Vacuum Solutions Application Support Service

LEYBOLD VACUUM

GA 05.133/4.02

TURBOVAC T 1600

Turbomolecular pump with grease-lubricated ceramics ball bearings and with integrated frequency converter

Cat. Nos.
103 18
114 21 /31 /32 /38
119 11 /13 /14 /21 /22

Operating instructions

Contents

Conventions used in these instructions.

Warning

This indicates procedures and operations which must be strictly observed to prevent hazards to persons.

Caution

This indicates procedures and operations which must be strictly observed to prevent damage to or destruction of the unit.

We reserve the right to change at any time the design and data given in these Operating Instructions.
The illustrations are approximate.

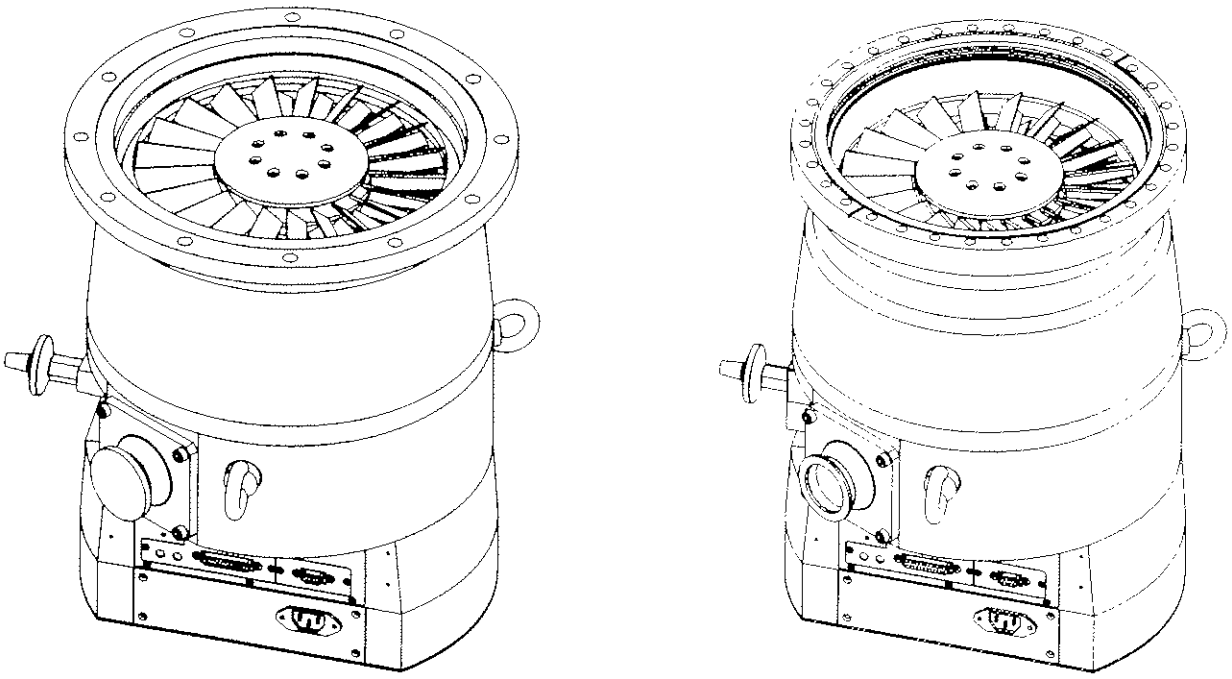

Fig. 1 TURBOVAC T 1600 with ISO-F or CF flange

1 Description

The TURBOVAC T 1600 is a turbomolecular pump featuring grease-lubricated ceramics ball bearings. It has been engineered to pump vacuum chambers down to pressures in the high-vacuum range. The frequency converter required for operation has been integrated in the pump itself. Operation of the T 1600 requires the use of a suitable backing pump.

These pumps are **not** suitable for operation without a backing pump.

Compatibility with pumped media

Turbomolecular pumps are **not** suitable for pumping either gases which contain dust particles or liquids.

Turbomolecular pumps **without** a purge gas feature are suitable only for pumping air or inert gases. They are **not** suitable for pumping aggressive or reactive gases or gases which contain particles.

For pumping of gases which are non-aggressive but which contain particles you must use the purge gas feature, see Chapter 4.2.

The T 1600 has a purge gas feature. The purge gas protects the area of the bearing and the pump's motor.

Some media (such as aluminum trichloride) can sublime inside the pump and form deposits. Thick deposits reduce the play between moving parts to the point that the pump could seize. In some processes deposits can be prevented by heating the pump. Please consult us in case such problems arise.

Corrosive gases (such as chlorine) can destroy the rotors. Pumping of such gases requires a pump specifically equipped for this kind of application.

During operation, the pressure inside the T 1600 is so low that there is no danger of an ignition (at pressures below about 100 mbar, 75 Torr). A hazardous condition will be created if flammable mixtures enter the hot pump at pressures above 100 mbar (75 Torr). During operation the pump can reach temperatures as high as 120 °C (248 °F). Sparks could occur in case of damage to the pump and these could ignite explosive mixtures.

We would be glad to consult with you as regards the media which can safely be handled with this unit.

Warning

Never expose any parts of the body to the vacuum.

1.1 Supplied Equipment

The TURBOVAC T 1600 is shipped in a sealed PE bag which also contains a desiccant. The desiccant will remain effective for about 1 year.

Included with the pump are:

- for the ISO-F high vacuum connection: splinter guard, centering ring, support ring and O-ring
- for the KF foreline connection: centering ring, clamping ring and a DN 40 KF O-ring
- for the ISO-K foreline connection: centering ring
- for the pumps equipped with a Profibus interface: a disk with the basic instrument data file (GSD)
- a mains cord with Euro plug

The purge gas connection has been sealed off. A gas filter with an adapter for screwing in have been included.

PE=Polyethylene

1.2 Ordering Data

T 1600	Cat. No.
DN 250 ISO-F / DN 40 KF	103 18 or 119 13
DN 250 ISO-F / DN 63 ISO-K	114 38 or 119 11
DN 200 ISO-F / DN 40 KF	114 21 or 119 21
DN 250 CF / DN 40 KF	on request

T 1600 with PROFIBUS	
DN 250 ISO-F / DN 40 KF	114 31 or 119 14
DN 200 ISO-F / DN 40 KF	114 32 or 119 22

