Installation and Operating Instructions

Turbomolecular pumps
Turbo TM 1600 A
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## Introduction

Congratulations on your purchase of the Busch turbomolecular pump. With watchful observation of the field’s requirements, innovation and steady development Busch delivers modern vacuum and pressure solutions worldwide.

This operating instructions contain information for
- product description,
- security,
- transport,
- storage,
- installation and commissioning
- maintenance,
- accessories,
- overhaul

of the turbomolecular pump.

For the purpose of these instructions, «handling» the turbomolecular pump means the transport, storage, installation, commissioning, influence on operating conditions, maintenance and overhaul of the turbomolecular pump.

The user should read this instruction manual and any other additional information supplied by Busch before operating the equipment. Busch will not be held responsible for any events occurring due to non-compliance, even partial, with these instructions, improper use by untrained persons, non-authorized interference with the equipment or any action contrary to that provided for by specific national standards.

Keep this operating instructions and, if applicable, other pertinent operating instructions available on site.
Use

The turbomolecular pump is intended for:
- the suction of air and other dry, non-aggressive, non-toxic and non-explosive gases.

The Turbo TM 1600 A is turbomolecular pump for high and ultra-high vacuum applications. It can pump any type of gas or gas compound. It is not suitable for pumping liquids or solid particles.

During normal operation, the motor is fed with a voltage of 54 Vac (between phases) three-phase at 555 Hz. To avoid rotor overheating, an automatic power management routine is implemented in the control unit microprocessor. The user can select (through serial line) the gas load type between "Argon" and "Nitrogen" (or lighter gases) with window 157 0=Argon and default 1=Nitrogen. When Nitrogen is selected the power limit is fixed at 400 W, for Argon selection the user must set the maximum foreseen water cooling temperature (Twater, max) by the window 158. After these settings the controller will operate as shown in the following diagram.

This equipment is destined for use by professionals.

Pump used with corrosive gases

To prevent damage to the bearings, an inert gas must flow into the pump body around the upper bearing towards the forevacuum line. To supply the inert purge gas (e.g. nitrogen) to the pump through the purge port, connect a gas purge line to the pump.

The purging device automatically provides 20 sccm when fed with 1 bar (14 psi) absolute (atmospheric pressure).
CAUTION
To prevent bearing damage, Busch suggests a minimum purge gas flow rate of 20 sccm (0.33 mbar l/s). This value can be exceeded, according to the process requirements. Please contact Busch for specific applications.

The purge gas throughput of 20 sccm with the recommended fore-pump allows to achieve a high vacuum pressure in the 10^-6 mbar range.

The recommended gas flow maintains a pressure into the pump body higher than the forevacuum pressure.

The recommended procedure to vent the system and the pump avoiding the contact between the pump bearings and the corrosive gas is described in the following points:

- Close the corrosive gas flow into the system.
- Leaving the Turbo TM 1600 A and the backing pump running and the purge gas flowing, wait for enough time to evacuate the corrosive gas from the system.
- Turn off the Turbo TM 1600 A.
- Open the Turbo vent port slowly until to reach atmospheric pressure in the system.
- When the Turbo pump and the backing pump are stopped and the system is at atmospheric pressure, for a better bearing protection it is advisable to leave the purge gas flowing into the Turbo pump, with the chamber or the Turbo vent valve opened, to avoid system overpressures. If the vent valve can’t be kept opened, the backing pump should be left operating.

#### Pump used in presence of magnetic fields

Magnetic fields induce eddy currents in the rotor of a turbomolecular pump that tend to oppose to its rotation. The result is increased electrical power consumption by the motor, most of which is dissipated in the rotor.

Since the rotor is not in contact with the stator the above power can leave the rotor mainly by radiation and hence the rotor may be over-heated while static parts of the pump remain cool.

This effect is strongly dependant from the intensity, time function and distribution of the magnetic field.

In general, therefore, an increase in jump current can be expected. However if the effect is grater, than the case should be carefully reviewed by Busch specialist.

As a matter of fact, in case of high magnetic fields, also important forces might be generated and applied to the rotor.

#### Principle of operation

The pumping action is obtained through a high speed turbine (max. 33000 rpm) driven by a high performance 3-phase electric motor. The Turbo TM 1600 A is free of contaminating agents and, therefore, is suitable for applications requiring a « clean » vacuum.

The pump consists of a high frequency motor a turbine fitted with 5 bladed stages and 2 Macrotorr stages. The turbine rotates in an anti-clockwise direction when viewed from the high vacuum flange end.

