of friction and overheating.

1. Place the pump housing upside down on its intake flange. If the pump assembly has been removed from its housing as described in Section 4.3.2, CAREFULLY reinsert the pump assembly into the pump housing (see Figure 4-5A).

2. Using a 4-mm Allen wrench, remove the three motor-housing screws from the pump base (see Figure 4-5B).

3. Grasp the motor housing with both hands and pull it straight up from the pump base (see Figure 4-5C). If necessary, CAREFULLY pry the motor housing up passed its O-ring using a flat blade screwdriver.

4. Check the motor stator (see Figure 4-2) for any possible friction marks; remove any marks by slightly polishing them with Emery cloth (120 grain). Marks indicate insufficient radial play.

5. Check for any indication that the motor stator has become too hot (such as discoloration). Using an ohmmeter, check the stator's inter-phase resistance at pump connector terminals 6+7, 7+8, and 6+8 (see Figure 4-5D). The resistance measured between any two phases should be 0.62 ±0.05 ohm.

4.3.4 Replacing the Rotor/Spindle Assembly

Customers shouldn't attempt to replace the rotor/spindle assembly because it requires special training and equipment for dynamic balancing. A vibration velocity of >0.15 mm/second results in premature bearing failure.

4.3.5 Reassembling the Stator Package and Pump

A new pump housing O-ring (P/N 239-50-735) should be installed whenever the pump housing is removed.

The order in which the stator-disk halves and stator rings are installed is very important. If the stator package was numbered and stacked upside down in sequence as it was disassembled, there shouldn't be a problem in reassembling the package in the correct order.

1. Apply a thin film of high-vacuum grease to the new pump housing O-ring and install the O-ring on the pump base (see Figure 4-6A). **Ensure that the O-ring isn't twisted.**

2. Install 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 them below the last rotor blade row. **Ensure that the abutting joints of the stator-disk halves DON'T overlap.**

   b. Remove the top stator ring from the upside-down stacked stator package and install it over the rotor. **Make sure that the gap between all the stator rings is uniform over their entire outer circumference.**

   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. You can use a small screwdriver to ensure that the stator disks don't overlap as you lower the stator ring. After you install 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 disks are overlapping.

   Its normal to hear blade contact and pinging when the rotor is slowly turned by hand after the stator package is installed. This is because the stator rings aren't yet sufficiently compressed downward to form the correct clearances between the stator and rotor blades. However, you shouldn't hear any pinging after the pump housing is installed and tightened down.

CAUTION: To prevent the stator package from becoming dislocated, DON'T invert or turn the turbopump on its side before the pump housing is replaced and tightened down.

3. Install 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. Ensure that the lateral venting port is positioned directly above exhaust port and that the screw holes in the pump housing and pump base are aligned. This hole alignment is essential since the pump housing O-ring prevents you from easily rotating the pump housing once it has been seated.

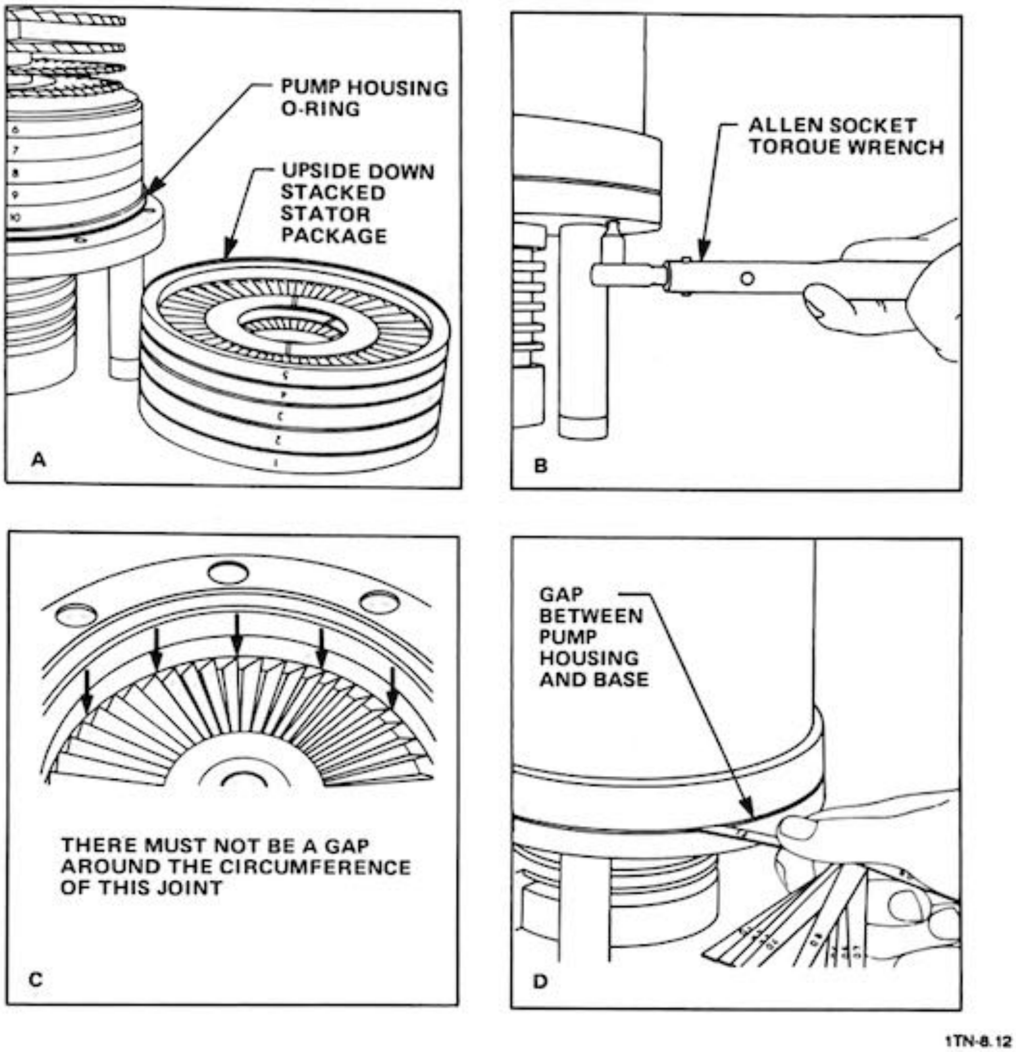


Figure 4-6. Reassembling the Stator Package & Pump Housing

b. Seat the pump housing by uniformly pressing down on the pump's high-vacuum flange.

c. Replace and hand tighten the eight pump housing screws. Using a 5-mm Allen torque wrench, uniformly cross tighten the pump housing screws to 6.6 ft-lb (9 Nm) (see Figure 4-6B). While tightening these screws, ensure that the housing is straight relative to the stator stack. If the gap between the top row of rotor blades and the inside of the top stator ring is larger on one side, straighten the housing so that this gap is uniform (see Figure 4-6C).

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

- Using a feeler gauge, ensure that the gap between the pump base and pump housing is uniform around the circumference of the pump base and that the gap doesn't vary by more than 0.02 inch (0.5 mm) (see Figure 4-6D).
- If the gap varies too much or isn't uniform, loosen the pump housing screws and retighten them again uniformly; then use the feeler gauge to recheck the gap. 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 3b, 3c and 3d.

4. After installing the pump housing, check for smooth running of the rotor by slightly pushing at the rotor hub. There shouldn't be any pinging noises or any perceptible resistance in the rotor bearings.

5. Install the inlet screen into the high-vacuum flange.

Proceed to Section 4.3.6 to reinstall the motor housing.

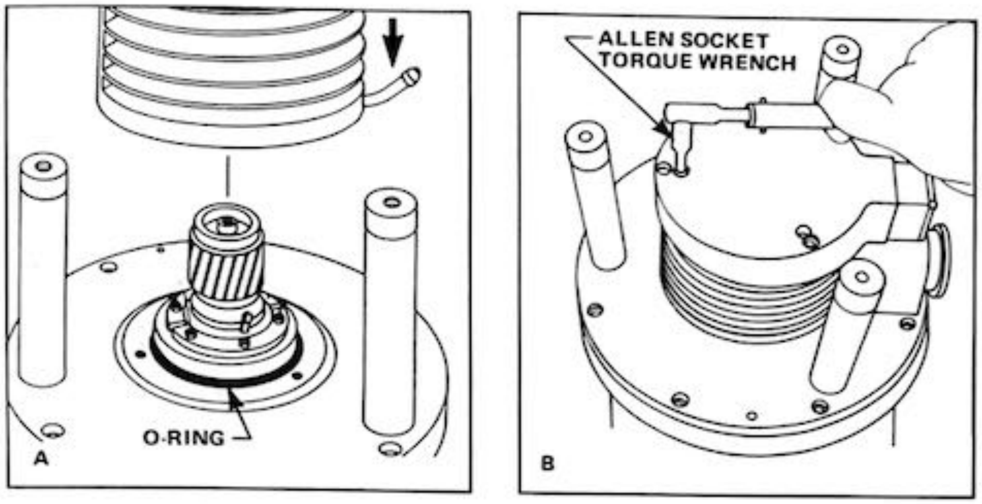


Figure 4-7. Remounting the Motor Housing

4.3.6 *Reinstalling the Motor Housing*

A new motor-housing O-ring (239-50-179) should be installed whenever the motor housing is removed. A new O-ring is supplied with each new rotor/spindle assembly.

1. Place the pump upside down on its intake flange.
2. Apply a thin film of high-vacuum grease to the new motor-housing O-ring and install the O-ring on the pump base (see Figure 4-7A). Ensure that the O-ring isn't twisted.
3. Set the motor housing on the pump base such that the electrical connector is directly above the exhaust port (see Figure 4-7B).
4. Replace and hand tighten the three motor housing screws.
5. Using a 4-mm Allen torque wrench, uniformly tighten the motor housing screws to 4 ft-lb (5.5 Nm) (see Figure 4-7B).

Proceed to Section 4.3.7 to ensure that the pump has been reassembled correctly.

4.3.7 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 the turbopump.

4. Observe that within 5 minutes, the converter should switch from acceleration (ACCEL) to normal operation (NORM). 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 an ULTRATEST 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 blank-flanged turbopump 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.

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

2. Vent the turbopump by removing the blank flange from its venting port. 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.

4.4 NT1000/1500 VH Adjustments

! WARNING — Electrical Shock !

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

This section contains information of how to adjust the following five controls located inside the NT1000/1500 Frequency Converter (See Figure 4-8):

- R71 Pump Cable Length Compensation
- R69 VCO Frequency
- R43 NT-1500 VCO Frequency Trimmer
- R22 Frequency Meter Calibration

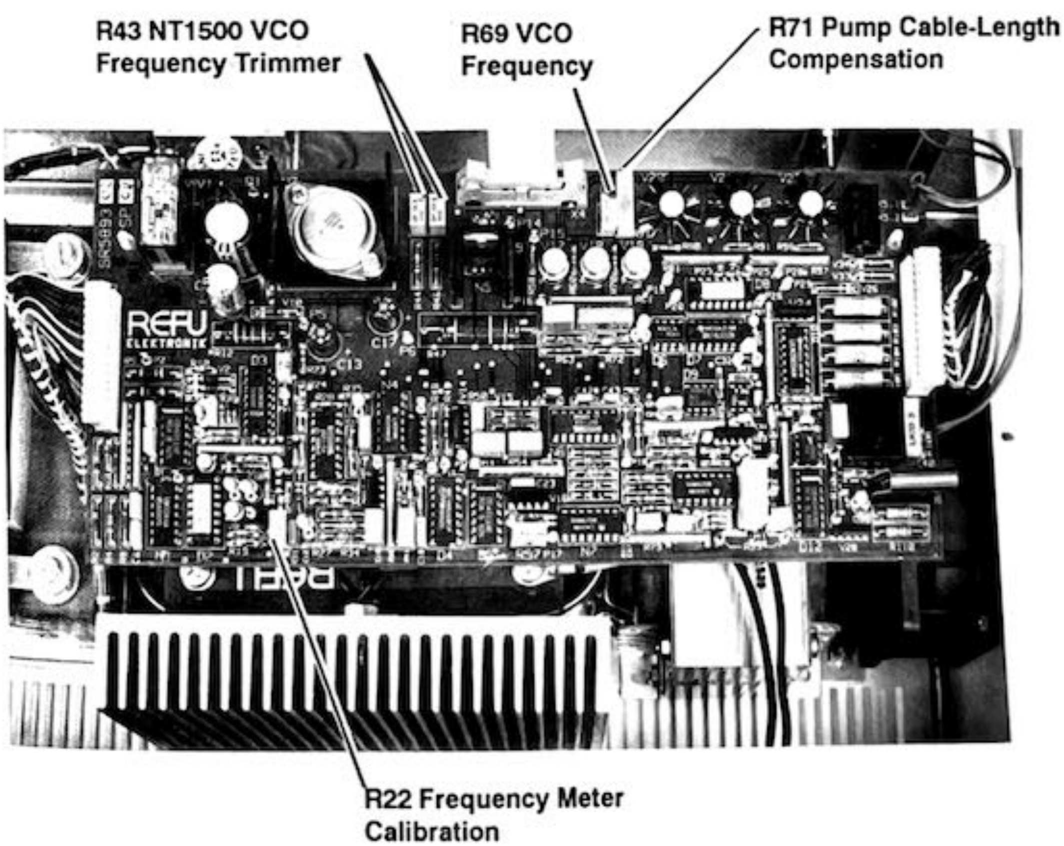


Figure 4-8. NT1000/1500 VH Internal Controls

4.4.1 R71 - Pump Cable Length Compensation Adjustment

Pump Cable Length Compensation control R71 compensates for the voltage drop in the pump cable (voltage at the turbopump will be less than the converter's output voltage).

If this control is misadjusted, the voltage/frequency ratio for start-up at the turbopump will be incorrect. A good indication that this control needs readjustment is when the FAILURE indicator turns ON shortly after the turbopump is started.

To adjust potentiometer R71, proceed as follows:

1. Disconnect the turbopump from the vacuum system.
2. Connect the turbopump to its frequency converter. A backing pump and water cooling connections aren't needed.
3. Using your hand, prevent the turbopump from rotating by blocking its rotor through the high vacuum inlet port; then, press the converter's START pushbutton. In a few seconds after start-up, you should feel the motor torque increasing as the drive frequency decreases.
4. With the rotor blocked, turn potentiometer R71 (see Figure 4-8) counterclockwise (CCW) until the FAILURE indicator turns on; then, turn R71 clockwise (CW) until the FAILURE indicator just turns off.
5. Observe that the FREQUENCY meter should indicate approximately 5% (corresponds to a start-up frequency of between 15 to 20 Hz for the TMP1000).
6. Press STOP.
7. This completes the pump cable length compensation adjustment procedure.

4.4.2 R69 VCO Frequency Adjustment and R43 NT1500 VCO Frequency Trimmer Adjustment

The VCO Frequency control, R69, and the NT1500 VCO Frequency Trimmer control, R43, are adjusted to produce maximum converter output frequencies of 595 Hz for the TMP1000 and 355 Hz for the TMP1500. Adjustment of a third potentiometer (R45) isn't described in this manual since it's included in the converter for a potential future use.

Proceed as follows to adjust R69 and R43:

1. Connect a frequency counter to the rear of the converter at terminals X1-7 and -8 as described in Section 2.2.4.5.

2. Disconnect the turbopump from the converter and connect a jumper to converter output connector terminals X0-4b and -5b, located at the converter's rear panel (this jumper simulates the connection of a TMP1000). Also connect a jumper to terminals X0-5a and -5b (this jumper closes the overtemperature circuit).

3. With power applied to the converter and with the pump stopped, the frequency counter should indicate 595 +10 Hz. Remove the jumper connected at terminals X0-4b and -5b (leave X0-5a and -5b connected) and observe that the frequency counter should now indicate 355 +5 Hz. If either frequency indication was out of tolerance, perform steps 4 and 5; otherwise, proceed to step 6.