Seal kit	Ref. No. 200 09 763
Mains cord with US plug	on request

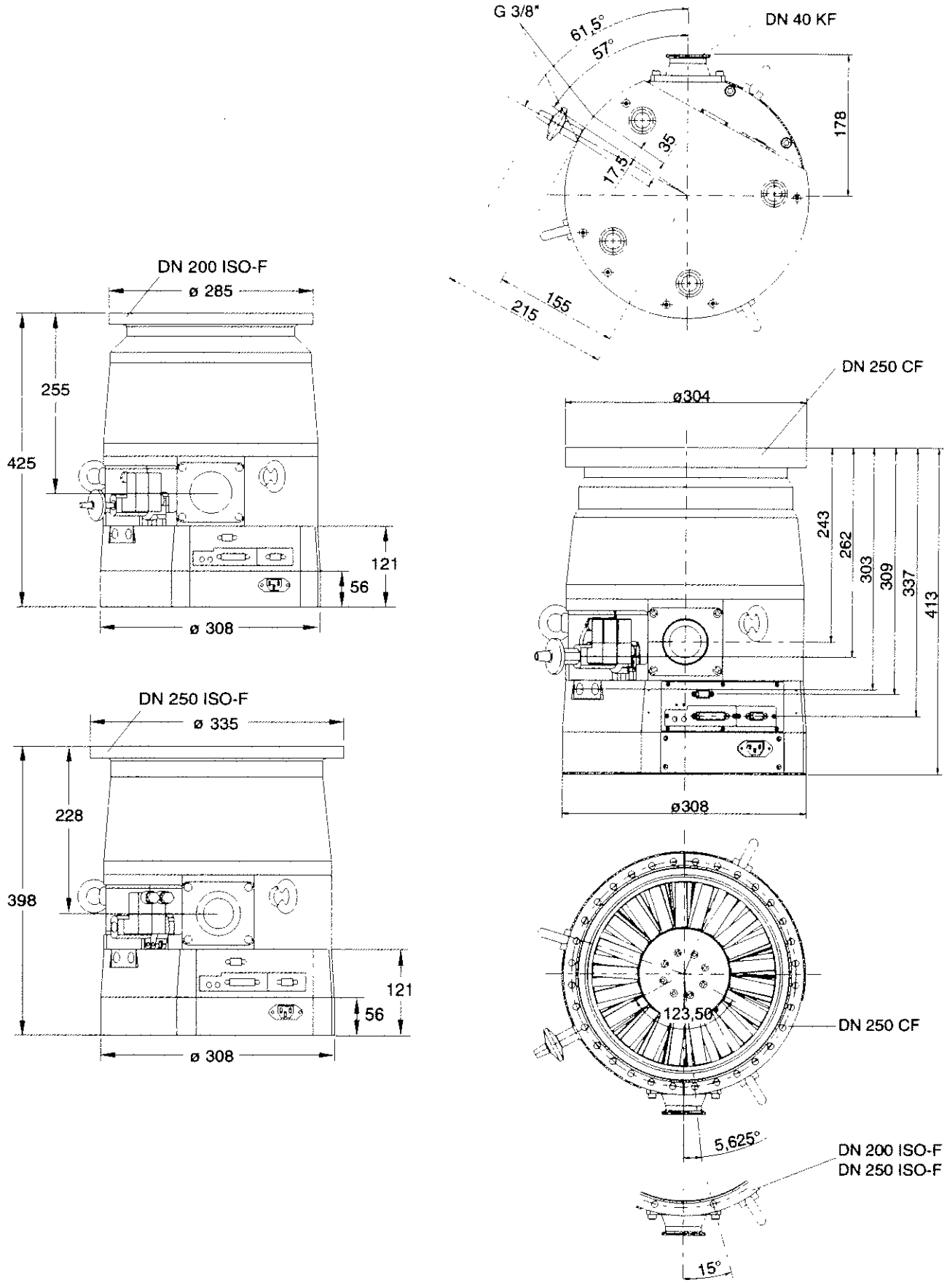

Fig. 2 Dimensional drawings for the T 1600; dimensions in mm

1.3 Technical Data

High vacuum port	DN	250 ISO-F	200 ISO-F	250 CF
Max. permissible high vacuum pressure (p_{HV}) for continuous operation	mbar	$5 \cdot 10^{-2}$	$5 \cdot 10^{-2}$	$5 \cdot 10^{-2}$
Pumping speed for N_2 at $p_{HV} \leq 10^{-3}$ mbar	$l \cdot s^{-1}$	1550	1280	1550
Forevacuum port	DN	40 KF / 63 ISO-K	40 KF	40 KF
Max. permissible forevacuum pressure (p_{VV}) at the forevacuum port for continuous operation	mbar	$5 \cdot 10^{-1}$	$5 \cdot 10^{-1}$	$5 \cdot 10^{-1}$
Max. gas throughput for continuous operation	sccm $mbar \cdot l \cdot s^{-1}$	1800 30	1400 23.3	1800 30
Nominal speed = nominal frequency	rpm Hz		30.000 500	
Minimum speed	rpm		18.000	
Run-up time	min		< 10	
Weight	kg	40	40	45
Purge gas port	G		1/4"	
Purge gas			dry ambient air or N_2	
Purge gas requirement	sccm $mbar \cdot l \cdot s^{-1}$		36 0.6	
Max. purge gas pressure, abs.	bar		1.0 - 1.5	
Max. humidity in the purge gas	ppm		10	
Cooling water connections	G		3/8"	
Cooling water requirement			See Chapter 2.4	
Voltage range, nominal mains frequency	V Hz		100 - 240 50 / 60	
Power consumption maximum while running up during normal operation without gas load	 VA VA VA		 1200 700 300	
Load rating for the relay outputs, max.	V / A		48 / 0.5	
Noise level	dB(A)		39	
Ambient temperature during operation	 ° C ° F		 0 to 40 32 to 104	
while shelved	° C ° F		- 15 to + 60 5 to 140	
Relative humidity of the air to DIN 400 40	Class		F	
Protection	IP		54	

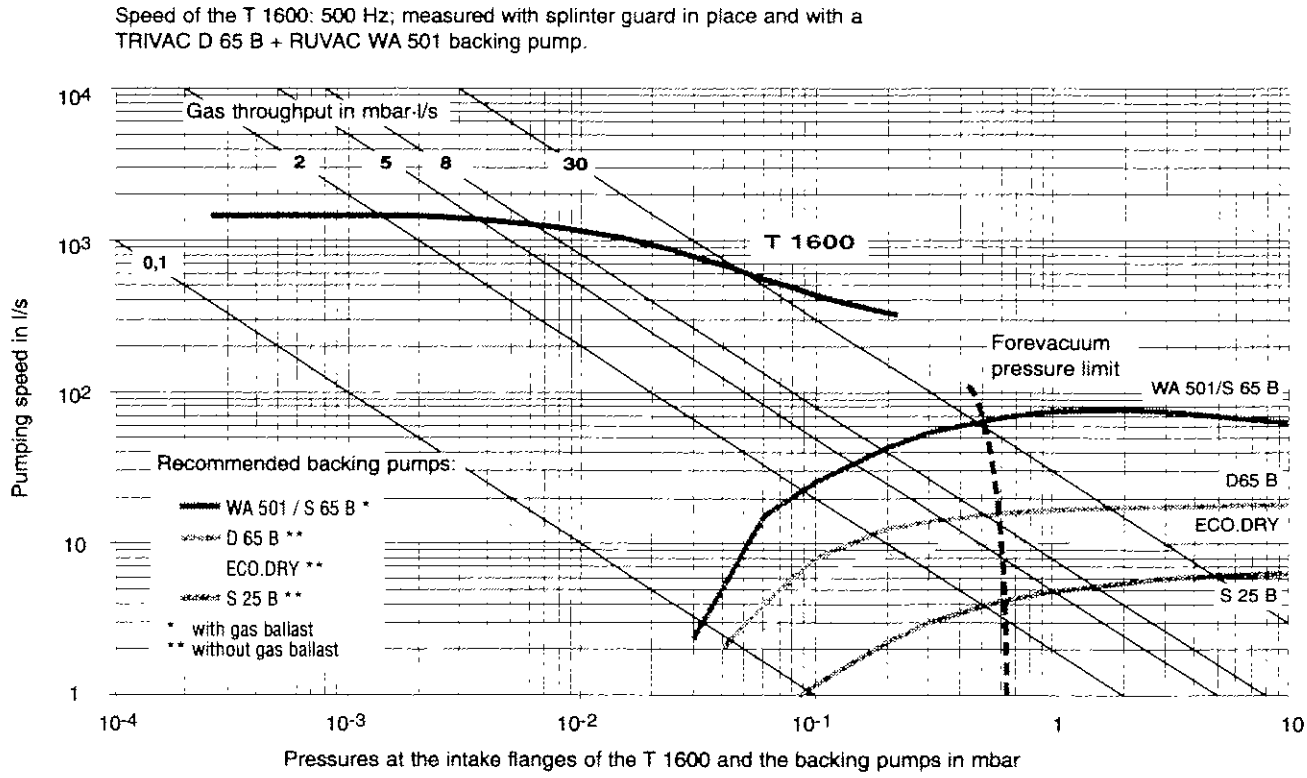

Fig. 3 Pumping speed for N_2

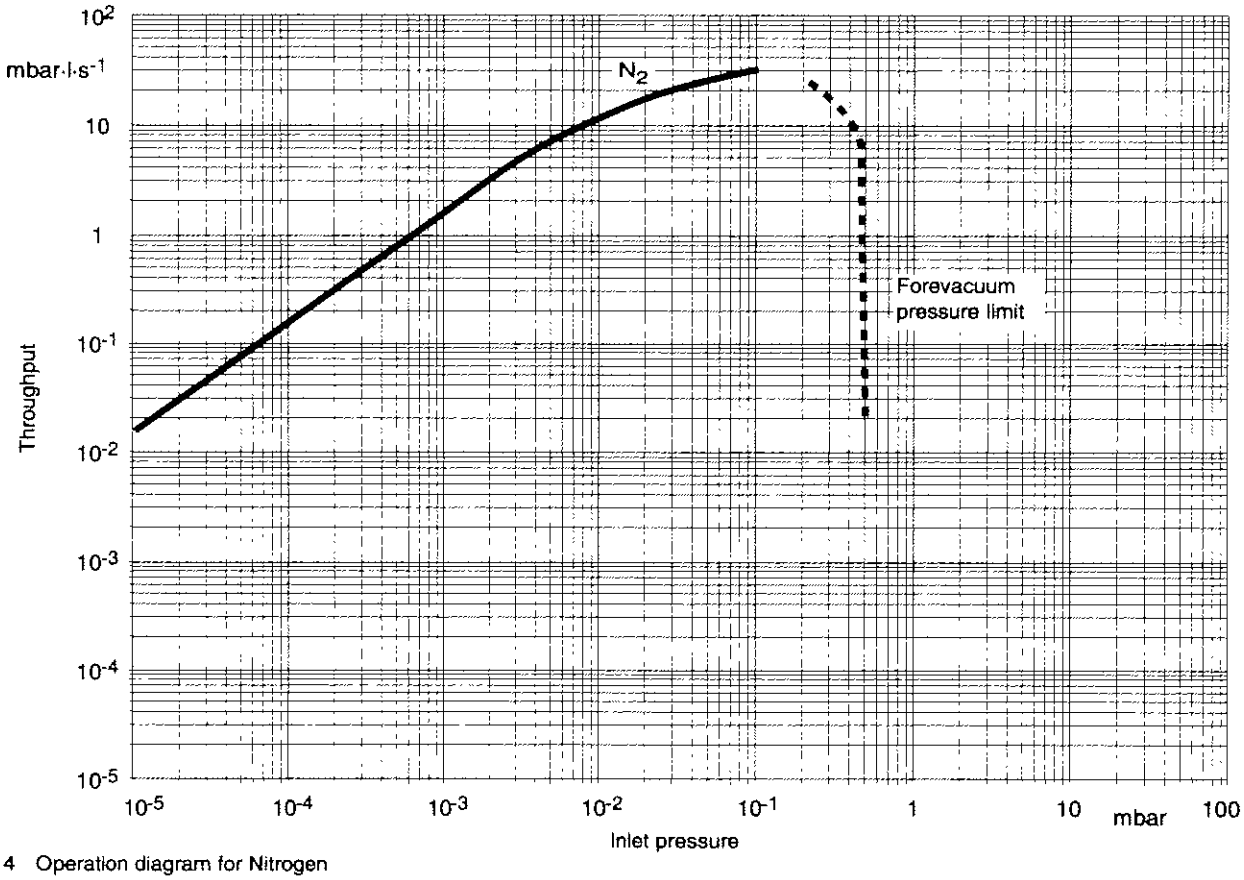

Fig. 4 Operation diagram for Nitrogen

2 Connection

Caution

When handling corrosive media the pumps must be operated with purge gas.
Observe the information on media compatibility, to be found at the beginning of these Operating Instructions and in Chapter 4.2.

Do not open the packaging until immediately prior to installation.

Remove the covers and the blank flanges at the turbomolecular pump only just before installing, to ensure that the T 1600 is installed under the cleanest possible conditions.

When moving the pump you must use the crane eyes provided on the pump.

Caution

Take care not to damage the plugs and coolant connections while handling the pump.

Do not stand below the T 1600 while it is being connected to, or detached from the system.

2.1 Operating Environment

When using the T 1600 inside a magnetic field, the magnetic induction at the pump housing surface may not exceed the following values:

B = 5 mT in case of radial impingement.
B = 15 mT in case of axial impingement.

Provide suitable shielding measures if these values are exceeded.

The standard version is resistant to radiation at levels up to 10^3 Gy.

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1 mT (milliTesla) = 10 G (Gauss)
1 Gy (Gray) = 100 rad

2.2 Connecting the Pump to the Vacuum Chamber

Remove the packing flange from the high-vacuum flange. Pay attention to maintaining maximum cleanliness during connection work.

Warning

The high-vacuum flange must be securely attached to the vacuum chamber. If the pump were to become blocked, insufficient attachment could cause the pump to break away from its mount or allow internal pump parts to be discharged. Never operate the pump (in bench tests, for instance) without it being flanged to the vacuum chamber.

If the pump should suddenly seize, the ensuing deceleration torque of up to 35,000 Nm will have to be absorbed by the system. To accomplish this, 12 bolts 8.8: M10x50 are required for the ISO-F high-vacuum flange. These bolts must be tightened to a torque of 20 Nm^{+5Nm}.