The turbine rotor is supported by permanently lubricated high precision ceramic ball bearings installed on the forevacuum side of the pump.

The static blades of the stators are made of aluminium alloy. These are supported and accurately positioned by spacer rings.

The Macrotorr stators are in the form of self-positioning machined discs with pumping channels and an opening restricted by the corresponding rotor discs. These are made of aluminium alloy.

#### Cooling

The pump can be water cooled only. For this purpose the customer must use the dedicated channel on the pump body.

Cooling may be carried out either through an open circuit with eventual discharge of the water, or using a closed circuit cooling system.

The water temperature must be between +10°C and +35°C, with an inlet pressure between 3 and 5 bar. In any case the water flow must not be less than 3.5 l/min.

#### On/ Off switch

The turbomolecular pump comes without on/ off switch. The control of the turbomolecular pump is to be provided in the course of installation.

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**Diagram:**

Purge and vent layout

1. Purge gas line
2. Pressure regulator
3. Purge and vent port
4. Forevacuum pump
5. Turbopump
6. Water line

Where:

- $T_b =$ upper bearing temperature
- $T_{body} =$ measured water cooling related temperature
- $T_{body, lim} =$ body temperature corresponding to $T_{water, max}$, according to fig. "Connector protections".
- $\text{WIN.118} =$ set the body temperature control

Is equipped with auxiliary connectors to be controlled from a remote site by means of an host computer connected through a serial line (RS232 or RS485).

Detailed information is supplied in the appendix « Technical information ».
Safety

Intended use

DEFINITION: For the purpose of these instructions, “handling” the vacuum pump means the transport, storage, installation, commissioning, influence on operating conditions, maintenance, troubleshooting and overhaul of the turbomolecular pump.

The turbomolecular pump is intended for industrial use. It must only be handled by qualified personnel.

The allowed media and operational limits according to the “Product Description” and the “Installation Prerequisites” of the vacuum pump shall be observed both by the manufacturer of the machinery into which the turbomolecular pump is to be incorporated and by the operator.

The maintenance instructions shall be observed.

Prior to handling the turbomolecular pump these operating instructions shall be read and understood. If anything remains to be clarified please contact your Busch representative!

Safety Guideline for Turbomolecular Pumps

Turbomolecular pumps as described in the following operating manual contain a large amount of kinetic energy due to the high rotational speed in combination with the specific mass of their rotors.

In case of a malfunction of the system for example rotor/ stator contact or even a rotor crash the rotational energy may be released.

AVERTISSEMENT

In case of non-compliance with the installation prerequisites:

Risk of damage or destruction of the vacuum pump and adjoining plant components!

Risk of injury!

The installation prerequisites must be complied with.

A thermistor sensor is mounted near the upper bearing in order to read the bearing temperature and to prevent the pump from overheating.

A thermistor sensor is mounted near the water cooling channel in order to evaluate the cooling efficiency.

Safety notes

The turbomolecular pump has been designed and manufactured according to the state-of-the-art. Nevertheless, residual risks may remain. These operating instructions inform about potential hazards where appropriate. Safety notes are tagged with one of the keywords DANGER, WARNING and CAUTION as follows:

DANGER

Disregard of this safety note will always lead to accidents with fatal or serious injuries.

WARNING

Disregard of this safety note may lead to accidents with fatal or serious injuries.

CAUTION

Disregard of this safety note may lead to accidents with minor injuries or property damage.

NOTE: The notes contain important information taken from the text.

Transport

The Turbo TM 1600 A is supplied in a special protective packing. If this shows signs of damage which may have occurred during transport, contact your local sales office.

When unpacking the system, be sure not to drop it and avoid any kind of sudden impact or shock vibration to it.

Do not dispose of the packing materials in an unauthorized manner. The material is 100% recyclable and complies with EEC Directive 85/399.

NOTE: Normal exposure to the environment cannot damage the Turbo TM 1600 A. Nevertheless, it is advisable to keep it closed until it is installed in the system. This will prevent the system from contamination.

Cause its weight (35 kg), use the three eyebolts screwed at 120° on the pump body to extract the pump from the package.

CAUTION

In order to prevent outgassing problems, do not use bare hands to handle components which will be exposed to vacuum.

Always use gloves or other appropriate protection.

CAUTION

Please check out the weight of the turbomolecular pump before lifting it up (see “Technical Data”).

Use adequate lifting gear for this.