4. Reconnect the jumper to terminals X0-4b and -5b, then adjust potentiometer R69 (see Figure 4-8) for a frequency counter indication of 595 Hz.

5. Remove the jumper connected in step 4 and adjust potentiometer R43 (see Figure 4-8) for a frequency counter indication of 355 Hz.

6. This completes the VCO frequency and NT1500 VCO frequency trimmer adjustment procedure.

NOTE: Adjusting R45 has no effect since it's the frequency adjustment for the oil-lubricated TMP1000 VH pump model which was never sold in the U.S.A.

4.4.3 R22 - Frequency Meter Calibration

Frequency Meter Calibration control R22 is adjusted to make the FREQUENCY meter indicate 100% when the turbopump is running at its rated rotational speed. To adjust this control, proceed as follows:

1. Connect a frequency counter to the rear of the converter at terminals X1-7 and -8 as described in Section 2.2.4.5.

2. Start the pumping system and allow the turbopump to reach its rated rotational speed. Observe that the frequency counter should indicate 595 +10 Hz for the TMP1000 (355 +5 Hz for the TMP-1500).

3. The front panel FREQUENCY meter should now be indicating 100%. If not, perform step 4; otherwise, proceed to step 5.

4. With the turbopump operating at its rated rotational speed, adjust potentiometer R22 (See Figure 4-8) for a FREQUENCY meter indication of 100%.

5. This completes the frequency meter calibration procedure.

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.
- See Section 4.3.7 for tests that you can perform if the pumping speed or ultimate pressure of your turbopump is deteriorating.
- See Section 7 for the parts lists for the turbopump and frequency converter, and for the converter's electrical schematic.

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.

CAUTION: Don't remove the rotor/spindle assembly unless you have the training and equipment to dynamic balance it after reassembly. A vibration velocity of >0.15 mm/second results in premature bearing failure.

5.1 Checklist of Simple Problems

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 4.3.7 for test that you can perform if the pumping speed or ultimate pressure of your turbopump is deteriorating..

☐ 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 setting 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).
- Ensure that the cooling-water temperature doesn't exceed 75°F (25°C), that the cooling water flow is at least 3 gal/hr (30 l/hr), 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's 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.
- If the turbopump is air cooled, ensure that the ambient temperature doesn't exceed 95°F (35°C) when it is being baked out and doesn't exceed 113°F (45°C) when it is continuously operating below 10^{-4} mbar.

- ☐ Is the vacuum system leak tight?
- ☐ Is your vacuum gauge operating properly?
- ☐ Is the backing pump adequate?

  The backing pressure should be lower than 1×10^{-1} mbar. A backing pump pressure of about 1×10^{-3} mbar is required to attain the turbopump's ultimate pressure. If you are purging the turbopump, have a high gas load, or have poor conductance in the foreline, a larger capacity backing pump is required.
- ☐ 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 when the converter is plugged into an AC outlet.	a. AC power	Converter isn't receiving AC power.	Check for presence of voltage at AC outlet	
		Fuse F1 is blown.	Refer to Symptom 11.	Figure 7-3
	b. POWER indicator	POWER LED burned out.	Check for +24 V at POWER LED. If +24 V is present, replace the LED.	Figures 7-3 and 7-6
	c. Power Supply	Power transformer is defective.	Check for secondary voltages at transformer T1. If no secondary voltages are present, replace T1.	Figs. 7-3 & 7-6 Section 6.4.1
		Low voltage power supply on A1 board is defective.	Check for +24 V on A1 board at test point P1. If no voltage is present, replace A1 board.	Figs. 7-3 & 7-6 Section 6.4.1
2. ACCELERATION indicator doesn't light after pressing START.	a. Rear panel connections	External start bypass jumper isn't installed.	Connect a jumper to terminals X1-2 and -3 when external start switch isn't used.	Figs. 2-2 & 7-6 Sec. 2.2.4.1 Sec. 2.2.4.3
	b. Optional water-flow switch	Insufficient water flow through pump has caused the optional water-flow switch to open and prevent the converter from starting.	Ensure that the cooling-water supply is turned on. Check for clogged water lines and clean if necessary.	Sec. 2.2.4.1
		Water-flow switch is misadjusted.	Adjust water-flow switch for a minimum flow rate of 0.13 gal/min (0.5 ltr/min).	Section 2.3.8
		Water-flow switch is defective.	Replace water-flow switch.	
	c.ACCELERATION indicator	ACCELERATION LED is burned out.	Check for +24 V at ACCELERATION LED. If +24 V is present, replace LED.	Figures 7-3 and 7-6
	d. Front panel START switch	START switch is defective.	Jumper external start terminals X1-1 and -2. If ACCELERATION indicator turns on, replace front panel START switch.	Figs. 7-3 & 7-6 Sec. 2.2.4.3 Section 6.4.2
	e. A1 Control & Regulator Board	START/STOP or Status and Control circuit is defective.	Replace A1 board.	Figs. 7-3 & 7-6 Section 6.4.2 Section 6.4.4

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
3. FAILURE indicator lights immediately after pressing START.	a. Electrical connections	Pump cable isn't plugged in or is improperly mated.	Ensure that pump cable connectors are mated properly with converter and pump connectors.	Section 2.2.6
		Pump cable is defective.	Check for broken wires in the pump cable. Repair or replace cable if necessary.	
	b. Pump overtemperature switch	Pump motor is too hot causing its overtemperature switch to be open.	Allow pump to cool and try to restart. Ensure that the pump is being cooled by the cooling-water flow or by the air cooling unit.	Section 2.3.4
		Overtemperature switch or pump cable is defective.	Disconnect the pump cable and jumper thermal switch connections at output connector XO-5a and -5b, then restart pump. If NORMAL OPERATION indicator lights after about 2 seconds, check for broken wires in pump cable or replace overtemperature switch.	Figures 7-2, 7-3, and 7-6
	c. A1 Control & Regulator Board	Pump Cable Length Compensation control is misadjusted.	Adjust potentiometer R71 as described in Section 4.4.1.	Figs. 4-8 & 7-6 Section 4.4.1 Section 6.4.9
		One of the circuits that apply a signal to the Failure Detector circuit is defective.	Replace A1 board.	Figures 7-3 and 7-6 Section 6.4.11
	d. A2 Six -Step Inverter Board	Fuse F2 is blown	Refer to Symptom 12.	Figure 7-5
		Short circuit on the A2 board	Disconnect pump cable and unplug converter. An ohmmeter with its positive lead connected to the chassis and its negative lead connected to the emitters of V5/V6, V9/V10, and V13/V14 should show infinite resistance. A resistance of about 5.6 K ohms should be measured at emitters of V7/V8, V11/V12, and V15/V16. If the ohmmeter indicates a much lower resistance, replace the A2 board.	Figures 7-3, 7-5, and 7-6.

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
4. Converter switches from ACCELERATION to FAILURE within 15 minutes after pressing START.	a. Pump	Pump didn't start.	Refer to Symptom 13.	
	b. DC Link Power Supply	SCR heatsink became too hot before pump achieved at least one third of its rated rotational speed.	Allow converter to cool and then try to restart pump. Ensure that there is sufficient air circulation around converter.	Section 2.2.2
	c. Converter output	Short circuit at converter output.	Disconnect pump cable and jumper thermal switch connections at output connector XO-5a and -5b, then restart converter. If the NORMAL OPERATION indicator lights after about 2 seconds, check for a short circuit in the pump cable.	Figure 7-6 Section 6.4.10
	d. A1 - Control & Regulator Board	Pump Cable Length Compensation control misadjusted.	Adjust potentiometer R71 as described in Section 4.4.1.	Figures 4-8 and 7-6 Section 4.4.1 Section 6.4.9
		One of the circuits that apply a signal to the Failure Detector circuit is defective.	Replace A1 board.	Figures 7-3 & 7-6 Section 6.4.11
5. Converter switches from ACCELERATION to NORMAL OPERATION before the pump reaches the desired operating speed.	a. Pump	Acceleration time period of 15 minutes has expired.	Refer to Symptom 14.	
	b. DC Link Power Supply	SCR heatsink became too hot.	Pump will continue to accelerate but at reduced torque. Ensure that there is sufficient air circulation around converter.	Section 2.2..2 Section 6.4.4
	c. A1 Control & Regulator Board	One of the circuits that control the operation of the NORMAL OPERATION indicator is defective.	Replace A1 board.	Figure 7-6 Section 6.4.3 Section 6.4.4 Section 6.4.13

Trouble-Shooting

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
6. Maximum drive frequency 355 Hz instead of 595 Hz.	a. Pump cable	Wrong cable installed.	Install 7-conductor cable marked at both ends with heat-shrink tubing.	Section 2.2.6
	b. A1 - Control & Regulator Board	Pump Select or VCO circuit defective.	Replace A1 board.	Figures 7-3 and 7-6 Section 6.4.9
7. NORMAL OPERATION indicator doesn't light when pump achieves desired operating speed.	a. NORMAL OPERATION indicator	NORMAL OPERATION LED burned out.	Check for +24 V at NORMAL OPERATION LED. If +24 V is present, replace LED.	Figures 7-3 and 7-6
	b. A1 - Control & Regulator Board	Acceleration Timer, Status and Control, or Voltage and Current Limiter circuit defective.	Replace A1 board	Figures 7-3 and 7-6 Section 6.4.3 Section 6.4.4
8. Converter never switches from ACCELERATION to NORMAL OPERATION.	a. A1 - Control & Regulator Board	Status and Control or Acceleration Timer circuit defective.	Replace A1 board.	Figures 7-3 and 7-6 Section 6.4.3 Section 6.4.4

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
9. FAILURE indicator lights after pump has been operating normally.	a. Pump	Pump became too hot, causing its overtemperature switch to open.	Check for clogged water lines, clogged water filter, low water pressure, or defective air cooling unit. Ensure that water temperature doesn't exceed 77°F (25°C) or ambient air temperature doesn't exceed 113°F (45°C).	Section 2.3.4
	b. Converter	Converter failure.	Disconnect pump cable and jumper thermal switch connections at output connector XO-5a and -5b, then restart converter. In about 2 seconds, the NORMAL OPERATION indicator should light. Output voltage should measure about 42 V AC between any pair of output terminals (XO-1, -2, -3). The DC Link Power Supply output across capacitors C4/C5 should measure about 56 V DC. If any of the above conditions aren't met, replace converter's A1 and/or A2 board, or troubleshoot DC Link Power Supply.	Figure 7-3 and 7-6
10 Converter turns itself off without FAILURE indicator turning on.	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, clogged water filter, or low water pressure.	Section 2.3.4.1
		Water-flow switch misadjusted.	Adjust water flow switch for a minimum flow rate of 0.13 gal/min (0.5 ltr/min).	Section 2.3.5
		Water-flow switch defective.	Replace water-flow switch.	
	b. FAILURE indicator	FAILURE LED burned out.	Simulate a failure by disconnecting pump cable. Check for +24 V at FAILURE LED. If +24 V is present, replace LED.	Figure 7-6

Trouble-Shooting

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
11 Fuse F1 is blown.	a. DC Link Power Supply	Short circuit in power supply.	Isolate the DC Link Power Supply by removing output connections X5 + and X5 -. Also remove A1 board connector X2. If F1 blows again, troubleshoot for defective part in power supply.	Figures 7-3 and 7-6.
	b. A2 — Six-Step Inverter Board	Short circuit on A2 board.	Disconnect pump cable and unplug converter. An ohmmeter with its positive lead connected to the chassis and its negative lead connected to the emitters of V5/V6, V9/V10, and V13/V14 should show infinite resistance. A resistance of about 5.6 K ohms should be measured at emitters of V7/V8, V11/V12, and V15/V16. If the ohmmeter indicates a much lower resistance, replace the A2 board.	Figures 7-3 and 7-6 Section 6.4.7
	c. A1 — Control and Regulator Board	Short circuit in the Low Voltage Power Supply.	After determining there are no short circuits in the DC Link Power Supply and on the A2 board, remove connector X2 from the A1 board and reapply power. If F1 doesn't blow, replace the A1 board.	Figures 7-3 and 7-6 Section 6.4.1
	d. Optional external hours meter	Hours meter failure.	Replace meter.	Figures 2-2 and 7-6 Sec. 2.2.4.6

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
12 Fuse F2 is blown.	a. Converter output.	Short circuit at converter output.	Disconnect pump cable and jumper thermal-switch connections at output connector XO-5a and -5b, then restart converter. If the NORMAL OPERATION indicator lights after about 2 seconds, check for a short circuit in the pump motor or pump cable.	Figure 7-6 Section 6.4.10
	b. A2 — Six-Step Inverter Board	Short circuit on the A2 board.	Disconnect pump cable and unplug converter. An ohmmeter with its positive lead connected to the chassis and its negative lead connected to the emitters of V5/V6, V9/V10, and V13/V14 should show infinite resistance. A resistance of about 5.6 k ohms should be measured at emitters of V7/V8, V11/V12, and V15/V16. If the ohmmeter indicates a much lower resistance, replace the A2 board.	Figures 7-3 and 7-6 Section 6.4.7
	c. A1 — Control and Regulator Board	The Short Circuit Protection circuit isn't turning off the Three-Phase Logic circuit when there is a short circuit at the converter's output.	Replace A1 board.	Figures 7-3 and 7-6 Section 6.4.10
13 Pump doesn't start.	a. Converter	No output voltage from converter.	Refer to Symptoms 1, 2, & 3.	
	b. Pump	Pump rotor can't turn due to an obstruction in the rotor blades or motor bearing failure.	Remove pump from system. Turn pump rotor by hand and check for smooth running. If any resistance is felt, disassemble pump as described in Section 4.3 and determine cause of obstruction. Contact Leybold Service to have new rotor/spindle installed if necessary.	Section 4.3
		Motor stator defective.	Using an Ohmmeter, check the stator's inter-phase resistance at pump connector terminals 6+7, 7+8, and 6+8. The resistance measured between any two phases should be 0.62 ±0.05 ohm. Replace stator, if necessary.	Figure 4-5 Section 4.3.3

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
14 Pump doesn't attain desired rotational speed after 15 minutes of acceleration.	a. Fore-vacuum side	Fore-vacuum pressure is $> 10^{-2}$ mbar.	Check operation of backing pump as described in its manual. A larger pump may be necessary.	Section 2.3.3
			Ensure venting port is closed.	Section 2.3.6
			Ensure conductance of foreline is adequate.	
			Leak test fore-vacuum line and repair any leaks found.	
			Ensure pump electrical connector screws are tight.	
	b. High-vacuum side	Vacuum chamber too large.	Pump down chamber with backing pump to at least 5×10^{-1} mbar before turning ON turbopump.	Section 3.3
		Leakage in chamber.	Leak test vacuum system and repair any leaks.	
	c. Pump cable	Cable voltage drop too large.	When cable is longer than 250 ft. (76 m), a larger diameter cable is required to reduce the voltage drop. Contact Leybold for correct pump cable required.	
	d. Converter	Maximum drive frequency 355 Hz instead of 595 Hz.	Refer to Symptom 6.	
		Pump Cable Length Compensation control misadjusted.	Adjust potentiometer R71 as described in Section 4.4.1.	Figures 4-8 and 7-6 Section 4.4.1 Section 6.4.9
	e. Pump	Pump motor is rotating in the wrong direction.	Check pump motor rotation as described in Section 2.2.7.	Section 2.2.7
		Motor bearing friction is too high.	Remove pump from system. Turn rotor by hand and check for smooth running. If rotor turns stiffly, contact Leybold to have rotor/spindle assembly replaced.	Section 4.3

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
15 Pump rotational speed drops from desired level.	a. High-vacuum side	Leakage in chamber is causing intake pressure to exceed 10^{-2} mbar.	Leak test vacuum system and repair any leaks.	
	b. Exhaust port	Fore-vacuum pressure is too high.	Check backing pump as described in its manual.	Section 2.3.3
			Ensure conductance of fore-vacuum line is adequate.	
			Ensure venting port is closed.	Section 2.3.6
			Ensure pump electrical connector screws are tight.	
			Leak test fore-vacuum line and repair any leaks.	
	c. Converter	Low output voltage.	Disconnect pump cable and jumper thermal switch connections at output connector XO-5a and -5b, then restart converter. In abut 2 seconds the NORMAL OPERATION indicator should light. Output voltage should measure abut 42 V AC between any pair of output terminals (XO-1, -2, -3). The DC Link Power Supply output across capacitors C4/C5 should measure about 56 V DC. If any of the above conditions aren't met, replace the converter's A1 and/or A2 board, or troubleshoot DC Link Power Supply.	Figure 7-6
	d. Pump	Motor bearing friction is too high.	Remove pump from system. Turn rotor by hand and check for smooth running. If rotor turns stiffly, contact Leybold service to have rotor/spindle assembly replaced.	Section 4.3
		Motor stator failure.	Using an ohmmeter, check the stator's inter-phase resistance at pump connector terminals 6+7, 7+8, and 6+8. The resistance measured between any two phases should be 0.62 ±0.05 ohm. Replace stator if necessary.	Figure 4-5 Section 4.3.3

Trouble-Shooting

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
16 FREQUENCY meter doesn't indicate 100% during normal operation.	a. A1 — Control and Regulator Board	Frequency meter calibration control misadjusted.	Adjust potentiometer R22 as described in Section 4.4.3.	Figure 4-8 Section 4.4.3 Section 6.4.9
		VCO frequency control(s) misadjusted.	Adjust potentiometer R69 & R43 as described in Section 4.4.2.	Section 4.4.2 Section 6.4.9
	b. Pump	Pump isn't running at its full rotational speed.	Refer to Symptom 15.	
17 Pump 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 intake and exhaust ports.	Appendix A.7 Section 2.3.2 Section 2.3.3
	b. Pump	Motor bearings failure or rotor has become unbalanced.	Remove pump from system. Turn rotor by hand and check for smooth running. If the rotor turns stiffly, is noisy, or turns irregularly, contact Leybold Service to have rotor replaced.	Section 4.3
		Pinging noise	See Symptom 23.	