When connecting the high-vacuum flange you must use a centering ring having a **supporting ring**.

In most cases the T 1600 will be flanged directly to the high vacuum flange of the system. Due to the lubricating system used in the T 1600 this pump may be installed and operated in any orientation. Extra supports for the pump are not required.

The T 1600 has been balanced with great precision and may thus generally be operated without vibration absorbers.

Splinter guard

A splinter guard is installed in the high-vacuum flange to protect the T 1600. Never remove the splinter guard!

Operate the pump only with this splinter guard in place as foreign objects passing through the intake port and into the pump can cause serious damage to the rotor. Damage caused by foreign objects in the rotor section is excluded from the warranty.

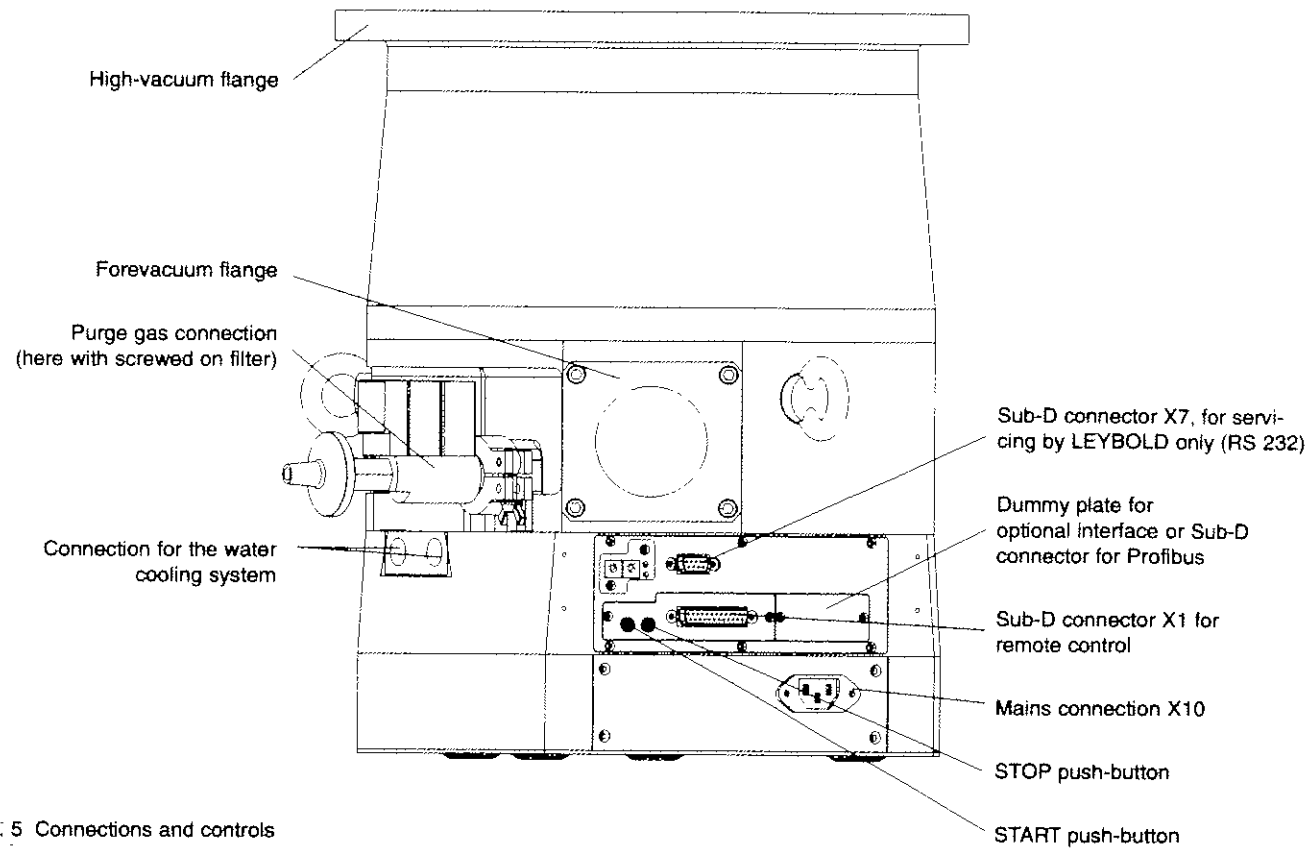


Fig. 5 Connections and controls

2.3 Forevacuum Connection

A suitable backing pump is to be connected via a vacuum line to the forevacuum connection flange. Select a backing pump and a connection line so that both forevacuum pressure and pumping speed at the forevacuum connection will be adequate during all pumping modes.

Connect the backing pump in such a manner that the T 1600 will **not** be vented from the side of the forevacuum when switching the system off or in case the backing pump fails or is at standstill. Venting the T 1600 from the forevacuum side may cause oil vapours to enter into the T 1600.

Be sure that there is sufficient vibration decoupling between the T 1600 and the backing pump.

Warning

The forevacuum line must be tight.
Hazardous gases could escape from leaks or the gases being pumped could react with air or humidity.

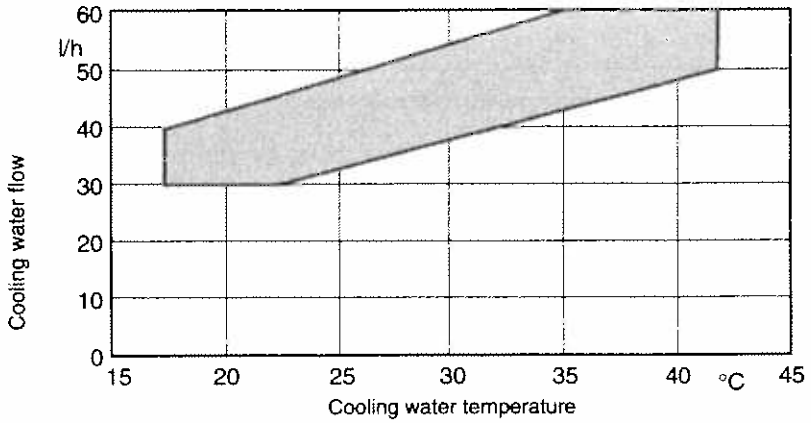


Fig. 6 Cooling water requirements

2.4 Connecting the Cooling

The T 1600 needs to be cooled with water.

Cooling water specifications

Feed temperature	20 - 40 °C 68 - 104 °F
Feed pressure	3 to 7 bar absolute
Cooling water requirement	See Fig. 6
Appearance	colourless, clear, free of oils and greases
Sediments	< 250 mg/l
Particle size	< 150 µm
pH value	7 to 8.5
Overall hardness (total alkaline earths)	max. 20 ° German hardness scale (= 3.57 mmol/l)

Further information on request.

Connecting the cooling water

Screw on the cooling water lines.

When switching the cooling water supply on and off by means of an electrically actuated valve, connect the valve so that it will be switched on and off together with the pump.

2.5 Connecting the Purge Gas and Venting Facility

The T 1600 is equipped with a purge gas and a venting valve. Depending on the kind of process either air or nitrogen may be used as the purge gas.

When using ambient air as the purge gas, screw in the supplied purge gas filter.

When using nitrogen as the purge gas, the purge gas may be connected directly at the valve or the hose nozzle of the purge gas filter.

Purge gas specifications

Required throughput	0.6 mbar·l·s^{-1} 36 sccm
Max. pressure, absolute	1.0 to 1.5 bar
Max. humidity	10 ppm

The purge gas and venting valve can only be opened via control connector X1 or the Profibus interface. Thus when operating the pump via the START and STOP push-buttons no purge gas and venting gas may be admitted into the pump via the purge gas valve.

Warning

Monitor the purge gas at all times. An insufficient flow of purge gas may
- cause process gases to enter into the motor and bearing volume of the pump or
- process gases may be ejected from the purge gas valve or
- humidity may enter into the pump.

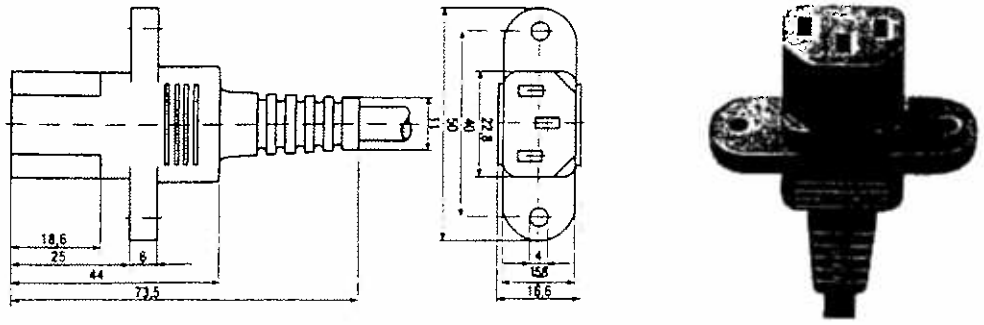


Fig. 7 Mains plug

2.6 Electrical Connection

In the case of all electrical connections the plugs can be protected against coming loose on their own when using the right kind of plug.

Insert the mains cord at X10 and connect it to the mains.

In order to protect the mains cord against coming loose, use the supplied mains cord or a plug in line with the recommendations provided in Fig. 7.

Caution

Compliance with IP 54 is only ensured with all plugs in place and only when using suitable plugs.

The RS 232 interface at connector X7 is only to be used during servicing by Leybold.

When no operation with purge gas is required you may operate the pump via the START and STOP pushbuttons; see Chapter 4.

How to connect the control connector X1 is described in Chapter 2.7. When the pump is being operated via the control connector X1, it can no longer be operated via the START and STOP pushbuttons.

For information on the Profibus interface see Chapter 3. When the pump is being operated via the Profibus interface, it can no longer be operated via the START and STOP pushbuttons or via the control connector X1.

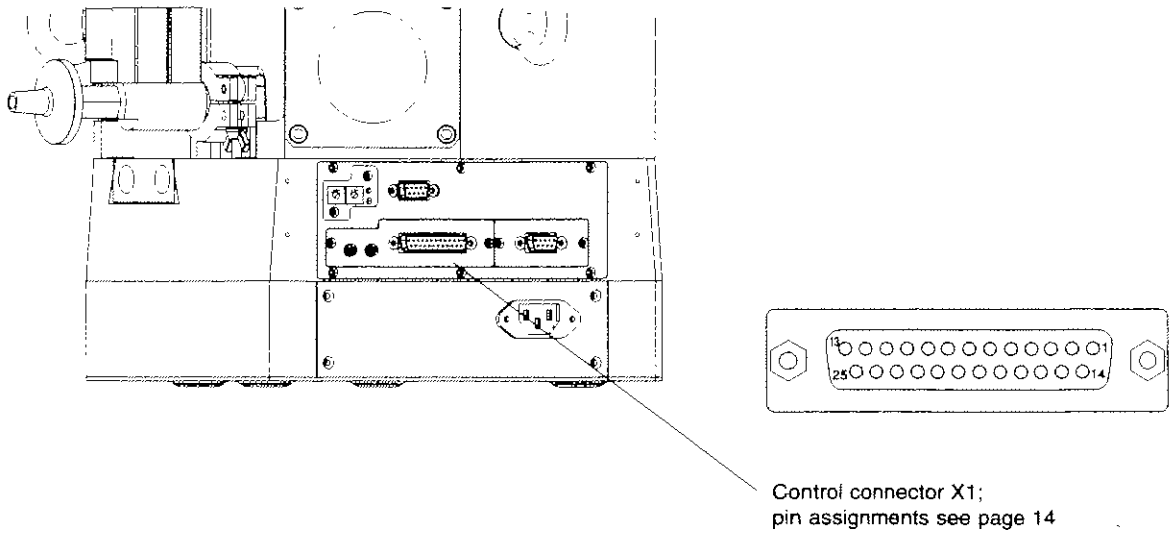


Fig. 8 Control connector X1

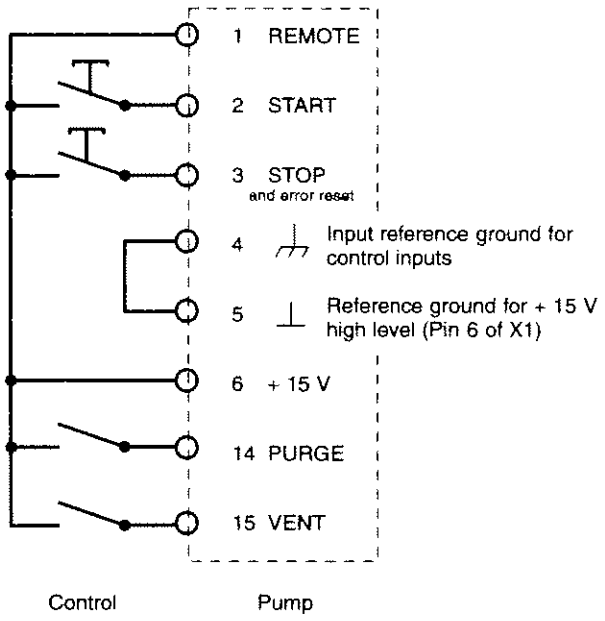


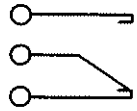
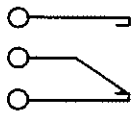
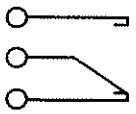
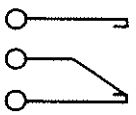
Fig. 9 Example of how to connect a remote control box.

2.7 Connecting the control connector

Connect control connector X1. The pin assignments are provided on page 14. Given in Fig. 9 is an example of how to connect a remote control unit. Instead of switches, relays may also be used in the remote control unit.

For an overview on the relays see next page.

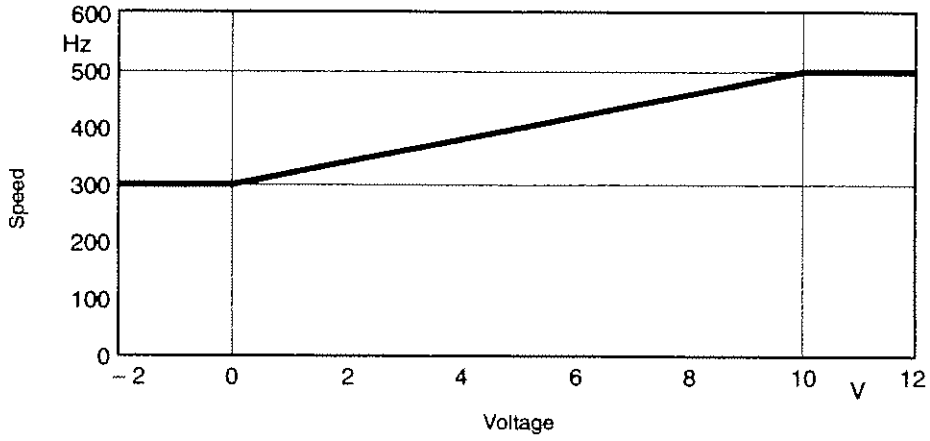
Relays

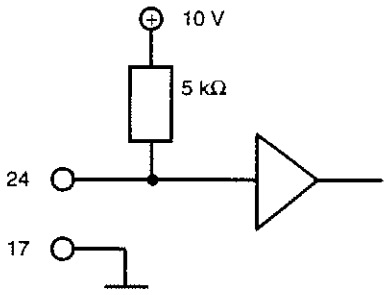
Pin	Relay		Possible cause	
18 19 20	Warning n.o. Warning com. Warning n.c.		Motor power of the pump is too great due to excessively high pressures or gas throughput. Because of excessive loading the pump is not able to maintain its nominal speed. The temperature at one bearing is too high. The temperature of the motor is too high. The self test of the frequency converter which is run upon applying the mains power will indicate that maintenance is due. Upon applying the mains power it was found that the clock is faulty (possibly an exhausted battery).	"Too high" means that the measured values are significantly higher than those for normal operation and that in the case of further operation the operator will have to expect that the pump will shut down.
8 9 21	Fault n.o. Fault com. Fault n.c.		Pump was overloaded for quite some time. The minimum speed was not attained within a certain time. Speed has dropped below the minimum. Motor or bearing temperatures have exceed the limit. Internal electrical fault.	As soon as this relay is activated the pump is shut down. Note: The relay picks up when the pump is in undisturbed operation.
10 11 23	Normal n.o. Normal com. Normal n.c.		Rotor speed has attained 95% of its nominal speed. (= normal operation)	
12 13 25	Pump running n.o. Pump running com. Pump running n.c.		Speed of the pump > 3 Hz (Pump has not yet arrived at standstill)	

Pin assignment for the control connector X1 (female)

Pin	Assignment	Description for the signal	
1	Floating control input	Remote control [H]	must be [H] so that the inputs Start [H], Stop [H], purge gas [H], venting [H] are enabled, disables START/STOP via the push-buttons
2	Floating control input	Start [H]	High pulse from prog. cont. starts the pump (pulse ≥ 1 s)
3	Floating control input	Stop [H]	High pulse from prog. cont. stops the pump (pulse ≥ 1 s)
4	Floating	Reference ground for the floating control inputs	
5	Power supply ground	Reference ground for prog. cont. H level (pin 6)	
6	Prog. cont. H signal	Prog. cont. H level with reference to pin 5, ≥ +15 V, 80 mA max.	
7	Analogue output	Programmable analogue output, range: 4 to 20 mA adjustable to; bearing temperature top / bottom, motor current, speed default: bearing temperature top (4 mA = 0 °C / 20 mA = 100 °C) Set-up: see parameter 30 (function) and parameter 31 (range), can be set up through Profibus interface or service PC via RS 232 (X7)	
8	N.O. contact	Error relay	General error indication; active when no error is present
9	Common contact	Error relay	General error indication
10	N.O. contact	Normal operation relay	Full speed almost reached; activated when setpoint frequency has been reached
11	Common contact	Normal operation relay	Full speed almost reached
12	N.O. contact	Pump running relay	Active at speeds ≥ 3 Hz
13	Common contact	Pump running relay	Active at speeds ≥ 3 Hz
14	Floating control input	purge gas [H]	Prog. cont. H activates purge gas valve
15	Floating control input	Venting [H]	Prog. cont. H activates venting valve
16	Not used		
17	Analogue ground	Reference ground for analogue input and output (pin 7 and pin 24)	
18	N.O. contact	Warning relay	General error indication; active when warning is present
19	Common contact	Warning relay	General error indication
20	N.C. contact	Warning relay	General error indication; active when no warning is present
21	N.C. contact	Error relay	General error indication; active when no error is present
22	Floating control input	Standby [H]	Enables standby speed (standby speed is defined through parameter 150; see list of parameters)
23	N.C. contact	Normal operation	Full speed almost reached; active when setpoint
		relay	frequency has been reached
24	Analogue input	Speed setpoint	0 V = minimum speed (parameter 20, default 300 Hz) 10 V = nominal speed (parameter 24, default 500 Hz) Input open : Nominal speed, proportional increase
25	N.C. contact	Pump running relay	Active at speeds ≥ 3 Hz
S	Shield	Connected to chassis ground and PE Caution: do **not** use for potential equalisation or ground connection.	

Prog. cont. = programmable control
[H] high level 13 ... 30 V
[L] low level 0 ... 5 V





If pin 24 is not connected the normal operation speed is 500 Hz as default.

Pin 24 is connected to an internal + 10 V supply via a 5 kΩ protective resistor resulting in a current of approx. 2 mA at 0 V at pin 24. Design the control supply corresondingly.

Fig. 10 Analogue input

3 Profibus DP

Upon request the T 1600 pump may be equipped with a field bus interface Profibus DP. Through this interface, process automation equipment may easily be hooked up in a network.

The field bus system Profibus DP is described in the standard EN 501 70 (corresponding to the previous standard DIN 19245 Part 1 and Part 3). The engineering and functional features of the Profibus DP have been laid down here. In the case of Profibus DP a difference is made between master and slave units. In this case the master units define the data traffic. They transmit data to the assigned slaves and request data from these. There exists the possibility of operating one or several masters in a system.

The T 1600 pump is a slave unit and thus responds when queried by the master. Thus it only supplies data when requested by the master to do so.

GSD - Basic instrument data file

Documented in the GSD file are the capabilities and the scope of the performance offered by a Profibus DP unit. The file format has been laid down in the standard so that software tools of different manufacturers may be used.

The current GSD file is on a disk which has been included with the pump. In addition, the contents of the GSD file are documented in the Annex to these Operating Instructions.

3.1 Connection

Connect the Profibus via the Profibus DP interface; see Fig. 11.