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
18 Pump is contaminated with oil.	a. Fore-vacuum valve.	Oil backstreamed from backing pump into turbopump due to failure of the fore-vacuum valve or anti-suckback valve.	Check that fore-vacuum valve or backing pump's anti-suckback valve automatically closes when backing pump is shutdown. Repair or replace as necessary.	Section 2.3.3
	b. Venting system	Turbopump isn't being properly vented during shutdown.	Ensure venting valve opens during shutdown. Repair or replace as necessary.	Section 2.3.6
			Check if metal filter or nozzle in venting port is clogged. Clean or replace if necessary.	
	c. Foreline pressure.	Oil can backstream from the backing pump into the turbopump when the foreline pressure is below 1×10^{-3} mbar.	Install a separate roughing line to rough the vacuum chamber.	
			Add an adsorption trap between the backing pump and turbopump. Ensure that the adsorbent isn't saturated with oil or water.	Appendix A.6
			Install a nitrogen purge in the foreline.	
19 Pump fore-vacuum pressure is too high ($>10^{-2}$ mbar)	a. Vacuum gauge	Vacuum gauge failure.	Ensure that the vacuum gauge is operating correctly before assuming a problem exists in the pumps.	
	b. Backing pump	Backing pump is malfunctioning or is too small	Check operation of backing pump as described in its manual. A larger pump may be necessary.	Section 2.3.3
	c. Venting system	Venting valve is open.	Ensure venting valve closes when the turbopump is switched on. Repair or replace if necessary.	Section 2.3.6
		Venting valve is leaky.	Leak check the venting valve. Repair or replace if necessary.	
	d. Fore-vacuum space	Leak in fore-vacuum line.	Leak test components in fore-vacuum line and repair any leaks.	
	e. Pump	Leak around pump housing or electrical connector	Leak test turbopump and repair any leaks.	Section 4.3.7

Trouble-Shooting

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
19 Pump fore-vacuum pressure is too high (>10^{-2} mbar) continued	f. Fore-vacuum line.	Line is too long.	Use shorter line between backing pump and turbopump.	
		Conductance of line is inadequate.	Check for restrictions in line. Ensure that inside diameter of line is adequate.	
20 Pumping speed is insufficient.	a. Fore-vacuum space	Fore-vacuum pressure is too high.	When pumping out lange chambers, the fore-vacuum pressure should be at least 5×10^{-1} mbar before turning on the turbopump.	Section 3.3
			Refer to Symptom 19.	
	b. Pump	The pump is contaminated.	Clean the pump as described in Section 4.2	Section 4.2
		Wire mesh splinter guard located at inlet port is clogged.	Remove pump from system and clean splinter guard.	Figure 7-1
		The pump is leaky.	Leak check the turbopump and repair any leaks.	Section 4.3.7.
		Pump isn't assembled correctly.	Perform turbopump run-up test as described in Section 4.3.7. If necessary, disassemble an then reassemble pump as described in Section 4.3.	Section 4.3 Section 4.3.7
	c. Cable	Older 6-conductor unmarked cable is being used resulting in TMP1000 running at slower rotational speed of the TMP1500 (21,000 rpm).	Use the 7-conductor cable that is marked at both ends by heat-shrink tubing.	

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
21 Pump doesn't attain desired ultimate pressure.	a. Vacuum gauge	Vacuum gauge is inaccurate.	Ensure that the vacuum gauge is operating correctly and is accurate in the high/ultra-high vacuum range before assuming a problem exists in pumping system.	
	b. Vacuum system	Vacuum system is dirty or outgassing is causing pressure to rise at about 10^{-5} mbar.	Clean and/or bake out vacuum system.	Section 3.8 Section 4.2
	c. Fore-vacuum space	Fore-vacuum pressure is too high (>10^{-2} mbar)	Refer to Symptom 19.	
	d. Pump	Vacuum leak	Leak check turbopump and repair any leaks.	Section 4.3.7
		High vacuum space is contaminated.	Clean pump as described in Section 4.2.	Section 4.2
		Pump isn't assembled correctly.	Perform turbopump run-up test as described in Section 4.3.7. If necessary, disassemble and then reassemble pump as described in Section 4.3.	Section 4.3 Section 4.3.7
22 Pump housing temperature exceeds 131°F (55°C) during continuous operation.	a. Cooling	Insufficient cooling water or air flow.	Check for clogged water lines, clogged water filter, low water pressure, or defective air cooling unit. Ensure the cooling water temperature doesn't exceed 77°F (25°C) or ambient air temperature doesn't exceed 113°F (45°C).	Section 2.3.4
	b. Operating pressure	Operating pressure is >10^{-1} mbar.	Leak test vacuum system and repair any leaks.	
	c. Strong magnetic field	Magnetic induction measured at the surface of the pump housing is > 50 gauss [5 mT (millitesla)] in a radial field or 150 gauss (15 mT) in an axial field.	Move pump out of the magnetic field or install suitable magnetic shielding.	

Table 5-A — Troubleshooting Chart

Symptoms	Trouble Area	Probable Cause	Recommended Corrective Action	References
23 Pump emits pinging noises during venting.	Rotor blades	Rotor blade is bent.	Disassemble pump and check if a single rotor blade is bent. If so, bend it into alignment with the other blades.	Section 4.3
		Stator disk haves are overlapped.	Assemble stator disks correctly.	Section 4.3.5
		Rotor is misaligned.	Contact Leybold Service to have rotor aligned and balanced correctly.	Section 4.3.4
24 ACCELERATION LED remains lit after the pump has run up and changed to NORMAL OPERATION.	Converter.	Your converter has the un-modified A1 board.	This incorrect indication doesn't affect the functioning of the converter or turbopump. However, if you want to have it corrected, send the converter to one of our service centers for modifications per "information service 05 15".	

Contents

6.1 TMP1000 Turbomolecular Pumps

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 and 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 below 10^{-8} mbar, the backing pressure must be at least 1×10^{-3} mbar, and the vacuum chamber and the turbopump must be baked out. Refer to Section 3.8 for information on bakeout.

The TURBOVAC pump consists of a multi-stage rotor/stator assembly and a drive assembly (see Figure 6-1). 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 6-1).

The rotor is made of aluminum and is dynamically balanced to produce a total vibration velocity of not more than 0.15 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 6-1). The motor is normally water cooled; however, an air cooling option is also available (see Appendix A.8).

A bi-metal thermal switch shuts down the pump if the temperature near the motor coil exceeds 133°F (56°C). This switch opens and causes the 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 TMP1000 turbopumps have a vent and a purge port (see Figure 6-1). The vent port is the upper 10KF port in the side of the pump housing; the purge port is the lower 10KF port on the pump's base housing. It is important to vent turbopumps during shutdown to prevent oil vapors from backstreaming from the backing pump into the high vacuum portion of the turbopump and to prevent the bearing from being damaged by a rotor spinning at low speeds for long periods.

For standard application, seal the purge port and vent the pump through the vent port.

However, if the pump is exposed to corrosive or aggressive process gases or gases that contain or abrasives or metallic dust, venting through the vent port would result in harmful process gases entering the bearing cavity and causing damage. 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 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 24 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.5).

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.

1. HIGH-VACUUM INTAKE PORT
2. WIRE-MESH SPLINTER GUARD
3. STATOR PACKAGE
4. ROTOR
5. VENTING PORT
6. SPINDLE ASSEMBLY WITH BALL BEARINGS
7. WATER COOLING
7a. HOSE NOZZLE
8. FOREVACUUM PORT
9. THREE-PHASE MOTOR
10. PURGE GAS AND VENTING PORT

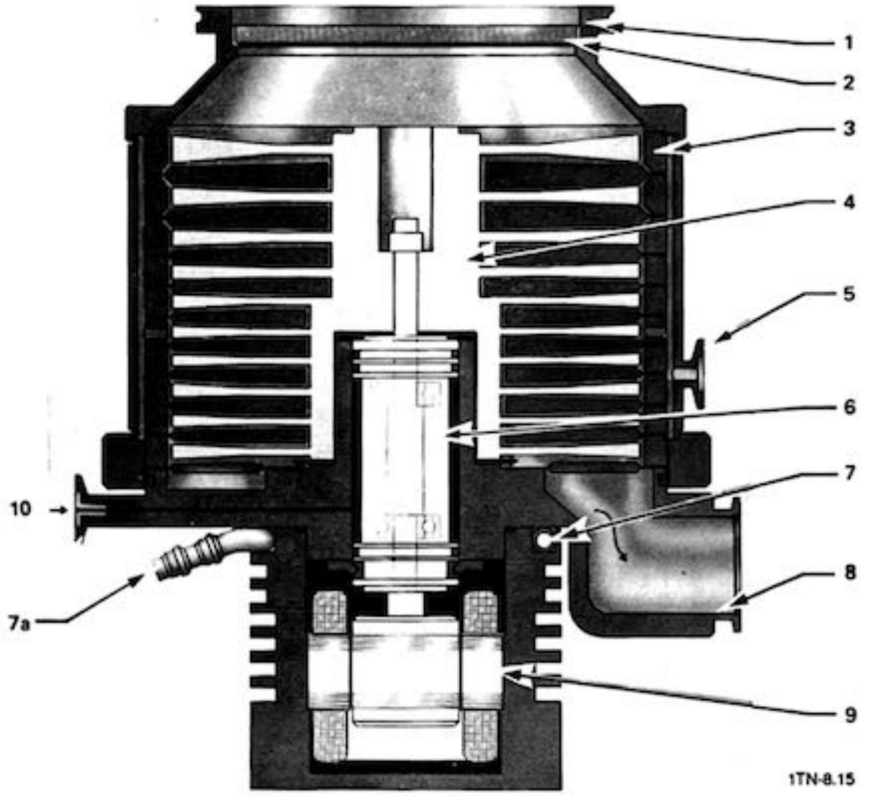


Figure 6-1. TMP1000 Cutaway View

6.2 *Functional Description of the Frequency Converter*

The primary function of the NT1000/1500 VH Frequency Converter is to convert single-phase, 50/60 Hz power into three-phase, high-frequency power as required by the three-phase induction motors of the TMP1000, TMP600, and the TMP1500 Turbomolecular Pumps. Besides its primary function of frequency conversion, the converter also contains circuits that vary the pump motor's drive frequency and drive voltage to operate the pump at maximum efficiency. The NT1000/1500 VH Frequency Converter is designed to function in the following manner.

Induction motors require that their drive frequency be closely related to their rotational speed. To achieve maximum rotational speed, the TMP1000 and TMP600 require a drive frequency of 595 Hz; the TMP1500 requires a drive frequency of 355 Hz. The first function of the frequency converter, therefore, is to generate the high-drive frequency required to drive the pump at its rated rotational speed.

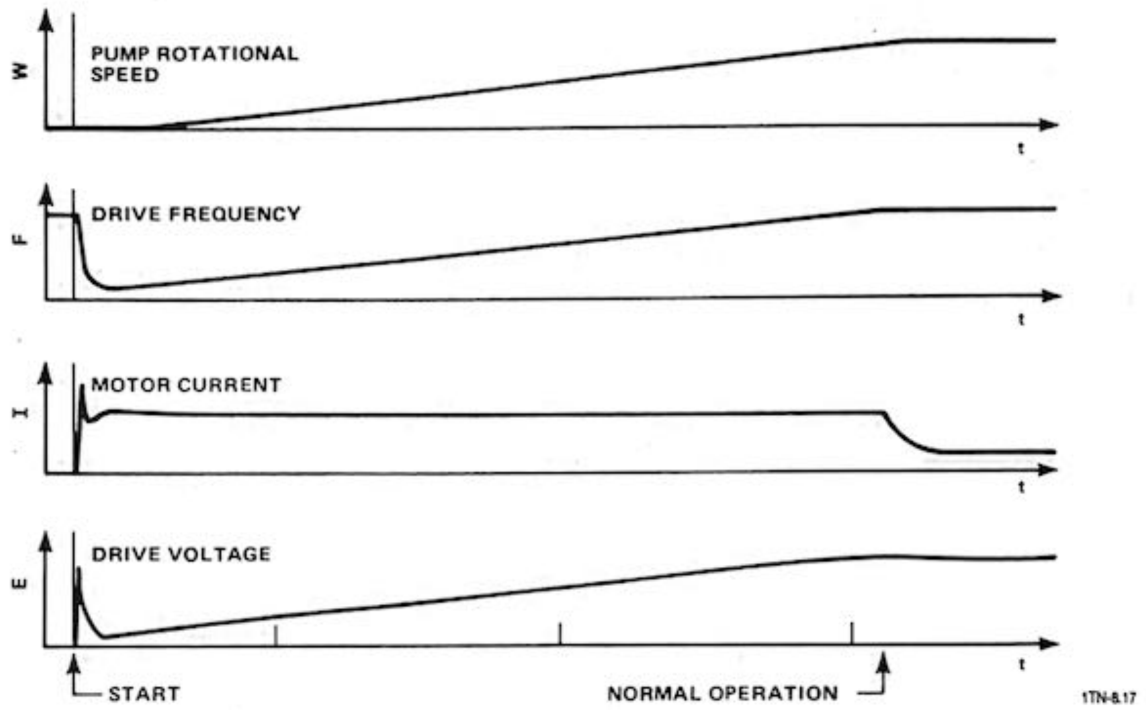


Figure 6-2. Typical Turbopump Start-Up Profile

To achieve minimum pump-acceleration time, the pump motor should be operated at maximum torque. Torque is a function of the motor's "slip" frequency, which is defined as the difference between the motor's drive frequency and its 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. Consequently, the second function of the frequency converter is to start the pump from rest with a low-drive frequency, and then slowly increase the drive frequency during start-up to keep the pump operating at maximum torque during acceleration.