At the ends of the bus, a terminating resistor must be connected. This is done by means of a special connector. The connections required for this are present in the interface plug. For this refer to the standard.

Use the bus cable SIEMENS-SINEC-L2 for the bus.; P/N. 6XV1830-0AH10.

Transmission rate (in kBits/s)	Max. length of a segment (in m)
9.6 - 93.75	1200
187.5	1000
500	400
1500	200
3000 - 12000	100

The length of a segment may be extended by using RS-485 repeaters; for example SINEC L2 Repeater RS 485; P/N 6GK1510-OAC00.

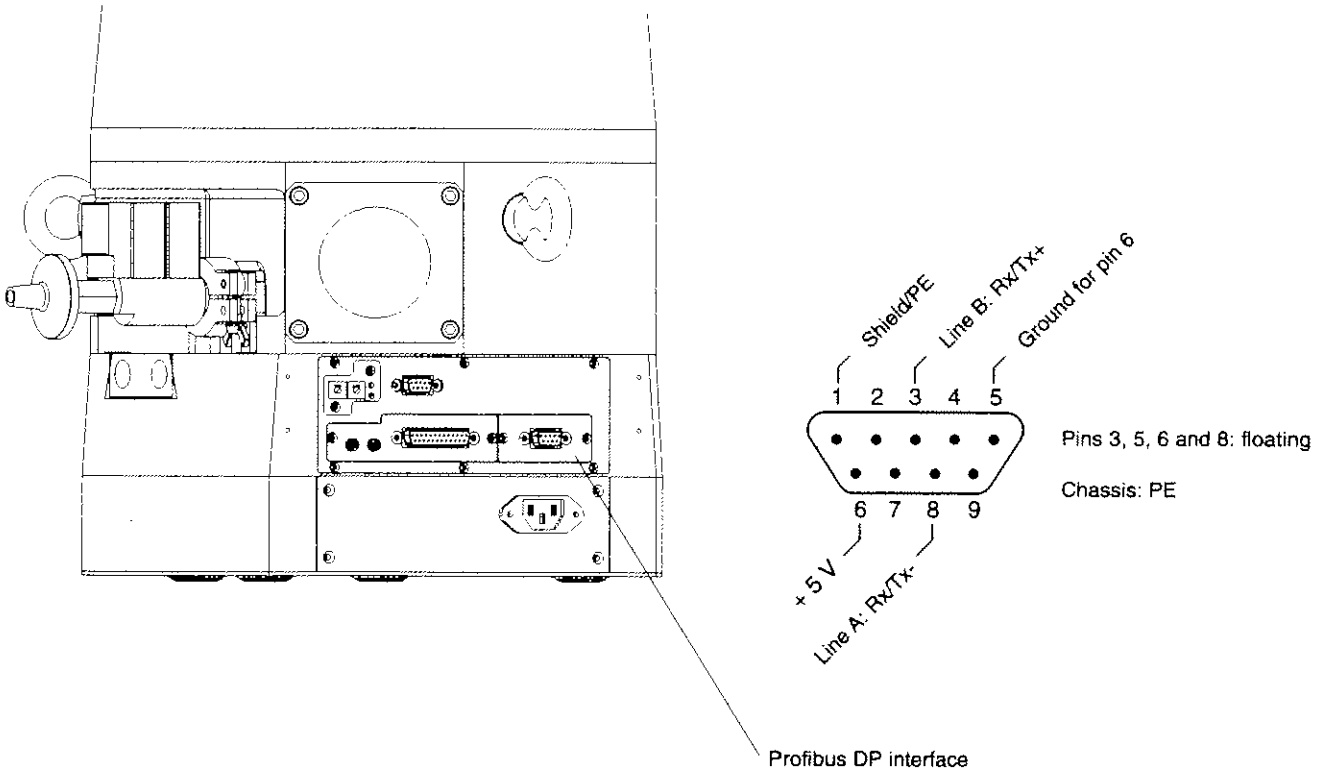


Fig. 11 Profibus DP interface

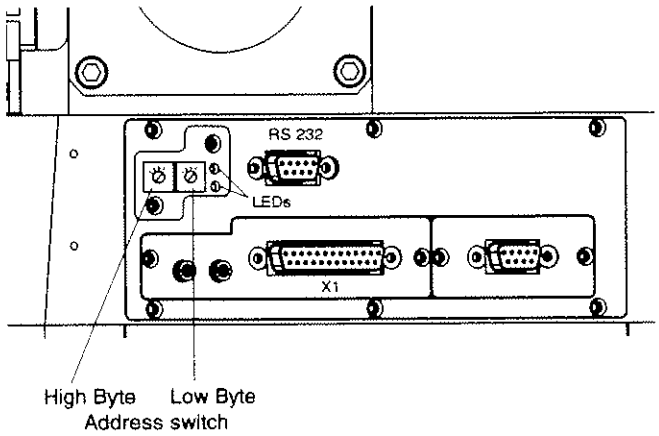


Fig. 12 Setting up the slave address

Supported Baud rates

9.6	k Baud
19.2	k Baud
45.45	k Baud
93.75	k Baud
187.5	k Baud
500	k Baud
1.5	M Baud
3	M Baud
6	M Baud
12	M Baud

The baud rate is adjusted automatically. No parameter or switch needs to be set.

Extended user parameter data are not required.

The sync. mode and the freeze mode are supported.

Slave address

The slave address is set up through two address switches; see Fig. 12.These address switches may be accessed after removing the transparent Plexiglas cover. After having set up the address, fit the Plexiglas cover once more so as to maintain the IP 54 protection rating specified for the pump.

The address switches are set according to hexadecimal codes resulting in a range from 03_{hex} to $7E_{hex}$ ($7E_{hex}$ = 126_{dec}).

The address which has been set up will only become effective after switching the unit on.

3.2 Configuration (PPO types)

For the T 1600, several different protocol types (PPO types) have been implemented.

PPO Type 1

Number of input and output data 6 words each = 12 byte

Identifier = 0xF3, 0xF1 (net. data assignment see VDI/VDE standard 3689, page 29).

For the way in which the control and status words are assigned in accordance with VDI/VDE standard 3689 page 14 to page 16; see Fig. 13 and 14.

Byte 0	Parameter order or reply and 3 most significant bits of the parameter number.
Byte 1	Parameter number (Low byte)
Byte 2	Parameter index for error data (P171 ... P174, otherwise always 0
Byte 3	Not used
Byte 4 to 7	Parameter value (high .... low)
Byte 8 and 9	Control and status word, same as for PPO type 6
Byte 10 and 11	Setpoint or actual value (target speed; bit 6 of the control word must be set to „1").

Remark: In the case of the word definition, the high byte is transmitted first (Motorola standard).

* In order to activate the control function through the Profibus interface, bit 10 must be set in the case of PPO types 1 or 6. Control via the control connector X1 or via the push-buttons is then disabled.

PPO type 6

Number of input and output data 1word each = 2 byte

Identifier = 0x00, 0xF0 (1 control word + 1 status word).

Control word for T 1600

Bit	
0	*Start pump
1 to 5	Not used
6	*Enable set point —(enable the principal setpoint (speed) in the case of PPO type 1; set always to „0" in the case of PPO type 6)
7	*Acknowledge error
8	*Standby speed
9	Not used
10	Enable process data (bit 0, 6, 7, 8, 11, 12)
11	*Purge gas ON
12	*Venting ON
13/14/15	Not used

Status word from the T 1600

Bit	
0	Ready to switch on
1	Always 0
2	Operation enabled — (converter active)
3	Error active
4	Not used
5	Not used
6	Switch on lock
7	Temperature warning
8	Not used
9	Not used
10	Normal operation
11	Pump is running (speed over 3 Hz)
12	Maintenance is required
13	Overload warning
14	Not used
15	Not used

PPO type 7

Number of input and output data 1 byte each

Identifier = 0x00, 0xB0 (1 control byte and 1 status byte)

Control byte for the T 1600

Bit	
0	*Start pump
1	Not used
2	Enable process data (bit 0, 4, 5, 6 and 7)
3	Not used
4	*Purge gas ON
5	*Venting ON
6	*Go to standby speed
7	*Acknowledge error

Status byte from the T 1600

Bit	
0	Normal operation has been attained
1	Pump is running (speed over 3 Hz)
2	Maintenance is required
3	Error active
4	Not used
5	Not used
6	Overload warning
7	Temperature warning

* In order to activate the control function through the Profibus interface, bit 2 must be set in the case of PPO type 7. Control via the control connector X1 or via the push-buttons in then disabled.

Parameter range (PKW)

Through the PKW feature it is possible to process the following:

- Operation and observation of parameters (write/read)
- Transmission and acknowledgement of spontaneous messages

The parameter range always comprises 4 words; see Fig. 14.