Induction motors also require that their drive voltage be proportional to, and closely related to, their drive frequency. A drive voltage that is too high or too low with respect to the drive frequency results in reduced torque, and increased motor heating. Therefore, a third function of the frequency converter is to maintain the proper relationship between drive voltage and drive frequency referred to as the pump's hertz-per-volt ratio.

The torque required to accelerate the pump is generally higher than the torque required to maintain the pump's normal operating speed. Thus, the fourth and final function of the frequency converter is to lower the pump motor's operating current level once the pump achieves normal operating speed. The lower current level during normal operation results in lower operating temperatures.

To aid in the understanding of the frequency converter's operating principles, a typical start-up profile of a turbomolecular pump is shown in Figure 6-2. This figure illustrates the relationship between rotational speed, drive frequency, motor current, and drive voltage of a turbomolecular pump as it accelerates from rest.

6.3 NT1000/1500 VH Block Diagram

A block diagram of the NT1000/1500 VH Frequency Converter is shown in Figure 6-3. Figure 7-6 is the electrical schematic of the converter.

The NT1000/1500 VH frequency converter can be used to drive the TMP1000, TMP600, or TMP1500 turbomolecular pumps. It also has the capacity to drive an oil-lubricated TMP1000 VH; however, these circuits and adjustments aren't described in this manual since we aren't currently selling the oil-lubricated TMP1000 VH.

The converter uses the variable-frequency, variable-voltage technique to control the induction motor 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 motor's rotor. Synchronous speed is related to the motor's drive frequency while slip is proportional to the load or torque demand on the motor.

The frequency converter uses the DC link method to convert the 110–240 VAC, 50/60 Hz power line into a variable-frequency, variable-voltage controlled three-phase AC power source. The DC link method converts AC into a variable DC voltage, and then inverts the DC voltage between the converter's three output lines in a sequence that synthesizes a three-phase AC output voltage. This type of converter is called a DC-Link converter because of the DC link between the input and output of the power inverter.

The turbopump is started by pressing the converter's START button. When START is pressed, the Start/Stop circuit removes an inhibit signal from the SCR Triggering circuit which, in turn, allows the SCR Bridge Rectifier to begin converting AC to DC. The level of the resultant DC voltage (hereafter called E_{LINK}) is varied by controlling the ratio of each SCR's "on-time" to its "off-time" during each rectified AC half cycle. The SCRs are turned ON by the application of a positive trigger pulse to their gate inputs from the SCR Triggering circuit. The timing of these trigger pulses is controlled by a DC control voltage produced by the Voltage and Current Limiters.

E_{LINK} is applied to the converter's three output lines by the Six-Step Inverter in a manner that synthesizes a three-phase AC output voltage. The sequence, polarity, and speed by which the transistors of the Six-Step Inverter switch E_{LINK} onto the converter's output lines is determined by turn-on pulses from the Three-Phase Logic circuit. The frequency of the turn-on pulses is determined by the VCO (Voltage Controlled Oscillator) circuit.

The drive frequency of the converter is made proportional to E_{LINK} by having E_{LINK} control the VCO circuit; thereby, maintaining the optimum hertz-per-volt ratio required to run the pump's induction motor at maximum torque.

The VCO frequency is displayed on the front panel FREQUENCY meter as a percentage of the pump's maximum drive frequency (100% corresponds to maximum pump speed).

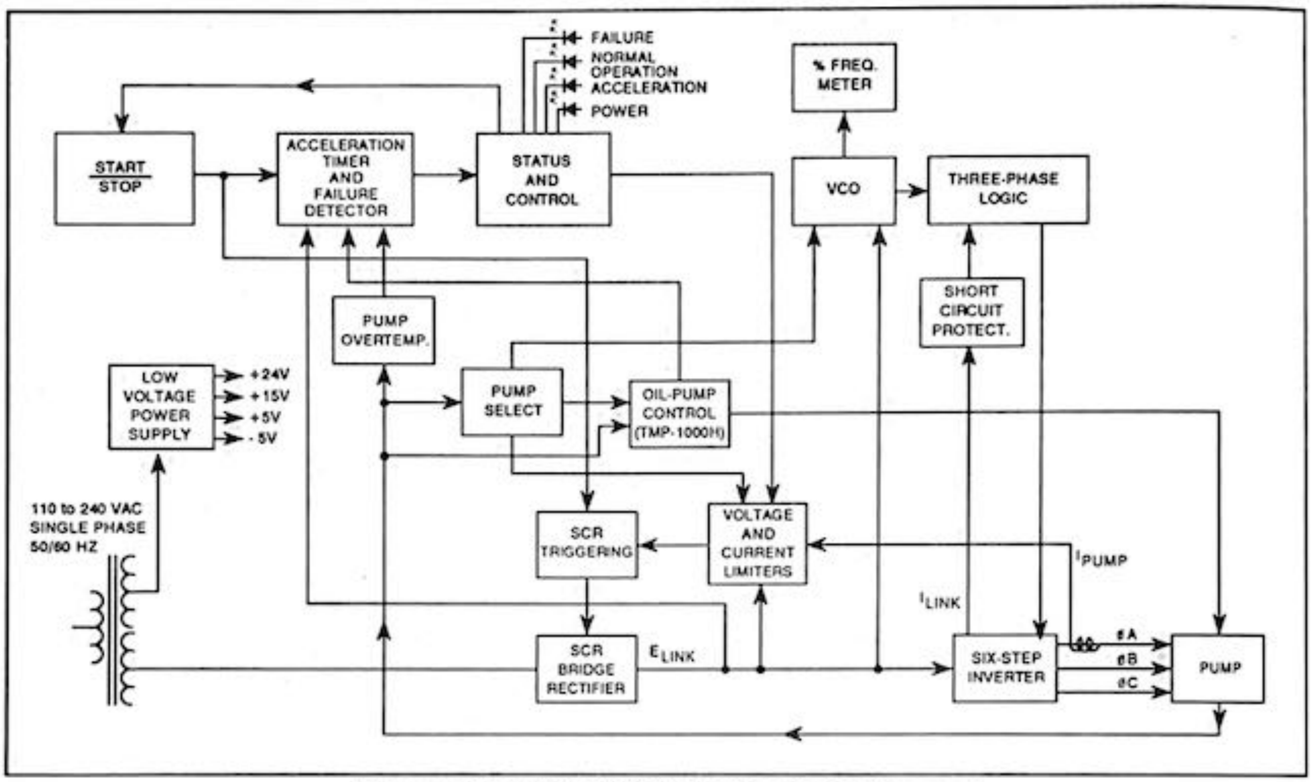


Figure 6-3. NT1000/1500 VH Block Diagram

ELINK is regulated by the Voltage and Current Limiters so as to keep the converter in either voltage or current limiting. When the pump is started from rest, the converter immediately goes into current limiting (due to the motor's low rotor impedance) and applies a very low drive voltage to the motor. As the pump accelerates, its motor current (IPUMP) starts to drop because of the motor's back emf; however, the converter senses this drop IPUMP and increases ELINK by an amount necessary to keep itself in current limiting. Once ELINK reaches a preset maximum level (corresponds to maximum pump speed), the converter goes into voltage limiting and allows IPUMP to decrease and seek its normal operating level (dependent upon pump loading).

When the pump is started, the Start/Stop circuit also starts an Acceleration Timer circuit which, in turn, causes the Status and Control circuit to light the ACCELERATION indicator. As the pump accelerates, the Voltage and Current Limiter circuit allows the pump motor to operate for 15 minutes at a 30%-higher current level than is normally permissible; thereby, reducing the pump's acceleration time. But, as soon as the pump reaches it maximum rotational speed (as indicated by the level of ELINK applied to the Acceleration Timer circuit) during the allotted acceleration-time period, the Status and Control circuit turns off the ACCELERATION indicator, turns ON the NORMAL OPERATION indicator, and reduces the current-limit level.

The Acceleration Timer allots the turbopump 15 minutes to reach a rotational speed that is at least 80% of its maximum speed. If the turbopump fails to reach its minimum speed level at the end of the acceleration-time period, the Failure Detector causes the Status and Control circuit to stop the pump and turn ON the FAILURE indicator. However, if the pump is above its minimum speed level when the acceleration-time period expires, the Status and Control circuit turns ON the NORMAL OPERATION indicator, and allows the pump to continue to operate at a reduced current-limit level.

In the event of a pump overload (i.e., heavy process gas load) I_{PUMP} will increase due to the higher torque demand of the pump. However, if the increasing I_{PUMP} level causes the converter to go back into current limiting, E_{LINK} and the drive frequency are reduced to increase motor torque. If E_{LINK} drops to a level that causes the pump to slow down to about one-third of its rated rotational speed, the Failure Detector stops the pump and turns ON the FAILURE indicator.

The Pump-Select circuit determines whether a TMP-1000, TMP-1000 V/H, or TMP-1500 turbopump is connected to the converter by measuring the resistance of a pump-select resistor mounted in the turbopump. Once the Pump-Select circuit determines which pump is connected, it sets up the circuits of the VCO, and the Voltage and Current Limiters to correspond to the requirements of the pump in use.

The TMP1000 VH option was added in case there is ever a need for an oil-lubricated versions of the TMP1000. The Oil-Pump Control circuit would be activated by the Pump-Select circuit only if a TMP1000 H pump is connected to the converter. The Oil-Pump Control circuit would cycle the electrical oil-pump motor of this turbopump ON for 1 minute and OFF for 6 minutes, rather than allowing it to run continuously. If the oil pump should fail, the Oil-Pump Control circuit would sense a rise in oil temperature via a thermistor (PT100) mounted in the turbopump, and then signal the Failure Detector to stop the turbopump and turn ON the FAILURE indicator.

If a short circuit occurs at the output of the converter, I_{LINK} increases and causes the Short Circuit Protection circuit to immediately disable the Three-Phase Logic circuit, thus protecting the transistors in the Six-Step Inverter. Note that this protection circuit acts independently of the Current Limiter circuit.

The pump motor is overtemperature protected by a bi-metal thermal switch contained in the motor housing. This normally closed switch opens if the motor temperature exceeds its safe operating limit [133°F (56°C)], in turn, causing the Failure Detector to stop the pump and turn ON the FAILURE indicator.

Pressing the STOP button turns off the converter by sending an inhibit signal to the SCR Firing Control circuit which, in turn, removes E_{LINK} by turning off the SCR Bridge Rectifier. Note that pressing the STOP button will also clear the failure detector circuit and turn off the FAILURE indicator.

6.4 NT1000/1500 VH Circuit Description

See Figure 7-6 for the electrical schematic of the NT1000/1500 VH frequency converter. To ease the job of understanding and fault isolation, the circuits descriptions are divided into the following functional blocks:

6.4.1 Low Voltage Power Supply (see Figure 7-6)

The low voltage power supply provides an unregulated voltage of +24 and regulated voltages of +15, +5, and -15. Also two AC reference signals are supplied to the zero crossing reference input of SCR triggering control IC D3.

The center-tapped secondary of transformer T1 supplies 18 V AC (reference to ground), which is then rectified by diode bridge V1, regulated by a Zener diode V10 and three-terminal regulators N2 and N5, and filtered by capacitors C1, C2, C13, C17, and C19; the remaining capacitors C41, C42, C43, C44, and C45 are for spike suppression and noise filtering.

6.4.2 Start/Stop Control (See Figure 7-6)

NAND gates D1A and D1C are cross connected to form a set-reset flip-flop which performs the converter's start/stop function.

When power is first applied, components R9 and C9 ensure that the flip-flop comes up in its reset state (P4 low, P5 high), causing the pump to be turned off. The converter is then prepared to be started as follows:

1) The flip-flop's low set output (P4) performs the following:

- Inhibits the operation of SCR triggering control IC D3.
- Turns off N3 through D5C which disables the front panel FREQUENCY meter.
- Disables fault detector circuit IC N4B.

2) The flip-flop's high reset output (P5) performs the following:

- Applies a positive voltage to the non-inverting input of IC N9A in the VCO control circuit, causing the VCO to be at its maximum frequency when the START button is pressed. This allows the converter to restart a pump which is already spinning, thus preventing the inverter transistors from being short circuited and possibly destroyed.
- Resets acceleration timer D4, causing its output (P9) to go low.
- Applies a positive voltage to the non-inverting input of IC N4D through V32 in the current limiter circuit, causing the converter to be in current limiting when the START button is pressed.
- Disables motor-speed sense IC N4A of the acceleration timer circuit, causing the output of N4A (P10) to be low when the pump is started.

Pressing the START button starts the converter by applying a low to NAND gate D1A pin 1, which causes the flip-flop to set (P4 high, P3 low). The high and low outputs of the flip-flop then start the converter as follows:

1) The flip-flop's high set output (P4) performs the following:

- Enables SCR triggering control IC D3, allowing it to start triggering the SCRs in the DC link power supply.
- Turns ON the front panel FREQUENCY meter.
- Enables fault detector circuit IC N4B through D5B and D5C, allowing it to turn off the converter in the event of a failure.
- Lights the front panel ACCELERATION indicator.

2) The flip-flop's low reset output (P3) performs the following:

- Allows acceleration timer D4 to start timing.
- Enables motor-speed sense IC N4A, allowing its output (P10) to go high when the pump motor reaches its maximum rotational speed.

Pressing the STOP button stops the converter by causing NAND gate D1B to reset the flip-flop (P4 low, P3 high) by applying a low to NAND gate D1C pin 8. The outputs of the flip-flop then stop the converter and prepare it to be restarted as previously described.

In the event of a failure, the failure detector circuit turns off the converter by applying a low signal to NAND gate D1C pin 8 from inverter D10A of the status and control circuit. The failure detector is then latched in its failure state by the conduction of transistor V5. The failure detector is reset by pressing the STOP button, which causes the output of NAND gate D1B to go low and remove the emitter voltage from transistor V5.

6.4.3 Acceleration Timer (See Figure 7-6)

During acceleration, acceleration timer D4 allows the pump motor to operate for up to 15 minutes at a 30%-higher current level than is normally permissible. This is accomplished by the current limiter circuit, thereby increasing the current limiting of the status and control circuit.

The acceleration timer also prevents the fault detector circuit from faulting during start up, when the DC link voltage (from R35) is low, by allowing a negative voltage to be applied through resistor R37 to the inverting input of fault detector circuit IC N4B.

When the START button is pressed, a low is applied to acceleration timer reset input D4 pin 2, causing the timer to start timing. The acceleration timer's output (Test Point P9) is low during this time period, causing a (+24) which is inputted into the Input Resistance Network (R31, R32, R33) of current Control Circuit, thus allowing more current to flow to the pump during acceleration.

At the end of the 15 minute acceleration time period, the acceleration timer's output (P9) goes high, making the output of inverter D10B go low and perform the following:

1) lights the NORMAL OPERATION indicator;
2) energizes normal operation relay K1;
3) turns off ACCELERATION indicator by causing the output of inverter D10C to go high;
4) lowers pump motor current limit level by removing the +24 Volt from input resis tance network R37, R32, and R33 of the current limit circuit N4D.

The high output of the acceleration timer also cancels the negative voltage applied through resistor R37 to the fault detector circuit, thereby allowing the fault detector to turn off the converter if the DC link voltage drops to a level that slows the pump down to about one-third of its rated rotational speed.

If the pump motor reaches its maximum rotational speed before the end of the 15-minute acceleration period, motor-speed sense circuit IC N4A allows a high to be applied to acceleration timer D4 pin 1, causing its output (P9) to go high and initiate a normal operation state. Note that IC N4A monitors the output of the current limiter circuit (P8), which goes negative shortly after the converter goes into voltage limiting.

6.4.4 Status and Control (See Figure 7-6)

Status of the frequency converter is displayed by a series of LEDs (POWER, ACCELERATION, NORMAL OPERATION, FAILURE) which are turned on and off by the status and control circuit. This circuit also generates signals which control the operation of the converter.

The POWER indicator is turned on by the +24 volt output of the low-voltage power supply whenever the converter is plugged into an AC outlet.