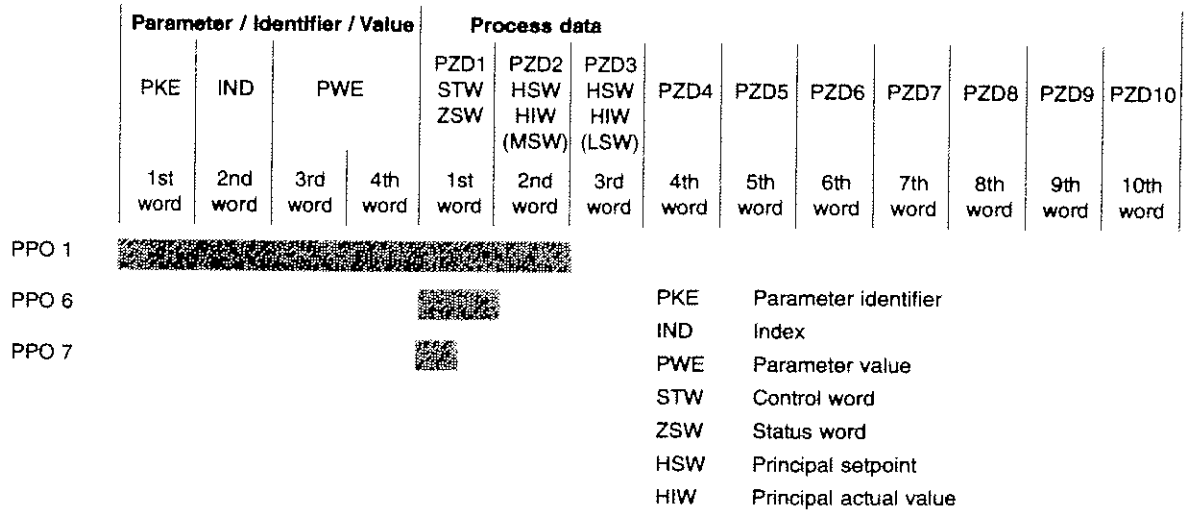
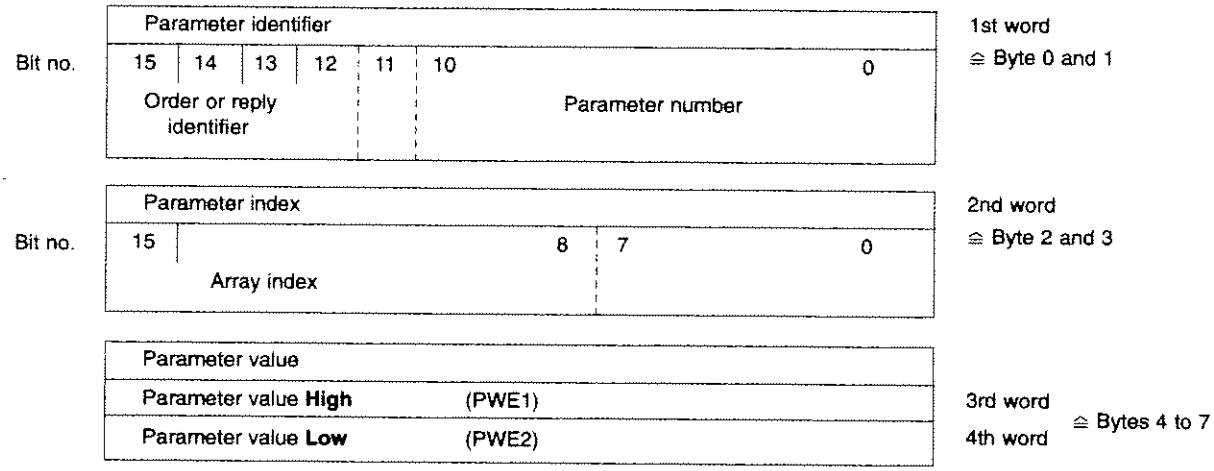


Fig. 13 Parameter process data object (PPO Types)



Note: Parameter values having a length of 16 bits are transmitted through parameter value low (PWE2).

Fig. 14 Structure of the parameter range (PKW = parameter identifier value)

Parameter identifier (PKE) (1st word)

The parameter identifier (PKE) is always a 16 bit value. The bits 0 to 10 (PNU) contain the number of the desired parameter. For the meaning of each parameter see list of parameters.

Bit 11 = 0 (reserved)

Bits 12 to 15 (AK) contain the order or reply identifier.

Meaning of the order identifier for the order message (master → main electronics or converter)

Order Identifier	Meaning	Reply identifier positive	Reply identifier negative
0	No order	0	7 or 8
1	Query parameter value	1 or 2	7 or 8
2	Change parameter value (word)	1	7 or 8
3	Change parameter value (double word)	2	7 or 8
4	Query descriptive element [1] (not for 181 35)	3	7 or 8
5	Change descriptive element (not for 181 35)	3	7 or 8
6	Query parameter value (array) [2]	4 or 5	7 or 8
7	Change parameter value (array, word) [2]	4	7 or 8
8	Change parameter value (array, double word) [2]	5	7 or 8
9	Query number of array elements	6	7 or 8
10			
11			
12			
13			
14			
15			

Meaning of the order identifier for the reply message (main electronics or converter → master)

Reply identifier	Meaning
0	No reply
1	Transmit parameter value (word)
2	Transmit parameter value (double word)
3	Transmit descriptive element[1]
4	Transmit parameter value (array, word)[2]
5	Transmit parameter value (array, double word)[2]
6	Transmit number of array elements
7	Order can not be executed (with error number)
8	Not authorised for PKW interface
9	
10	
11	
12	
13	
14	
15	

Depending on the order identifier only certain reply identifiers are possible. If the reply identifier has a value of 7 (order can not be executed), then an error number will be available under parameter value 2 (PWE 2).

Parameter index IND (2nd word)

The index complies to the Profibus standard VDI/VDE 3689.

1) The desired element of the parameter description is stated in IND (2nd word).
2) The desired element of the indexed parameter is stated in IND (2nd word).

3.3 List of parameters

No.	Designation	Range	Unit	Default	Type	Access
0	Not used	-	-	0	-	
1	Unit identifier	100 - 102	-	102	u16	r
2	Software version	02.01.01 - 6.55.35	0.00.00	2.03.05	u16	r
3	Actual value of the frequency	0 - 510	Hz	0	u16	r
4	Intermediate circuit voltage Uzk	0 - 100.0	0.1V	591	u16	r
5	Actual value of the motor current	0 - 100.0	0.1A	0	u16	r
6	Power	0 - 6553.5	0.1W	0	u16	r
7	Actual value of the motor temperature	0 - 250	°C	23	s16	r
11	Actual value of the converter temperature	0 - 100	°C	29	s16	r
12	Operating mode 0 = Key pad or control connector 1 = Serial interface 2 = Serial interface and STOP push-button	0 - 2	-	0	3 Bits	r/w
13	Remote/local 0 = Local (key pad) 1 = Remote (control connector)	0 - 1	-	0	1 Bit	r
16	Warning temperature for the motor	0 - P133	°C	80	u16	r
17	Nominal current for the motor	0 - 31.9	0.1A	80	u16	r
18	Nominal frequency	0 - 500	Hz	500	u16	r
19	Minimum frequency	0 - P18	Hz	300	u16	r
20	Frequency threshold for run-up until minimum frequency; shutdown frequency at overload	P19 - P18	Hz	280	u16	r
21	Motor current threshold: is checked after P32 seconds for P17 x P12; in case the current is exceeded: overload warning	1 - 100	%	73	u16	r
22	Run-up time until shut down frequency (P20)	0 - P32	s	360	u16	r
23	Pump model (T 1600 = 20)	20 - 30	-	20	u16	r
24	Setpoint frequency	P20 - P18	Hz	500	u16	r/w
25	Nominal operating factor of the setpoint frequency P24 but > P20	35 - 99	%	95	u16	r/w
30	Mode for the analogue output 0 = Bearing temperature, top 1 = Bearing temperature, bottom 2 = Motor current 3 = Frequency	0 - 3	-	0	u16	r/w

No.	Designation	Range	Unit	Default	Type	Access
31	Ranging S factor for the analogue output 1.0	0 - 2.0	0.1	10	u16	r/w
32	Max. run-up time; max. overload time	600 - 3600	s	600	u16	r/w
34	General status Bit 0: bearing change	0 - 65535	-	0	u16	r
36	Start delay time	0 - 1200	s	-	u16	r/w
38	Number of start bits	0 - 65535	-	-	u16	r
40	Number of all errors	0 - 65535	-	-	u16	r
41	Number of errors relating to overloads	0 - 65535	-	-	u16	r
42	Number of errors relating to motor temperature	0 - 65535	-	-	u16	r
43	Number of errors relating to mains failures	0 - 65535	-	-	u16	r
44	Number of operating hours for the pump	0 - 167772.16	0.01h	-	u32	r
50	Cat. No. of the pump	0 - 16777216	-	11421	u32	r
52	Serial number of the pump	0 - 16777216	-	27600	u32	r
54	Manufacturing date	0 - 1677.72.16	0.00.00	101198	u32	r
56	Service date	0 - 1677.72.16	0.00.00	10198	u32	r
58	Service identifier	0 - 16777216	-	0	u32	r
60	Operating hours counter at last maintenance	0 - 167772.16	0.01h	0	u32	r
62	Repair date	0 - 1677.72.16	0.00.00	10198	u32	r
64	Repair identifier	0 - 16777216	-	0	u32	r
66	Operating hours at last repair	0 - 167772.16	0.01h	0	u32	r
68	Service center identifier	0 - 16777216	-	0	u32	r
70	Customer identifier	0 - 16777216	-	0	u32	r
72	Inspector identifier	0 - 16777216	-	31	u32	r
84	Serial number for the converter	0 - 65535	-	5	u16	r
85	Serial number for the power supply unit	0 - 65535	-	6	u16	r
86	Option converter 1	0 - 65535	-	0	u16	r
87	Option converter 2	0 - 65535	-	-	u16	r
125	Bearing temperature top, actual value	0 - 100	°C	21	u16	r
126	Warning temperature bearing top	0 - P131	°C	70	u16	r
127	Bearing temperature bottom, actual value	0 - 100	°C	23	u16	r
128	Warning temperature bearing bottom	0 - P132	°C	65	u16	r

No.	Designation	Range	Unit	Default	Type	Access
131	Shut down temperature bearing top	0 - 100	°C	75	u16	r
132	Shut down temperature bearing bottom	0 - 100	°C	70	u16	r
133	Shut down temperature motor	0 - 140	°C	100	u16	r
150	Standby speed	P20 - P24	Hz	350	u16	r/w
151	Enable standby 0 = Normal operation 1 Standby speed	0 - 1	-	0	u16	r/w
152	Acknowledge maintenance of moving parts Write „1" and reset to „0" within 1 minute	0 - 1	-	-	u16	r
153	Acknowledge bearing exchange Write „1" and reset to „0" within 1 minute	0 - 1	-	-	u16	r
160	Set clock: Write „1" and reset to „0"	0 - 1	-	0	u16	r/w
161	Real time seconds	0 - 59	-	7	u16	r/w
162	Real time minutes	0 - 59	-	25	u16	r/w
163	Real time hours	0 - 23	-	8	u16	r/w
164	Real time days	1 - 31	-	10	u16	r/w
165	Real time months	1 - 12	-	11	u16	r/w
166	Real time years	1991 - 2089	-	1998	u16	r/w
167	Real time clock	0 - 2359	-	825	u16	r
168	Real time date	01.01.00 - 31.12.99	-	101198	u32	r
171	Error number (0..39) See Chapters 3.4 and 3.5	0 - 55	-	-	u16	r
172	Error date (0..39) See Chapter 3.5	0 - 31.12.99	-	-	u32	r
173	Error time (0..39) See Chapter 3.5	0 - 23.59	-	-	u16	r
174	Error frequency (0..39) See Chapter 3.5	0 - 510	Hz	-	u16	r
227	Warning_bits 1, see Chapter 3.6	0 - 65535	-	-	s16	r
228	Warning_bits 2, reserved	0 - 65535	-	-	s16	r
918	Active Profibus address	3 - 126	-	-		
947	Current error number	0 - 55	-	0		
967	Control word (USS, Profibus)	-	-	-		
968	Status word (USS, Profibus)	-	-	-		