The ACCELERATION indicator lights as soon as the output of inverter D10C goes low when the START button is pressed.

Normal operation begins whenever the output of acceleration timer IC D4 (Test Point P9) goes high which, in turn, makes the output of inverter D10B go low and perform the following:

1) lights the NORMAL OPERATION indicator;
2) energizes normal operation relayK1;
3) turns off ACCELERATION indicator by causing the output of inverter D10C to go high;
4) lowers pump motor current limit level to 3.5 amperes for the TMP1000 (8 amperes for the TMP1500) by switching the input to decoder IC D2 inturn changing the input resistance to current limit circuit.

When normal operation relay K1 is energized, it starts the optional external hours meter connected to rear panel terminals X1-12 and -13. This relay also has a set of N.O. and N.C. contacts available at rear panel terminals X1-4, -5, -6 which can be connected to an external monitor or control device. These contacts are rated 4 A at 250 V AC and 120 W at 30 V DC.

When a failure occurs, the failure detector causes the output of inverter D10A to go low and perform the following: 1) lights the FAILURE indicator; 2) turns off the converter by causing the start/stop flip-flop to reset (P4 low, P3 high); 3) latches ON the failure detector by turning ON transistor V5.

The output of inverter V10D goes low and lights the FAILURE indicator if cable compensation control R71 of the VCO circuit is misadjusted.

The output of inverter D10E goes low if the SCR controlled bridge rectifier heatsink becomes too hot during acceleration. This low signal lowers the voltage input to the current limit circuit which, in turn, lowers the converter's current limit level to 3.5 amperes for the TMP1000 (8 amperes for the TMP-1500). This circuit action is similar to current reduction when the converter goes into normal operation, but doesn't cause the converter to switch from acceleration to normal operation.

6.4.5 DC Link Power Supply (See Figure 7-6)

The DC link power supply provides a variable DC output (E_{link}) of up to -56 volts to the six-step inverter circuit, where Elink is inverted between the converter's three output lines in a sequence which synthesizes an 3-phase AC output signal.

Control of E_{link} is accomplished by means of the gate inputs to the SCR controlled bridge rectifier. Positive trigger pulses at the gate inputs turn ON the SCRs sometime in each half cycle of the AC line voltage (see Figure 6-4). The SCRs then turn themselves off at the end of each half cycle. E_{link} is increased by turning ON the SCRs early during each half cycle, while E_{link} is lowered by turning ON the SCRs late in each half cycle.

Resistor R4 on the six-step inverter board is the link current (I_{link}) sense resistor, providing a voltage of +20 mV per ampere of link current. This I_{link} voltage is used by the short circuit protection circuit.

6.4.6 SCR Triggering Control (See Figure 7-6)

The SCR controlled bridge rectifier is turned ON by positive trigger pulses from IC D3 pins 14 and 15. The timing of these trigger pulses is determined by a DC control voltage applied to IC D3 pin 11 (P31) from the voltage and current limiter circuits. A zero control voltage causes the SCRs to be turned ON all the time, while a control voltage of +8 keeps them turned off. The conduction of the SCRs can thus be changed by varying the DC control voltage between 0 and +8 volts.

The SCR triggering control circuit consists of IC D3, which is a general purpose trigger device composed of a zero-crossing detector, a comparator, a sawtooth generator, and an output stage.

The zero-crossing detector produces a negative-going output pulse at IC D3 pin 10 (P32) whenever the AC power line voltage is crossing through zero. This pulse is used to discharge capacitor C8 at the beginning of each AC half cycle, thus synchronizing the timing of the SCR trigger pulses with the beginning of each half cycle of the AC line voltage. AC input signals to the zero-crossing detector come from the low-voltage power supply and are applied to IC D3 pin 5 (P30).

The Triggering Control Circuit provides positive SCR trigger pulses at IC D3 pins 14 and 15 when its inhibiting input (pin 6) is high and its control input (pin 11) is between 0-7 VDC.

The SCRs are turned off when the STOP button is pressed by a low signal applied to IC D3 pin 6 from the start/stop circuit.

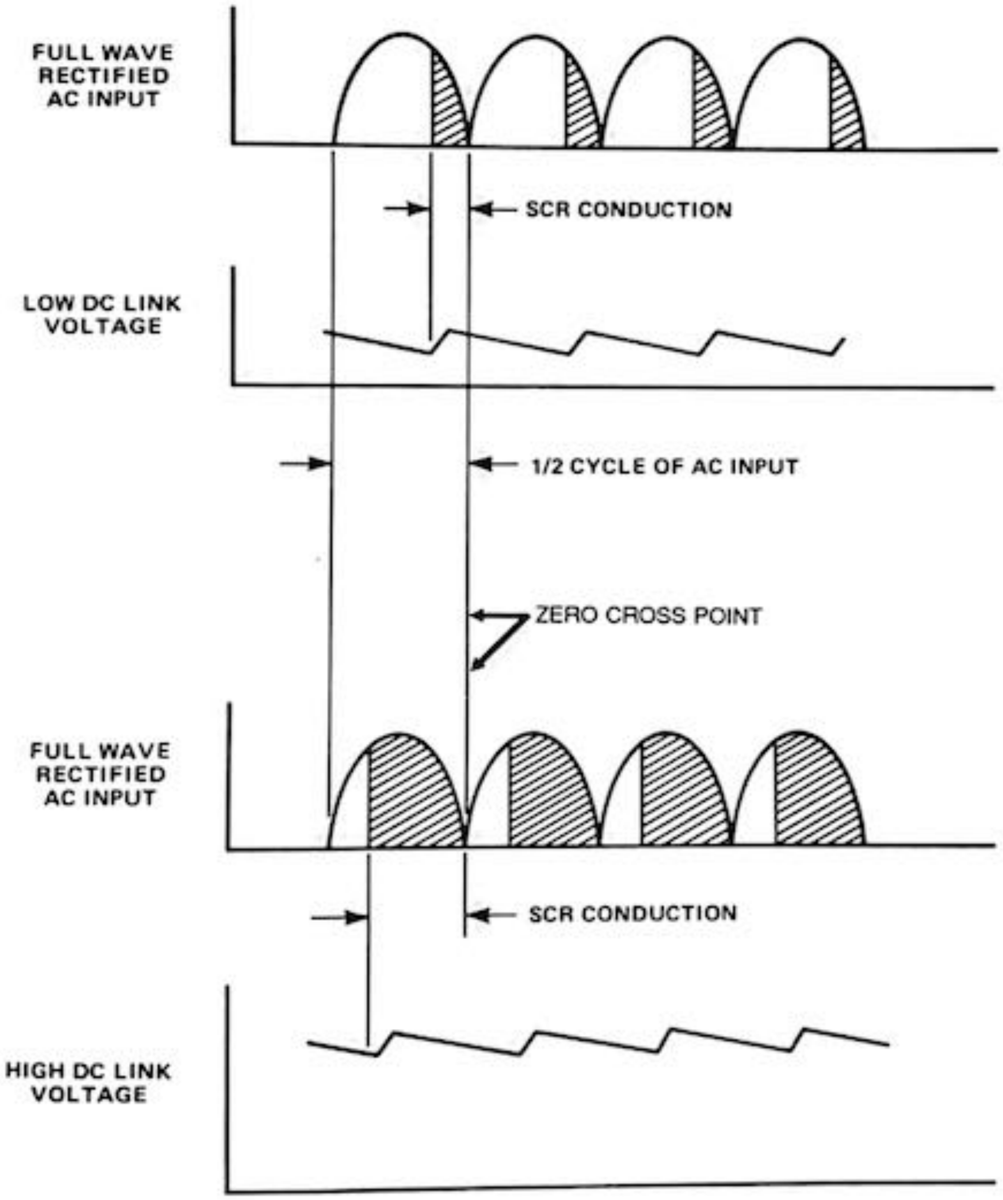


Figure 6-4. Output Voltage Control through SCR Timing

6.4.7 Six-Step Inverter (See Figure 7-6)

The DC link voltage is switched onto the converter's output lines by the six-step inverter circuit in a sequence which synthesizes a three-phase AC output. The inverter's six pairs of output transistors are switched ON and off at the desired frequency and in the correct sequence by the three-phase logic circuit.

Figure 6-5 shows a simplified schematic of a variable frequency, variable voltage six-step induction motor drive, 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 - hence, the name six-step.

Pump motor current is measured by current transformer T2, rectifier bridge V17, and load resistor R5. These components produce a negative voltage that is proportional to pump current. This negative voltage is used by the current limiter circuit.

6.4.8 Three-Phase Logic (See Figure 7-6)

The three-phase logic circuit consists of divide-by-six counter IC D7, six-step sequencer IC D8, and drive transistors V17 thru V22. This circuit is driven by the output of the VCO and is responsible for the proper sequencing of the transistors in the six-step inverter.

The output of the VCO IC D6 (Test Point P29) is applied to divide-by-12 counter IC D7 which produces a three-bit binary output (pins 8, 9, 11) that drives six-step sequencer IC D8 at one-sixth the VCO frequency. (Note each output is 1/2 a wake signal; it takes 2 outputs from P8 to make one phase of the pump drive signal.)

The outputs of IC D8 (pins 1 thru 6) go low and turn ON their associated drive transistors (V17 thru V22) in a sequence determined by IC D7's internal logic arrangement. IC D7 thus establishes the turn-on sequence of the Six-Step Inverter Board's source and sink transistor pairs.

IC D8 pin 7 provides an output that corresponds to the pump drive frequency. This output is buffered by inverter D10F, which produces at rear-panel terminals X-1, 7, & 8 a square-wave output at an amplitude of +24 volts. A frequency counter can be connected to these terminals for a quantitative readout of the pump drive frequency.

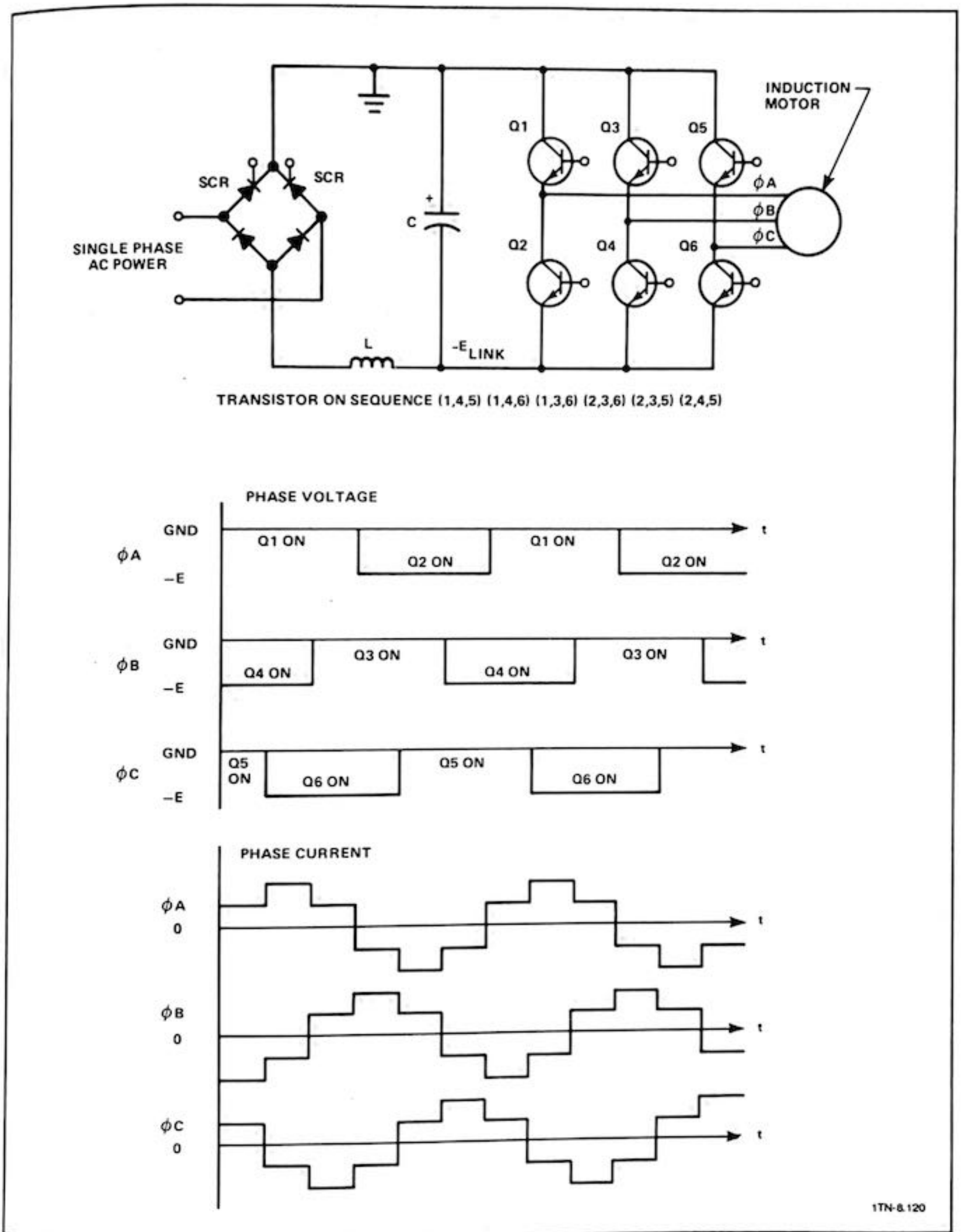


Figure 6-5. Six-Step Induction Motor Drive, Simplified Schematic and Waveforms

6.4.9 VCO (Voltage Controlled Oscillator) (See Figure 7-6)

The switching frequency of the six-step inverter is determined by the VCO (voltage controlled oscillator) circuit consisting of VCO IC D6 switch N6A.

VCO IC D5 operates at a maximum frequency of 3D730 Hz for the TMP1000 and 2130 Hz for the TMP1500. This frequency can be varied from about 5 to 100% of its maximum value by changing the positive control voltage applied to IC D6 pin 7.

The VCO control voltage (Test Point P26) is generated by comparator N9A and voltage follower N9B. This circuit monitors the DC link voltage and then produces a control voltage that causes the VCO frequency to track any changes in link voltage, so as to maintain a constant voltage-to-frequency ratio.

When the converter is stopped, a positive voltage from the start/stop circuit charges capacitor C34 through resistor R83 and diode V23B. The voltage across C34 makes the output of comparator N9A go to its maximum positive level which, in turn, causes the VCO to run at its maximum frequency. Then when the converter is started, capacitor C34 discharges through resistor R87, causing the VCO frequency to slowly decrease until it reaches the correct voltage-to-frequency ratio, at which time the frequency starts to increase with increasing link voltage. This design feature of starting the converter at its maximum frequency allows the pump to be restarted from any rotational speed.

If during start-up the output of comparator N9A goes negative, the output of comparator N9D will go positive and light the FAILURE indicator. This condition indicates that cable length compensation control R71 is misadjusted and should be readjusted as described in Section 4.4.1.

Analog switches D3C and N6A set up the VCO circuit to automatically operate with either the TMP1000 or TMP1500, and are controlled by the pump select circuit. These switches are N.O. devices that close with the application of a positive voltage to their control inputs (pins 6 and 12). Both switches are open when the converter is connected to a TMP-1000 and are closed for a TMP1500.

The front panel FREQUENCY meter indicates converter frequency as a percentage of the maximum drive frequency at the pump's rated rotational speed. Note that analog switch N3 enables the FREQUENCY meter when the pump is started by the application of a positive voltage from the start/stop circuit.

6.4.10 Short Circuit Protection (See Figure 7-6)

The short circuit protection circuit provides a fast response time to link-current overloads greater than 25 amperes by immediately turning off the converter's output transistors.

In operation, link-current-sense resistor R4 applies a positive voltage of 20 mV per ampere of link current to the inverting input (Test Point P27) of comparator N8A. At current levels greater than 25 amperes, this positive voltage becomes greater than the reference voltage applied to the comparator's non-inverting input, causing the comparator's output (P22) to go low and trigger pulse stretcher IC D9. Once pulse stretcher IC D9 is triggered, it's output (P26) goes high for about 25 mS and disables three-phase logic IC D8. During this time period, drive is removed from transistors V17 to V21.

As soon as the output of pulse stretcher IC D9 (P26) returns low, drive is reapplied to the inverter transistors; however, if the short circuit is still present, drive is again removed for 25 mS. This process continues until either the short circuit is removed, or the converter goes into its failure mode.

6.4.11 Failure Detector (See Figure 7-6)

The failure detector circuit consists of comparator N4B and NAND gate D5A. The output of failure detector circuit IC N4B (Test Point P7) is high (+14V) during both acceleration and normal operation, but goes low (-13V) if a fault occurs which causes the converter to turn itself off.

The failure detector's output is high when the sum of all negative and positive voltages applied to its inverting input is negative enough to turn ON diode V12C, which clamps the comparator's inverting input one diode drop (6.7V) below ground. This negative voltage causes the comparator's output (P7) to be high, the output NAND gate D5A to be low, and the output of inverter D10A of the status and control circuit to be high which, in turn, causes the FAILURE indicator to be off.

In the event of a failure, the output of the failure detector is made to go low by having its inverting input go positive as follows:

- If the pump motor overheats, its thermal switch will open and cause the output of programmable decoder IC D2 output 9 of the pump select/overtemperature circuit to go high and apply a positive voltage to FET V9, which causes the inverting input of comparator N4B to go positive.
- If the pump motor slows down to about one-third of its rated rotational speed (e.g., leak in vacuum system causing intake side pressure to rise), the negative DC link voltage applied to resistor R35 will have decreased to a level that causes the inverting input of comparator N4B to go positive. Note that the fault detector circuit is inhibited from activating during acceleration, when the DC link voltage is low, by acceleration timer D4 (refer to Section 6.4.3).

When the sum of all negative and positive voltages at the inverting input of comparator N4B is positive, diode V12B turns ON and clamps the comparator's inverting input one diode drop (~0.7V) above ground. This positive voltage causes the comparator's output to go low, the output of NAND gate D5A to go high, and the output of inverter D10A to go low which, in turn, causes the following to occur:

1) Diode V24A conducts and lights the FAILURE indicator.

2) Diode V24B conducts and causes the output of inverter D10C to go high during acceleration, which turns off the ACCELERATION indicator.

3) Diode V24C conducts and causes transistor V5 of the fault detector latch circuit to turn ON and latch the detector in its failure mode.

4) Diode V24C by conducting also causes the converter to be turned off by applying a low to start/stop circuit IC D1C pin 8, which causes the start/stop circuit's flip-flop to reset (P4 low, P3 high).

6.4.12 Failure Detector Latch (See Figure 7-6)

The failure detector latch circuit consists of transistor V5. This transistor is turned off during acceleration and normal operation, but is turned ON in the event of a failure by the status and control circuit.

As soon as a fault is detected, transistor V5 is turned ON by a low signal applied to its base from inverter D10A of the status and control circuit. A positive voltage from the collector of V5 is then applied to resistor R15C of the failure detector circuit, causing the detector to latch in its failure mode.

Transistor V5 also turns ON if fuse F2, on the six-step inverter board, has blown. In this situation, V5 causes the failure detector circuit to turn off the converter.

The failure detector latch circuit is reset by pressing the STOP button, which causes the output of NAND gate D1B to go low and remove the emitter voltage from transistor V5.

6.4.13 Voltage and Current Limiters (See Figure 7-6)

The voltage and current limiter circuits regulate the DC link voltage so as to keep the converter in either current or voltage limiting. At start up the converter immediately goes into current limiting due to the motor's low rotor impedance, thus causing the converter to apply both a very low drive voltage and drive frequency to the motor. As the motor accelerates, however, its back e.m.f. causes the rotor impedance to increase which, in turn, causes the converter to increase both drive voltage and drive frequency by an amount necessary to keep itself in acceleration current limiting. Once the DC link voltage reaches a preset level (corresponds to the desired pump speed), the converter then goes into voltage limiting and allows the motor current to decrease to its normal operating level (dependent upon pump loading).

The output of the voltage and current limiter circuits (Test Point P31) regulates the DC link voltage by applying a DC control signal of between 0 and +7 volts to SCR triggering control IC D3 pin 11 which, in turn, controls the conduction of the SCR bridge rectifier (refer to section 6.4.6). Note that 0 volts causes maximum link voltage while +7 volts causes minimum link voltage.

The current limiter circuit consists of high-gain amplifier N4D, which amplifies the difference between a negative feedback voltage that is proportional to pump current (P14) and a positive reference voltage R developed across R39 and R38C. The feedback is loaded differently for different pumps as detected by pump select circuit. The loading takes place by switching different combinations of resistors of the resistors network R31, R32, and R33 via analog switch N3 as instructed by decoder chip D2.

The current limiter circuit then outputs an SCR DC control signal (P8) which varies the DC link voltage as necessary to limit the motor current of a TMP-1000 pump at 8.5 amperes during acceleration, and 3.5 amperes during normal operation (11.5 and 8 amperes, respectively for the TMP-1500). For example, during start-up the current level begins to decrease as the pump motor accelerates, causing the negative feedback voltage applied to the current limiter to decrease (go less negative). This positive going voltage at the inverting input of amplifier N4D causes its output to decrease, thereby raising the DC link voltage by causing the SCR triggering circuit to increase the conduction time of the SCRs in the DC link power supply.

Analog switch N3 is used to raise the current limit level during acceleration by switching resistors R31, R32, and R33 thus changing the load on the feedback voltage applied to amplifier N4D pin 13.

Then after either the acceleration time period has expired, or after the pump reaches its rated rotational speed, analog switch N3 switches as instructed by IC D2. N3 opens and causes the current limit level to be reduced to its normal operating value. Analog switch N3 is controlled by the output of decoder IC D2 (outputs 4, 5, and 6).

The voltage limiter circuit consists of amplifier N4C. The operation of this circuit is similar to the current limiter, in that it amplifies the difference between the negative link voltage (P16) and reference potential sample developed across R48 and R49. N4C's output (P12) is summed with N4D's output; the sum is applied to D3 Pin 11. D3 varies the DC link voltage as necessary to limit the converter's output at its maximum level of 42 volts. For example, if the DC link voltage increases (becomes more negative) due to AC line fluctuations, this negative going voltage at the inverting input of amplifier N4C causes its output to increase, and thus lowers the DC link voltage by causing the SCR triggering circuit to reduce the conduction time of the SCRs in the DC link power supply.

7 — Parts Lists and Diagrams

This section includes part numbers for replacement parts for the TMP1000 turbopump and the NT1000 VH converter. An electrical schematic for the NT1000 VH converter is also included. The part numbers for ordering the turbopump, the converter, 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 107 lists "1" for the "Half stator disk". On Figure 7-1, the number "1" is pointing to a drawing of this half stator disk.

The second series of five columns indicates which pump model uses the part and how many each pump requires. For example, on page 107, the "16" in the 160 ISO-K column for Item No. 1 indicates that 16 half stator disks (P/N 221 02 261) are required for the TMP1000 model that has the 160 ISO-K high-vacuum flange.

Contents

Parts

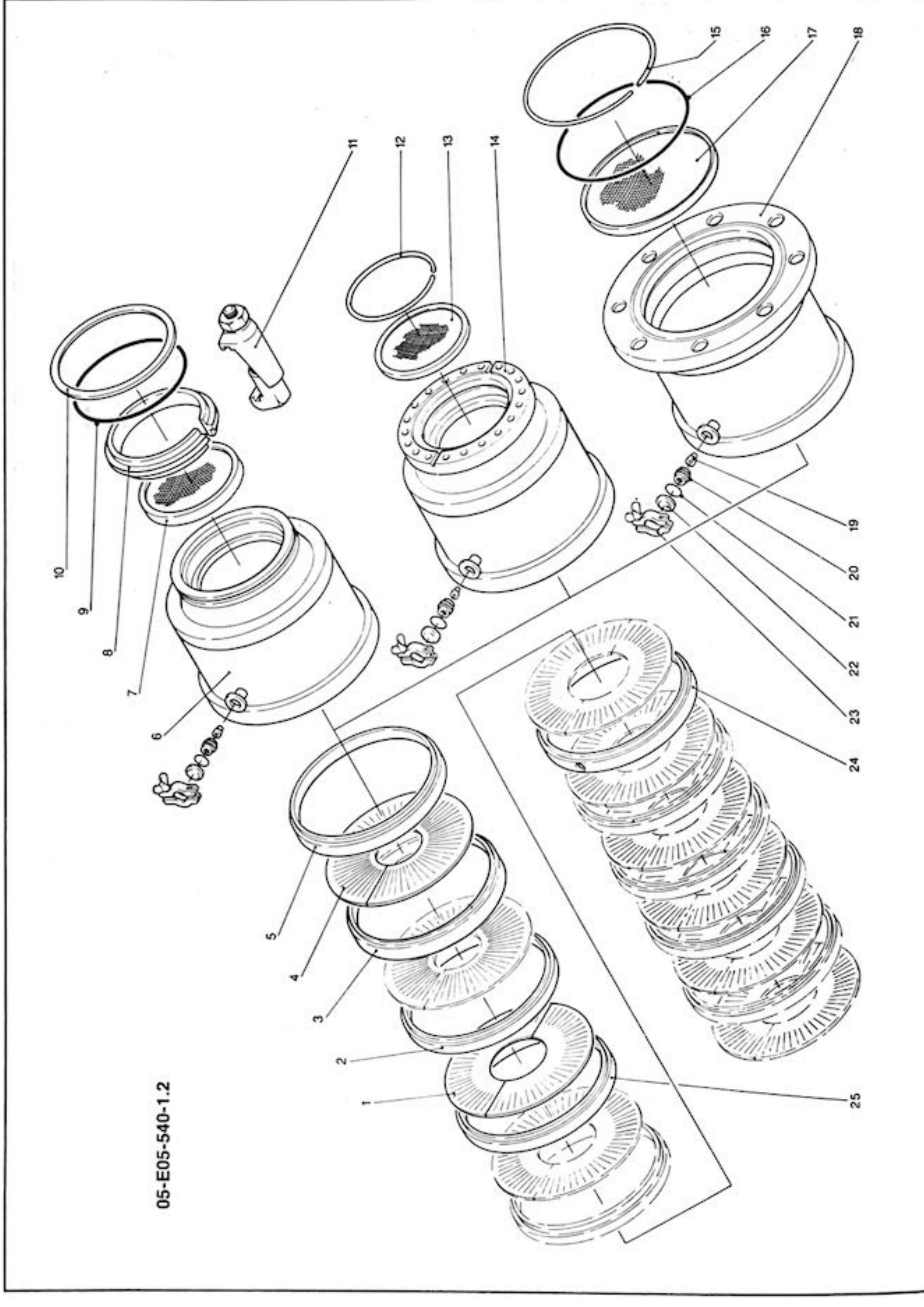


Figure 7-1. Drawing of the TMP1000 Housing and Stator

Table 7-A — TMP1000 Housing & Stator Parts List (see Figure 7-1)

Item No.	Quantity: 160 ISO-K	Quantity: 250 ISO-K	Quantity: 160 CF	Quantity: 200 CF	Quantity: 6 Inch ASA	Description	Dimensions (mm)	Material	Part Number	Remarks
1	16	16	16	16	16	Half stator disk	223 x 0.6/87	Aluminum	221 02 261	
2	1	1	1	1	1	Wide spacer ring	226 x 17.6	Aluminum	233 81 178	
3	1	1	1	1	1	Spacer ring	226 x 20.6	Aluminum	233 81 176	
4	4	4	4	4	4	Half stator disk	223 x 0.6/70	Aluminum	221 02 260	
5	1	1	1	1	1	Spacer ring	226 x 17.6	Aluminum	233 81 177	
6	1					Housing, complete	DN 160 ISO-K		331 68 060	
		1				Housing, complete	DN 250 ISO-K		331 68 063	
7	1					Inlet screen	149 x 10	Stainless Stl	200 17 247	
		1				Inlet screen	260 x 11	Stainless Stl	200 17 249	
8	1					Centering ring	DN 160	Aluminum	200 07 328	
		1				Centering ring	DN 250	Aluminum	233 93 340	
9	1					O-ring	151.77 x 5.33	Viton	239 70 512	
		1				O-ring	265 x 5	Viton	239 70 167	
10	1					Outer supporting ring	DN 160	Aluminum	200 07 330	
		1				Outer supporting ring	DN 250	Aluminum	233 93 339	
11	2	2				Clamp	M 10 x 24	Steel	201 98 163	
12			1			Circlip	DN 160 CF, 1.4310		231 02 418	
				1		Circlip	DN 200 CF, 1.4310		200 17 403	
13			1			Inlet screen	149 x 10	Stainless Stl	200 17 247	
				1		Inlet screen	199 x 19	Stainless Stl	200 17 248	
14			1			Housing, complete	DN 160 CF		331 68 061	
				1		Housing, complete	DN 200 CF		331 68 064	
15					1	Circlip	DN 200 CF, 1.4310		200 17 403	
16					1	O-ring	202.79 x 3.53	Viton	200 17 009	
17					1	Inlet screen	199 x 19	Stainless Stl	200 17 248	
18					1	Housing, complete	DN 6" ANSI		331 68 068	
19	1	1	1	1	1	Nozzle	0.6	Brass	392 25 109	
20	1	1	1	1	1	Sintered metal filter	DN 10	Steel	200 17 093	
21	1	1	1	1	1	O-ring	15 x 5	Buna	239 50 193	
22	1	1	1	1	1	Blank flange	DN 10, 1.4301		321 20 216	
23	1	1	1	1	1	Locking ring	DN 10/16	Aluminum	230 60 101	
24	1	1	1	1	1	Spacer ring with hole	226 x 14.7	Aluminum	233 81 179	
25	6	6	6	6	6	Narrow spacer ring	226 x 14.7	Aluminum	233 81 180	