Access: r: read only; r/w: read and write

3.4 Error memory

No.	Description	Shut down	Remark/Condition (P = parameter)
0	No error	—	
1	Overload (load limit has been exceeded)	no	P3 < P25 x P24
2	Motor temperature too high	yes	P7 > P133
3	A mains failure has occurred	no	P4 <
4	Converter temperature too high	yes	P11 > 74 °C
5	The pump has been running at overspeed	no	P3 > (P24 + 10 Hz)
6	Speed has fallen below shutdown frequency threshold at overload	yes	P20 > P3
7	Max. run-up time has been exceeded	yes	(P3 > P25 x P24) not reached in P32
8	Error in the communication identifying the pump	yes	Internal electronic error
9	Temperature at bearing 1 top too high	yes	P125 > P131
10	Temperature at bearing 2 bottom too high	yes	P127 > P132
16	Max. overload time has been exceeded	yes	(P3 < P25 x P24) for longer than P32
17	No motor current	yes	
19	Run-up time exceeded	yes	P20 not reached in P22
25	Overload operation	no	P5 > P17 x P21
26	Short circuit in the temperature sensor for the top bearing	yes	P125 < 1 °C
27	Short circuit in the temperature sensor for the bottom bearing	yes	P127 < 1 °C
28	Short circuit in the temperature sensor for the motor	yes	P7 < 1 °C
29	Maintenance of moving parts is required	no	The T 1600 will indicate this warning every 48,000 operating hours. This maintenance can only be done by Leybold Service.
31	Max. overload time has been exceeded	yes	P5 > P17 x P21 for longer than 2 x P32
43 to 55	Internal error	yes	If you experience one of the error codes 43 to 55, you should check operation of the T 1600 for safety reasons. Please contact us in such a case.

3.5 Real time clock - error memory

In pump memory block 8, the past 40 errors are saved (ring counter). This block contains 8 bytes indicating the following (sequence MSB → LSB)

1 byte error number: see Chapter 3.4 „Error memory"

3 byte date of the error (day, month, year) in **decimal code** (140201 indicates Feb. 14 (20)01)

2 byte time of the error (hour, minute) in **decimal code** (1345 is 13.45 hours)

2 byte frequency upon occurrence of the fault

Processing of the data relating to the internal clock is ensured until the year 2090.

The parameter 171 (with index 0 to 39) contains the error number.

The parameter 172 (with index 0 to 39) contains the date of the error.

The parameter 173 (with index 0 to 39) contains the time of the error.

The parameter 174 (with index 0 to 39) contains the frequency at which the error occurred.

If one of the parameters 171 to 174 under an index is queried for the first time, the data for this index need to be requested from the pump's memory first. This results in slight delay for the first access. All further accessing to this index is performed at full speed until there are new entries in the error memory.

3.6 Warnings relating to Parameters

The parameter 227 (Warning_bits 1) has been assigned as follows:

P227 Bit	Meaning	Remark
0	Motor temperature	if P7 > P16
1	Converter temperature	if P11 > 64
2	Temperature bearing 1 (top)	if P125 > P126
3	Temperature bearing 2 (bottom)	if P127 > P128
4	—	not used
5	PK communication	read or write
6	Overspeed	if P3 > (P24+10 Hz)
7	—	not used
8	Overload	P32 seconds after starting if P5 > (P17 x P21)
9	Maintenance for moving parts	if P44 > (P60+48000h)
10	Bearing change	if P125 > P131 or P127 > P132

3.7 Acknowledging errors

An error can only be acknowledged if

- the cause for the error no longer persists (for example because the pump has cooled down)
- the frequency of the pump has dropped below 25 Hz and
- no Start command is present.

Operating mode LED	Normal	Warning	Fault
Run-up or shut down	LED flashes green	LED flashes 1x red & 2x green	LED flashes 2x red and 1x green
Normal operation	LED is green	LED flashes 1x red &1x green	
Pump has stopped	—	LED flashes red	LED is red

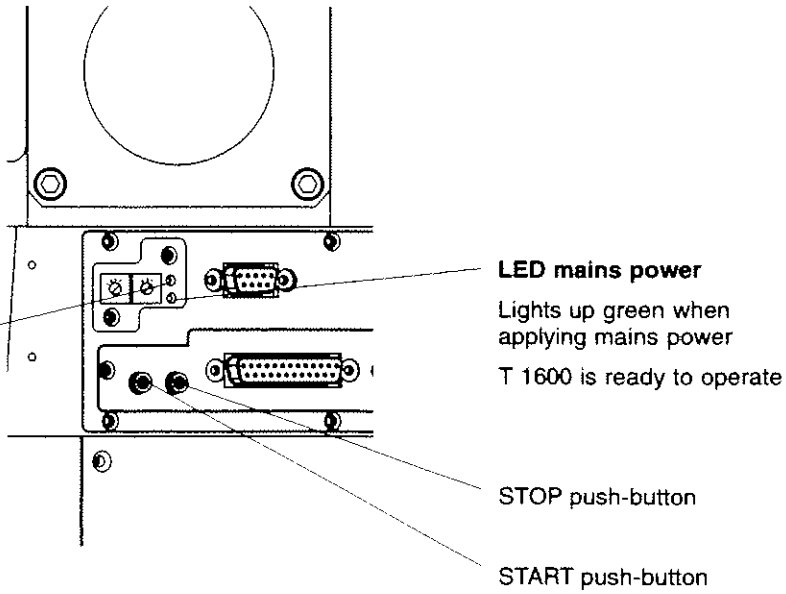
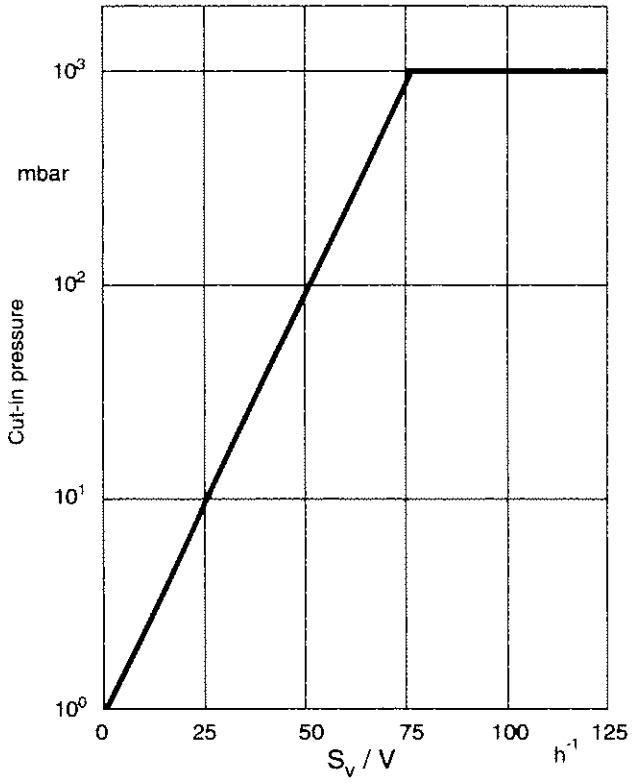


Fig. 15 LEDs and controls



Sv = Pumping speed of the backing pump ($m^3 \cdot h^{-1}$)
V = Volume of the vessel (m^3)

Fig. 16 Determining the cut-in pressure for a T 1600 when evacuating large volumes

4 Operation

The pump may be operated in three different ways:

1. **Via the START and STOP push-buttons;** see Chapter 4. However, in this mode no purge gas may be admitted and the pump can not be vented via the purge gas valve.
2. **Via control connector X1;** see Chapters 2.7 and 4. When the pump is being operated through the control connector X1, it can then no longer be operated using the START and STOP push-buttons.
3. **Via the Profibus interface;** see Chapters 3 and 4. When the pump is being operated through the Profibus interface, it can then no longer be operated using the START and STOP push-buttons nor can it be controlled through the control connector X1.

4.1 Start-Up

Open the cooling water and purge gas supplies.

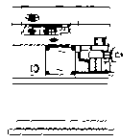
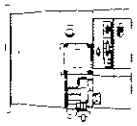
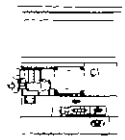
Large vessels must first be evacuated by the backing pump or a backing pump system.

In the case of smaller vessels the cut-in pressure for the T 1600 may be taken from Fig. 16.

If S_V / V > 75 [h^{-1}] then both T 1600 and the backing pump may be switched on simultaneously.

Operate the START push-button or start the pump via the interface.

Table: Purge gas operation depending on *- the installation orientation of the turbomolecular pump*
- the particle content and
- the pumping process step

Installation orientation of the turbomolecular pump	Particles	Purge gas operation during the pumping process step		
		Pumping	Continuous operation	Venting
 vertical (headover) on top of the vacuum vessel	none slight high	no yes yes	no no yes	no yes yes
 horizontal to the side of the vacuum vessel	none slight high	no yes yes	no no yes	no yes yes
 vertical at the bottom of the vacuum vessel	none slight high	no yes yes	no yes yes	no yes yes

4.2 Operation

Avoid sudden changes of attitude, extreme outside vibrations and shock to the pump during operation.

If particles are present in the gas, the pump should always be operated with purge gas. If this is not possible it must be at least operated with purge gas in line with the information given in the table above.

4.3 Shut-Down

Operate the STOP push-button or switch the pump off via its interface.

In order to avoid any damaging back-diffusion of aggressive gases or particles the pump should be vented after shut-down; see Chapter 4.4.

While the system is down make sure that neither ambient air nor cleaning agents can enter into the T 1600.

After having switched the T 1600 off, immediately shut down the cooling water supply too so as to prevent the formation of condensate within the pump.

4.4 Venting

The T 1600 may be vented in several different ways.

1. In the case of processes which require the use of purge gas the pump, when shut-down, must be vented via the purge gas and venting valves.

   In the case of additional venting of the vacuum vessel with inert gas, the venting valve must be opened first or at the same time. Only in this way will it be possible to maintain in the motor chamber a higher pressure compared to that in the forevacuum volume, thereby avoiding any damaging back-diffusion of aggressive gases or particles.