Parts

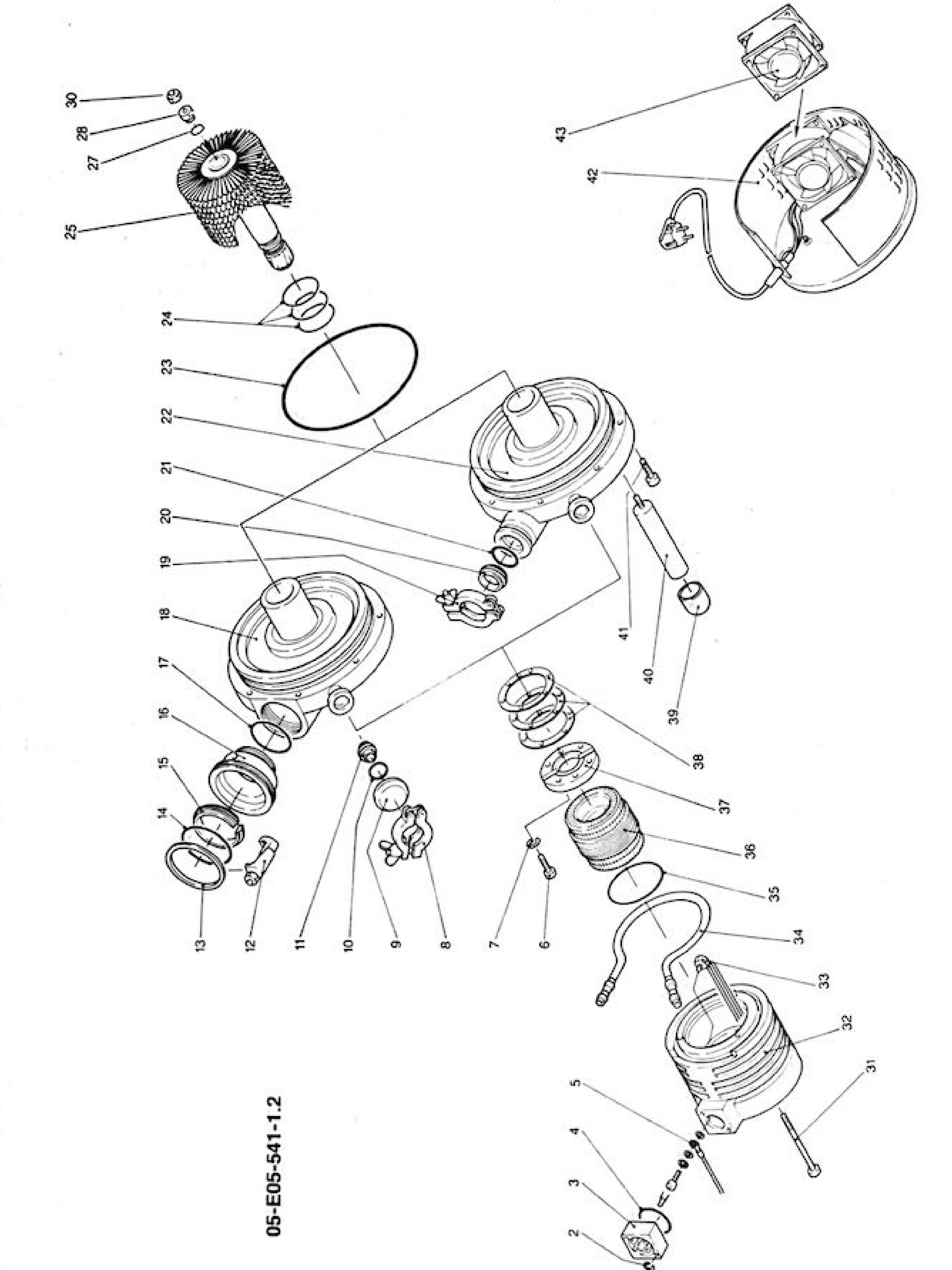


Figure 7-2. Drawing of the TMP1000 Rotor and Base

Table 7-B — TMP1000 Rotor/Base Parts List (see Figure 7-2)

Item No.	Quantity 160 ISO-K	250 ISO-K	160 CF	200 CF	6 Inch ASA	Description	Dimensions (mm)	Material	Part Number	Remarks
1	2	2	2	2	2	Capscrew	M 4 x 30, DIN 912		200 17 492	
2	2	2	2	2	2	Washer	A 4.3, DIN 125		221 01 201	
3	1	1	1	1	1	Current leadthrough	38 x 38 x 21	Pocan	200 17 386	
	1	1	1	1	1	Socket	35.4, 8 pol		200 17 399	
4	1	1	1	1	1	O-ring	28 x 3.5	Buna	200 17 414	
5	1	1	1	1	1	Earth wire			232 03 178	For pump models with a 40 KF fore-vacuum flange
	1	1			1	Earth wire			20017608	For pump models with a 63 ISO-K fore-vacuum flange
6	6	6	6	6	6	Cylinder screw	M4 x 12, DIN 912		201 03 204	
7	6	6	6	6	6	Spring washer	B 4, DIN 127		231 01 106	
8	1	1	1	1	1	Locking ring	DN 10/16	Aluminum	230 60 101	
9	1	1	1	1	1	Blank flange	DN 10		321 20 216	
10	1	1	1	1	1	O-ring	15 x 5	Buna	239 50 193	
11	1	1	1	1	1	Centering ring	DIN 10 KF		231 94 201	
12	2	2			2	Clamp	M 10 x 24	Steel	201 98 163	For pump models with a 63 ISO-K fore-vacuum flange
13	1	1			1	Outer support ring	DN 63 ISO-K	Aluminum	233 93 201	
14	1	1			1	O-ring	70 x 5	Buna	239 50 207	
15	1	1			1	Centering ring	DN 63 ISO-K	Aluminum	231 93 305	
16	1	1			1	Flange	DN 63 ISO-K	Aluminum	200 17 474	
17	1	1			1	O-ring	64 x 3	Buna	239 50 210	
18	1	1			1	Base flange			200 17 470	
19	1	1			1	Locking ring	DN 32/40	Aluminum	230 60 103	For pump models with a 40 KF fore-vacuum flange
20	1	1			1	Centering ring	DN 40 KF	Aluminum	231 94 207	
21	1	1	1	1	1	O-ring	42 x 5	Buna	239 50 115	
22	1	1	1	1	1	Base flange			200 17 675	
23	1	1	1	1	1	O-ring	205 x 5	Buna	239 50 735	
24	3	3	3	3	3	O-ring	40.87 x 3.53	MVQ	200 17 924	
25	1	1	1	1	1	Rotor/Spindle assembly			85564	Use P/N 200-17-017 for a rebuilt assembly
27	1	1	1	1	1	O-ring	17 x 3	Viton	239 70 154	
28	1	1	1	1	1	Pressure ring		Steel	200 18 163	

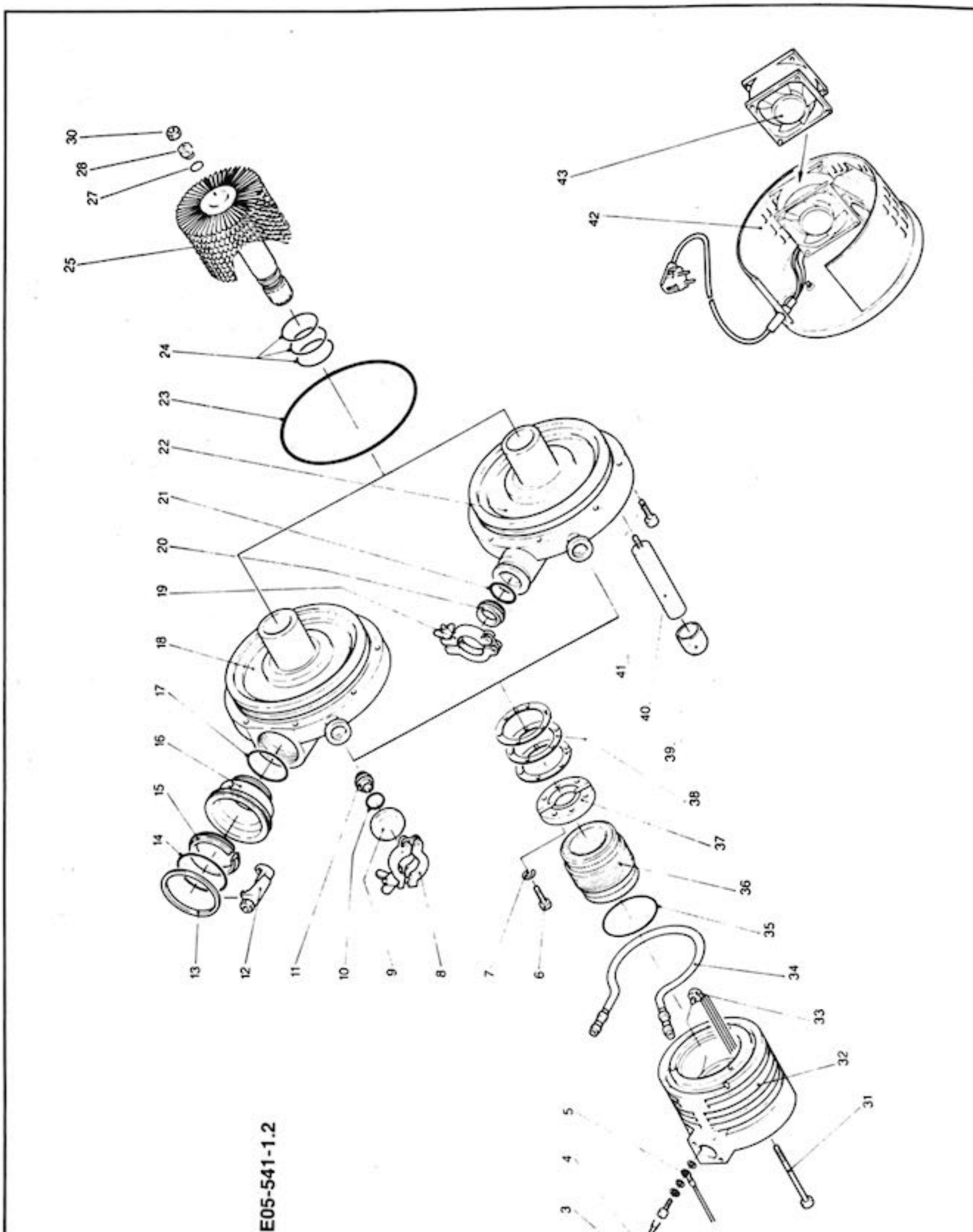


Figure 7-2. Drawing of the TMP1000 Rotor and Base

Table 7-B — TMP1000 Rotor/Base Parts List (see Figure 7-2)

Item No.	Quantity 160 ISO-K	250 ISO-K	160 CF	200 CF	6 Inch ASA	Description	Dimensions (mm)	Material	Part Number	Remarks
30	1	1	1	1	1	Hex nut	M 6		200 18 069	
31	3	3	3	3	3	Capscrew	M 5 x 90, DIN 912		201 03 115	
32	1	1	1	1	1	Motor casing	D 133 x 105	Aluminum	331 68 280	For pump models with a 40 KF fore-vacuum flange
	1	1			1	Motor casing	D 133 x 108	Aluminum	200 17 420	For pump models with a 63 ISO-K fore-vacuum flange
33	1	1	1	1	1	Thermal switch			500 36 043	For pump models with a 40 KF fore-vacuum flange
	1	1			1	Thermal switch			200 17 157	For pump models with a 63 ISO-K fore-vacuum flange
34	1	1	1	1	1	Cooling coil			431 31 379	For pump models with a 40 KF fore-vacuum flange
	1	1			1	Cooling coil			200 17 472	For pump models with a 63 ISO-K fore-vacuum flange
35	1	1	1	1	1	O-ring	84 x 3	Buna	239 50 179	
36	1	1	1	1	1	Stator			380 26 163	
37	2	2	2	2	2	Spindle rest halves	68 x 6	Aluminum/MVQ	221 02 262	
38	7	7	7	7	7	Pair of spacer disks	68 x 0.1	Stainless Stl	221 02 258	
39	3	3	3	3	3	Cap	25 x 25	PVC	200 17 047	
40	3	3	3	3	3	Foot, complete			401 57 357	
41	8	8	8	8	8	Cylinder screw	M 6 x 25, DIN 912		201 03 105	
42	1	1	1	1	1	Optional air cooler	115 V		894 45	
	1	1	1	1	1	Optional air cooler	220 V		854 98	
43	2	2	2	2	2	Fan	115 V		200 17 037	
		2	2	2	2	Fan	220 V		380 91 106	

20018284

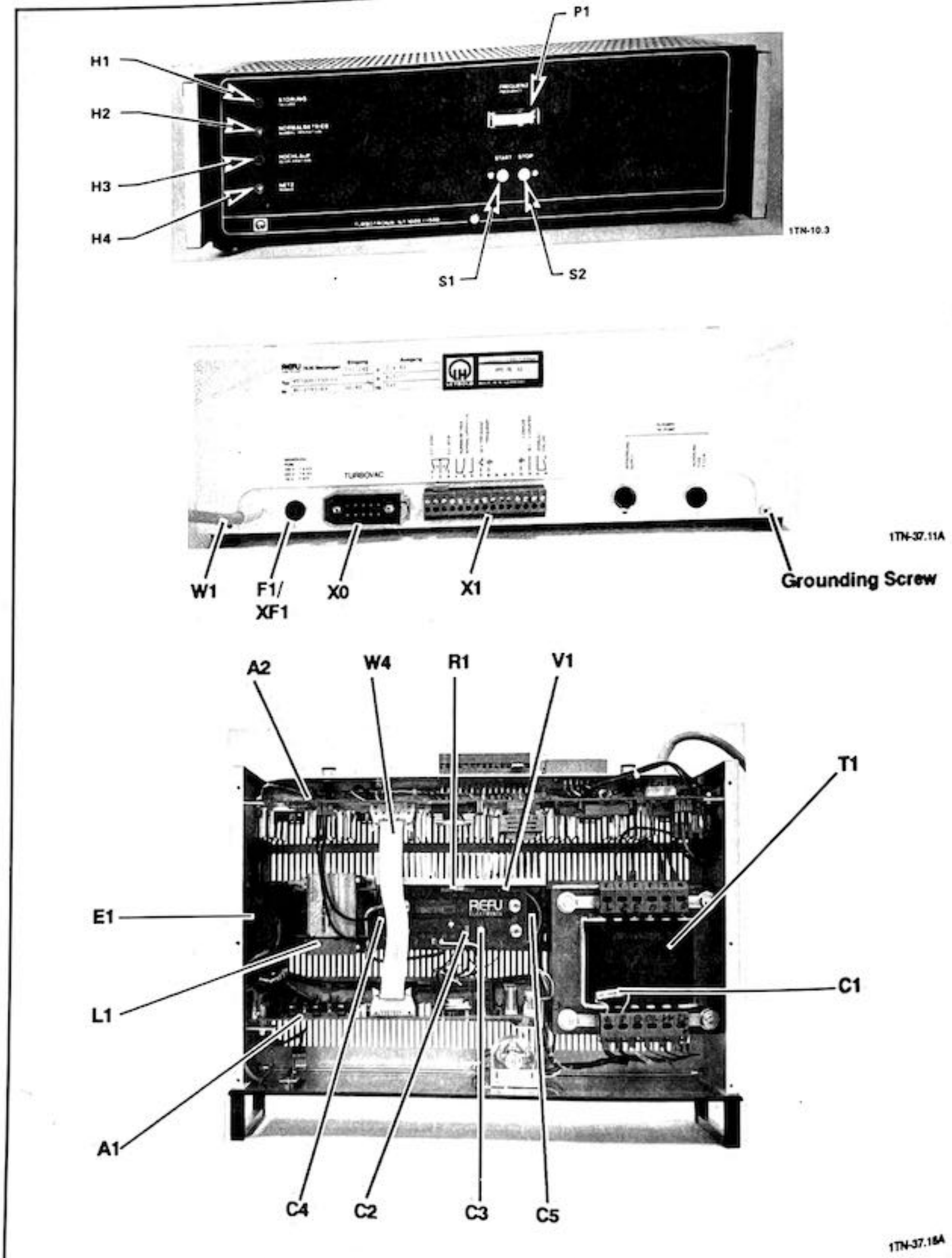


Figure 7-3. NT1000/1500 Chassis Part Locations

Table 7-C — NT1000/1500 VH Converter Parts List

Item Number	Description	Part Number	Remarks
A1	Control & Regulator Board, Complete	200 18 194	See Table 8-D for individual parts.
A2	Six-Step Inverter Board, Complete	200 17 044	See Table 8-E for individual parts.
C1	Capacitor, 1 μF, 250 V	—	
C2	Capacitor, 0.01 μF, 32 V	—	
C3	Capacitor, 0.01 μF, 32 V	—	
C4	Capacitor 10,000 μF, 63 V	—	
C5	Capacitor 10,000 μF, 63 V	—	
E1	Cooling Fan, 24 VDC, ⅜″ diameter	721 14 002	
F1	Fuse, T 10A/250 D, 110–120 V AC	99 180 054	Used with 115/120 line voltage
	Fuse, T 6.3/250 D, 200–220 V AC	520 25 321	Used with 200-240 line voltage
F2	Fuse, 16A, 250 G	520 25 122	On six-step inverter board
F3	Fuse, T 0.5/250	520 25 312	
H1	LED, Red	510 43 128	
H2 & H4	LED, Yellow	510 43 239	
L1	Choke	—	
P1	Meter, Frequency, 1 mA	—	
R1	Thermistor, 60°C	—	
S1	Switch, START	—	
S2	Switch, STOP	—	
T1	Transformer	—	
V1	SCR Controller Bridge Rectifier	723 03 002	
WO	Pump Cable assembly, 7 conductor, 5m	200 17 045	
W1	AC Power Cord Assembly	—	Includes 115 V AC plug (99-123-003)
W4	16 Conductor Cable Assembly	—	
XO	Connector, Pump	—	
X1	Connector, External/Optional Equipment	723 31 008	P/N is for one individual terminal
XF1	Fuse holder, Socket, F1	528 28 103	
	Fuse holder, Cap, F1	528 28 104	
—	Power Cord Plug, 250 V AC	99 122 049	Straight blade
—	NT 1000 V/H Handles	331 22 280	Two required
—	Extender Ears for 19″ Rack-Mount Installation	721 75 000	Two required