Caution

The pressure in the motor chamber of the T 1600 must at all times be greater than the pressure in the forevacuum volume.

2. The pump may be vented from the high-vacuum side.

The pump may be vented immediately after the STOP command. Normally, the venting to 1000 mbar should take more than 20 seconds.

Do not vent the T 1600 via the forevacuum port. If doing so, oil vapours from the forevacuum stage might enter the pump.

4.5 Removing the Pump from the System

Switch off the pump and vent it as per the instructions in Chapters 4.3 and 4.4.

Warning

Take the appropriate precautionary measures prior to opening the intake or discharge connection if the pump has previously handled hazardous gases.

If necessary, use gloves, a respirator and/or protective clothing and work under an exhaust hood.

If the pump previously handled corrosive gases, then allow the purge gas to flow for as long as possible before detaching the pump from the system.

Remove the T 1600 from the system.

Pumps which are used in semiconductor processes, for example, will be contaminated with process gases. These gases may be toxic and hazardous to health. In addition, deposits with similarly dangerous properties may have formed. Many of these gases and deposits form acids when they come into contact with humid air. This will result in serious corrosion damage to the pump.

To avoid health hazards and corrosion damage when T 1600 is detached from the system, lay desiccant on the splinter guard and then seal off the pump immediately at all flange connections. Store the pump, with a desiccant, in a PE bag.

We recommend to use the seal kit for the T 1600; Ref. no. see Chapter 1.2.

Faulty (leaky) packing of the pump will void the warranty.

Package the pump so that it will not be damaged during transportation and so that no hazardous substances can escape from the packaging. When returning a pump to Leybold please observe the information provided in Chapter 5.1.

5 Maintenance

The T 1600 is a low-maintenance pump by design. We recommend that you have the bearings exchanged after 12,000 to 15,000 operating hours and the rotor after 45,000 operating hours. Contact us for more information on this.

Depending on the quality of the purge gas, the purge gas filter will clog sooner or later and it will have to be exchanged (approx. every 1 to 6 months).

5.1 LEYBOLD Service

Whenever you send a pump to LEYBOLD, indicate whether the pump is contaminated or is free of substances which could pose a health hazard. If it is contaminated, specify exactly which substances are involved. You must use the form we have prepared for this purpose; we will forward that form on request.

A copy of the form is printed at the end of the Operating Instructions: "Declaration of contamination for vacuum equipment and components".

Attach the form to the pump or enclose it with the pump. Do not place it together with the pump inside the PE bag.

This statement detailing the contamination is required to satisfy legal requirements and for the protection of our employees.

LEYBOLD must return to the sender any pumps which are not accompanied by a contamination statement.

5 Troubleshooting

Fault	Possible cause	Remedy
T 1600 will not start.	Mains power has not been applied or is out of limit.	Check mains voltage and mains cord.
The message „Warning" is indicated.	The self test of the frequency converter which is run upon applying the mains power will indicate that maintenance is due.	We recommend that you have the bearings exchanged after 12,000 to 15,000 operating hours and the rotor after 45,000 operating hours. Contact us for more information on this.
	Upon applying the mains power it was found that the clock is faulty (possibly an exhausted battery).	Contact Leybold Service.
	The temperature at one bearing is too high.	Check the cooling water supply. Possibly plan with Leybold an exchange of the bearings.
	The temperature of the motor is too high.	Check loading of the pump and reduce the load to acceptable levels. Check cooling water supply.
	Motor power of the pump is too great due to excessively high pressures or gas throughput.	Check loading of the pump and reduce the load to acceptable levels. Check cooling water supply.
	Because of excessive loading the pump is not able to maintain its nominal speed.	Check loading of the pump and reduce the load to acceptable levels.
The T 1600 shuts down with the message "Fault".	Internal electrical fault.	Contact Leybold Service.
	The minimum speed was not attained within a certain time.	Check loading of the pump and reduce the load to acceptable levels.
	Speed has dropped below the minimum.	Check loading of the pump and reduce the load to acceptable levels.
	Pump was overloaded for quite some time.	Check loading of the pump and reduce the load to acceptable levels. Contact Leybold Service.
	Motor or bearing temperatures have exceeded the limit.	Contact Leybold Service.
The T 1600 produces a lot of noise and vibrations.	Unbalanced rotor.	Balance the pump (Leybold Service only).
	Failed bearing.	An exchange of the bearings is required (Leybold Service only).
	Pump is running at the resonance frequency of the remaining system.	Change the mass of the system or fit vibration absorbers for decoupling the vibrations.
The T 1600 does not attain its ultimate pressure.	Faulty vacuum gauge.	Check the vacuum gauge.
	Contaminated gauge head.	Clean the gauge head or replace it.
	Leak in the system, lines or the pump.	Leak search.
	Contaminated pump.	Have the pump cleaned (Leybold Service only).
	Backing pump does not provide enough pumping speed or its base pressure is too high.	Check ultimate pressure of backing pump; if required install a larger backing pump system.
	Forevacuum pressure is too high.	Check the backing pump; if required install a larger backing pump system.
	Quantity of gas too great / leak in the system.	Seal off the leak; if required install a larger backing pump.

LEYBOLD

VDMA

Declaration of Contamination of Vacuum Equipment and Components

The repair and/or service of vacuum equipment and components will only be carried out if a correctly completed declaration has been submitted. Non-completion will result in delay. The manufacturer could refuse to accept any equipment without a declaration.
This declaration can only be completed and signed by authorized and qualified staff.

1. Description of Vacuum Equipment and Components

- Equipment type/model: _____
- Code No.: _____
- Serial No.: _____
- Invoice No.: _____
- Delivery date: _____

2. Reason for Return

_____
_____
_____
_____
_____
_____

3. Condition of the Vacuum Equipment and Components

- Has the equipment been used?
  yes ❒ no ❒
- What type of pump oil/liquid was used? _____
- Is the equipment free from potentially harmful substances?
  yes ❒ (go to Section 5)
  no ❒ (go to Section 4)

4. Process related Contamination of Vacuum Equipment and Components:

- toxic	yes ❒	no ❒
- corrosive	yes ❒	no ❒
- explosive*)	yes ❒	no ❒
- biological hazard*)	yes ❒	no ❒
- radioactive*)	yes ❒	no ❒
- other harmful substances	yes ❒	no ❒

*) Vacuum equipment and components which have been contaminated by biological explosive or radioactive substances, will not accepted without written evidence of decontamination!

Please list all substances, gases and by-products which may have come into contact with the equipment:

Trade name Product name Manufacturer	Chemical name (or Symbol)	Dangerous material class	Measures if spillage	First aid in case of human contact
1.				
2.				
3.				
4.				
5.				

5. Legally Binding Declaration

I hereby declare that the information supplied on this form is complete and accurate. The despatch of the contaminated vacuum equipment and components will be in accordance with the appropriate regulations covering Packaging, Transportation and Labelling of Dangerous Substances.

Name of organisation or company: _____

Address: _____ Post code: _____

Tel.: _____

Fax: _____ Telex: _____

Name: _____

Job title: _____

Date: _____ Company stamp:

Legally binding signature: _____

Copies: Page 1 (white) to manufacturer or representative - Page 2 (yellow) attach to consignment packaging securely - Page 3 (blue) copy for file of sender

Order No.: 2121

Annex

A disk with the basic instrument data file (GSD) is included with each pump equipped with a Profibus interface. In addition, the contents of the GSD are documented in this Annex.

```
;=======================================
GSD file for LEYBOLD SS18135
Date : 24.09.98 - Harald Fleischmann
Sync_mode_supp  Freeze_mode_supp
;=======================================

#Profibus_DP
Vendor_Name = "Leybold AG      "
Model_Name = "NT 1600C         "
Revision = "Ausgabestand 1"
Ident_Number = 0x00F1
Protocol_Ident = 0
Station_Type = 0
FMS_supp = 0
Hardware_Release = "A01"
Software_Release = "A01"
9.6_supp = 1
19.2_supp = 1
93.75_supp = 1
187.5_supp = 1
500_supp = 1
1.5M_supp = 1
3M_supp = 1
6M_supp = 1
12M_supp = 1
MaxTsdr_9.6 = 60
MaxTsdr_19.2 = 60
MaxTsdr_93.75 = 60
MaxTsdr_187.5 = 60
MaxTsdr_500 = 100
MaxTsdr_1.5M = 150
MaxTsdr_3M = 250
MaxTsdr_6M = 450
MaxTsdr_12M = 800
Redundancy = 0
Repeater_Ctrl_Sig = 2
24V_Pins = 0

--Values relating specifically to the slave-----

Freeze_Mode_supp = 1
Sync_Mode_supp = 1
Auto_Baud_supp = 1
Set_Slave_Add_supp = 0
Min_Slave_Intervall = 1
Modular_Station = 1
Max_Module = 1
Max_Input_Len = 20
Max_Output_Len = 20
Max_Data_Len = 40
Max_Diag_Data_Len = 6

Module = "PPO 1" 0xF3, 0xF1
EndModule
Module = "PPO 6" 0x00, 0xF0
EndModule
Module = "PPO 7" 0x00, 0xB0
EndModule
```

EC Manufacturer's Declaration

in the sense of Appendix IIb to the 89/392/EEC Machinery Guidelines

We, the Leybold Vakuum GmbH, declare herewith that the commissioning of the incomplete machine designated below is prohibited until such time as it has been determined that the system in which this incomplete machine is to be installed corresponds with the EC Machinery Guidelines.

Designation: turbomolecular pump with integrated frequency converter.

Model: T 1600

Cat. Nos.: 103 18
114 21 /31 /32 /38
119 11 /13 /14 /21 /22

The products comply with the following guidelines:

- EC Low Voltage Guideline (73/23/EWG)
- EC Guideline on Electromagnetic Compatibility (89/336/EWG)

Applied harmonised standards:

- EN 292 Part 1 and Part 2 Nov. 1991
- EN 1012 Part 2 1996
- EN 60 204 1993
- EN 61010-1: 1993
- EN 50081-1: 1992
- EN 50082-2: 1992

Applied national standards and technical specifications:

- DIN 31 001 April 1983
- DIN ISO 1940 Dec. 1993
- VDE 0411 Part 1/03.94

Cologne, December 10, 1999

Dr. Götz, Business Area Manager
Turbomolecular Pumps

Cologne, December 10, 1999

Hölzer, Design Manager
Turbomolecular Pumps

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