Parts

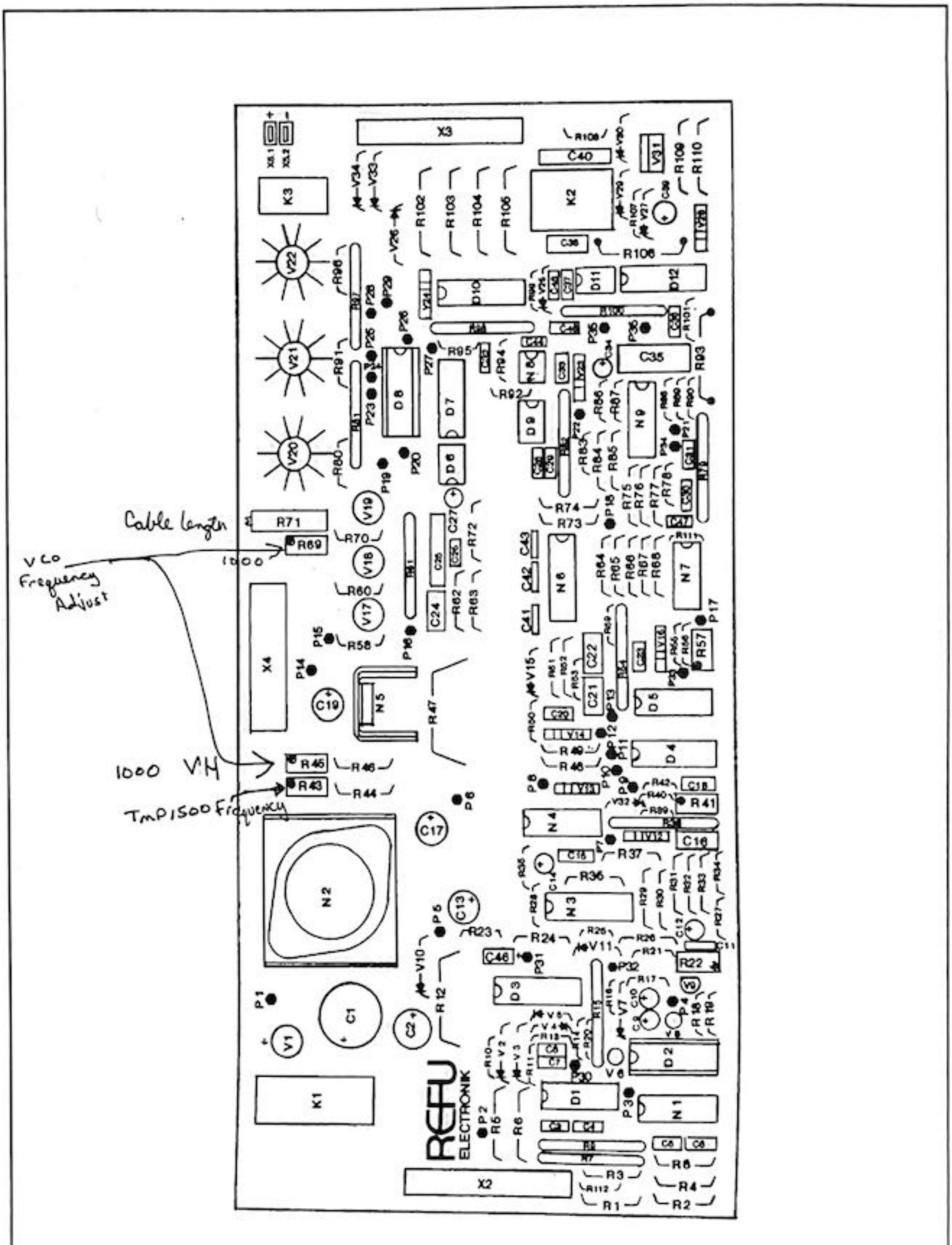


Figure 7-4. NT 1000/1500 VH A1 Control & Regulator Board

Table 7-D — A1 Control and Regulator Board Parts List*

Item Number	Description	Part Number	Remarks
D1, D5	IC, MC14011BCL, Quad Nand Gate	722-39-151	
D2, D8	IC, TBP 18S030 N, 32 x 8 Bit PROM	722-39-814	
D4	IC, CD4536B, Programmable Timer	722-39-812	
D6	IC, RV4151, Voltage Controlled Oscillator	722-39-813	
D7	IC, DM74LS92N, Divider	722-39-810	
D9	IC, ICM7555, Timer	722-39-704	
D12	IC, Hex Inv, MC14049	722-39-143	
N2	IC, LM 340 K-15, 15 V Regulator	722-39-566	
N8	IC, TAA 762, Op Amp, High Current	227-39-285	
V1	IC, 880C800GI, Rectifier	722-39-811	
V9	Transistor - FET, VN 1304 N3	723-35-282	
V26	Diode, 1N4007	510-43-329	

* See the NT1000/1500 VH electrical schematic (Figure 7-6) for component type numbers not listed in this table.

Parts

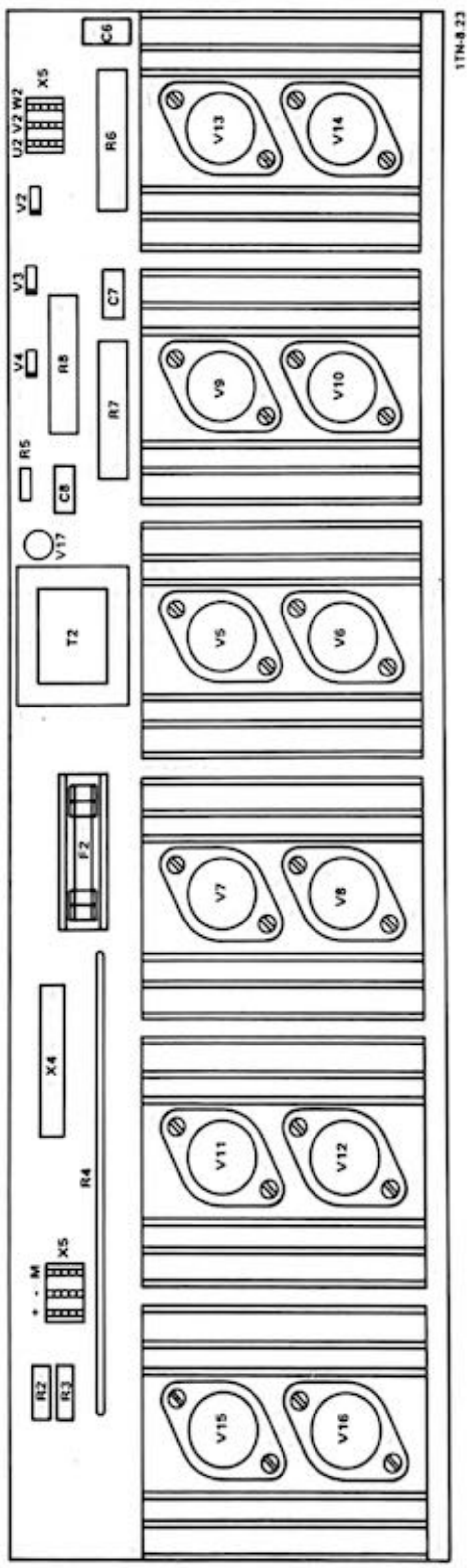


Figure 7-5. NT 1000/1500 VH Six-Step Inverter Board

Table 7-E — A2 Six-Step Inverter Board Parts List*

Item Number	Description	Part Number	Remarks
F2	Fuse, F 16A/250 G	520-25-122	
V2 thru V4	Diode, 1N4007	510-43-329	
V5 thru V16	Transistor, MJ 11014	723-35-004	
V17	Diode Bridge Rectifier, B80 C 800 GI	722-39-811	

* See the NT1000/1500 VH electrical schematic (Figure 7-6) for component type numbers not listed in this table.

Parts

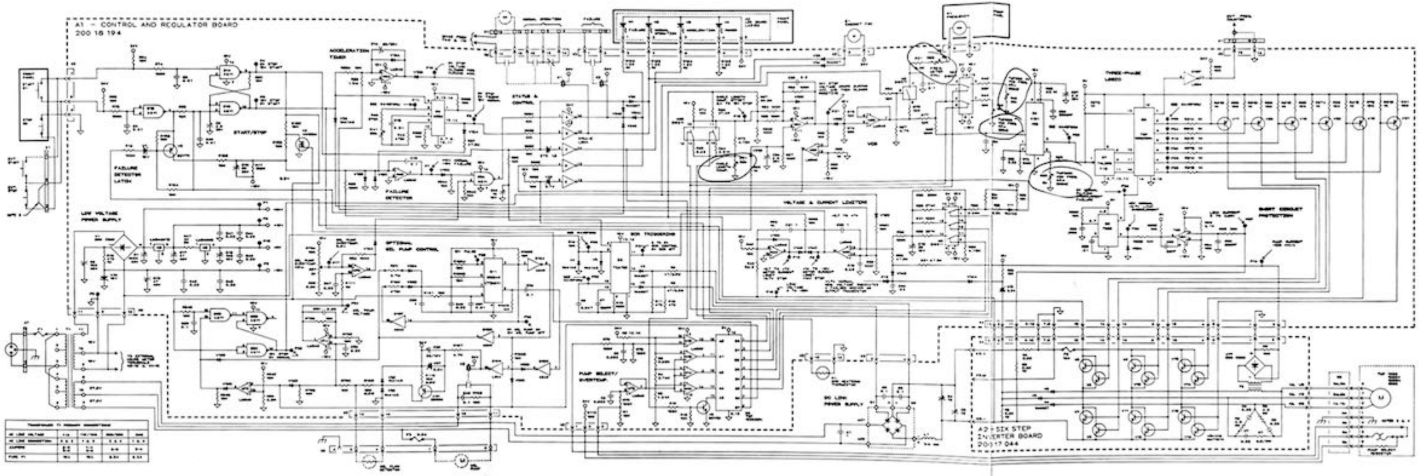


Figure 7-6. NT1000/1500 VH Electrical Schematic

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

Accessories

A.1 Water Refrigeration Unit

The optional Water Refrigeration Unit (see Figure A-1) is used where the ambient temperature is too high for air cooling, where normal tap water isn't available for water-cooling, or where the 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.8 for information on the optional Air Cooler.

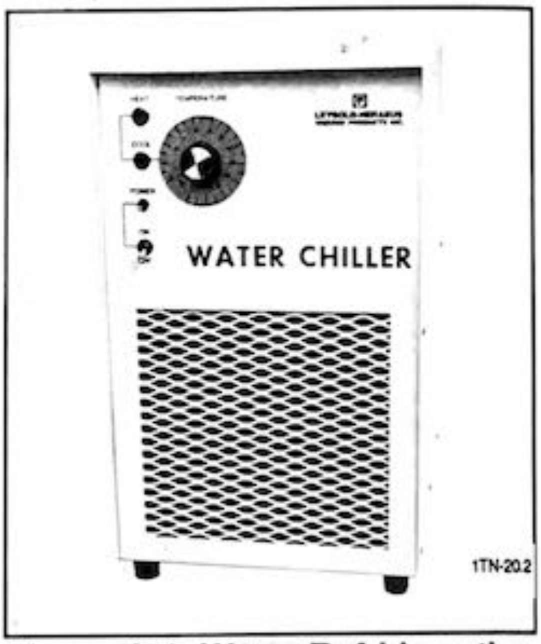


Figure A-1. Water Refridgeration Unit

A.2 Water-Flow Switch

The optional Water-Flow Switch (see Figure A-2) 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-2. Water Flow Switch

A.3 Flange Heater

The optional CF flange heater (see Figure A-3) 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.

Power consumption is as follows:

160CF flange heater 150watts
200CF flange heater ...... 250 watts

Bakeout of the turbopump and vacuum chamber is only necessary when operational pressures of $<10^{-8}$ mbar 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.

Figure A-3. CF Flange Heater

A.4 Automatic Vent Valve

An automatic vent valve (see Figure A-4) is used in standard applications to vent the pump during shutdown. See Appendix A.5 for information on venting and purging for process gases that are corrosive, aggressive, or that contain abrasives.

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.

Figure A-4. Automatic Venting Valve

The vent valve mounts on the turbopump's KF10 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.5 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.

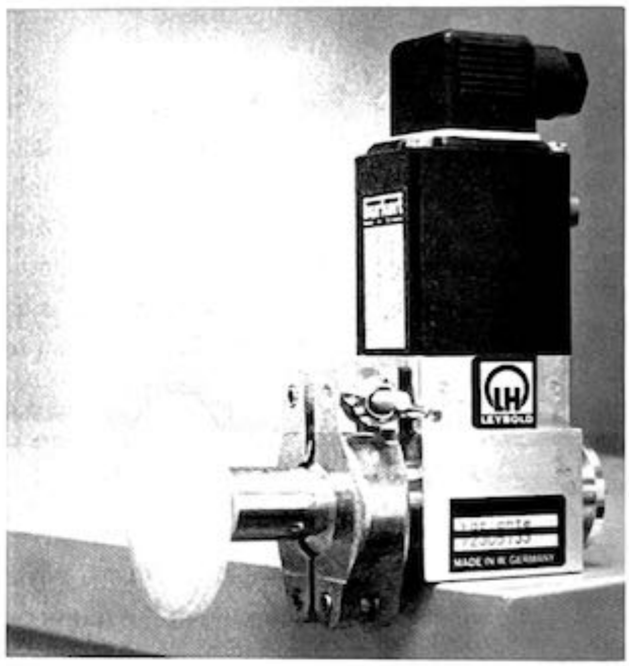

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Figure A-5. Purge/Vent Valve

The optional Purge/Vent Valve (Figure A-5) is required 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 (24 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-C.

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.

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

If you plan to use your own valve for purging and venting, ensure that it has the correct capacity (minimum 24 sccm purge/4800 sccm vent) and that it can perform both purging and venting at the pump's purge port.

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.

See Section 2.3.6.2 for installation information for the Purge/Vent Valve.

A.6 Adsorption Trap

Figure A-6. 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-6) 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.

Accessories

A.7 Vibration Damping Bellows

The optional Vibration Damping Bellows assembly (Figure A-7) 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 only available for the turbopump models with the 160 ISO-K or 160 CF high-vacuum flange. See Table IV in the front of this manual for the part numbers.

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.

Figure A-7. Vibration Damping Bellows

In addition to absorbing vibration, the 160 CF bellows is strong enough to support the weight of the pump. If the 160 ISO-K bellows or a standard bellows are used, you must provide support for the turbopump.

A.8 Air-Cooling Unit

The optional Air Cooling Unit (see Figure A-8) consists of two fans mounted on vibration dampers. This unit is mounted around the motor housing, and is secured in place from below the pump using the supplied hardware. Either a 115 or 220 VAC model can be ordered.

The maximum ambient temperature for a TMP1000 during bakeout with air-cooling is 95°F (35°C), while the ambient temperature for an unheated TMP1000 turbopump at operating pressures lower than 10^{-4} mbar is 113°F (45°C).

See Section 2.3.4.2 for the Air Cooling Unit's installation procedure.

Figure A-8. Air Cooler Mounted on the TMP1000 Base

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LEYBOLD

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 notification 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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