The Turbo TM 1600 A package includes:

- Pump with integrated controller
- Inlet screen (mounted)
- This instruction manual on CD-ROM
- Accessories bag
- 15 pin mating connector IP 54 for “REMOTE I/O” connector with all the interconnections necessary to start the pump.
- 9 pin mating connector IP 54 for ”SERIAL” connector to be used for serial connection
- 9 pin mating connector for ”Network” MoniTorr
- Retaining bracket to retain the power cable (mounted)

Storage

Short-term Storage

In order to guarantee the maximum level of performance and reliability of turbomolecular pumps, the following guidelines must be followed:

- Make sure that the suction connection/gas inlet and the gas discharge/ pressure connection are closed (leave the provided plugs in)

- The storage of turbomolecular pumps must take place under the following environmental conditions:
  - Temperature range: -20°C to +70°C
  - Relative humidity range: 0 to 95% (non condensing)

- The turbomolecular pumps must be always soft-started when received and operated for the first time by the customer.

- The shelf life of a turbomolecular pump is 10 months from the shipping date.
CAUTION
If for any reason the shelf life time is exceeded, the pump has to be returned to the factory.

Please contact the local Busch Vacuum Sales and Service representative for informations.

NOTE: If the Turbo TM 1600 A pump has been stored at a temperature below 5°C, please wait for the system to reach an ambient operating temperature of +5° to 35°C.

Installation and Commissioning
Installation prerequisites

CAUTION
In case of non-compliance with the installation prerequisites:
Risk of damage or destruction of the turbomolecular pump and adjoining plant components!
Risk of injury!
The installation prerequisites must be complied with.

- Make sure that the integration of the turbomolecular pump is carried out such that the essential safety requirements of the Machine Directive 2006/42/EC are complied with (in the responsibility of the designer of the machinery into which the vacuum pump is to be incorporated; see also the note in the EC-Declaration of Conformity)

Mounting Position and space

WARNING
Cause its weight, the pump must be handled by means of suitable moving and handling tools. Use the suitable handling kit eyebolts screwed into the holes of the pump body.

- Do not install or use the pump in an environment exposed to atmospheric agents (rain, snow, ice), dust, aggressive gases, or in explosive environments or those with a high fire risk.
- Make sure that the environmental conditions comply with the protection class of the drive motor (according to the nameplate)
- During operation, the following environmental conditions must be respected:
  - Maximum pressure: 2 bar above atmospheric pressure
  - Temperature: from +5°C to +40°C
  - Relative humidity: 0-95% (non condensing)

CAUTION
Do not remove the adhesive and protective cap before connecting the turbopump to the system.

CAUTION
Do not remove the bolted cap before connecting the turbopump to the system.

WARNING
In the presence of magnetic fields the pump must be protected using a ferromagnetic shield. See the chapter « Technical data ».
- The turbopump must be connected to a primary pump (See « Technical Data »).
- Fix the Turbo TM 1600 A in a stable position mounting the inlet flange of the turbopump to the system counter-flange, with a connection capable of withstanding a torque of 10600 Nm around its axis.
- The Turbo TM 1600 A can be installed in any position.
NOTE: The Turbo TM 1600 A cannot be fixed by means of its base.
- The pump can operate in any position and can be supported on the high vacuum flange (suction).
- Make sure that the turbomolecular pump can neither inadvertently nor intentionally be stopped on and cannot be used as a support for heavy objects.
- Make sure that the turbomolecular pump cannot be hit by falling objects.
- Make sure that the turbomolecular pump will not be touched inadvertently during operation, provide a guard if appropriate.
- The pump is balanced after assembly with a residual vibration amplitude less than 0.01 µm.

Suction Connection

CAUTION
Do not put hands into the inlet aperture.
Risk of body damage!

CAUTION
Intruding foreign objects or liquids can destroy the vacuum pump.

WARNING
If a rotor failure occurs, the connection of the pump to the system could be subjected to a significant torque. If the connection is not sufficient to withstand that torque, the pump could detach from the system or the motor housing could detach from the pump envelope.
In this case metal fragments could be projected from the pump or system, which could cause serious injury or death and/or damage to surrounding equipment.
Dimension of the inlet flange:
- ISO 250 F

The following table shows, for the ISO-F suction flange, the necessary number of screws and the relevant fixing torque.

<table>
<thead>
<tr>
<th>Suction flange</th>
<th>Number of screws</th>
<th>Fixing torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO 250 F</td>
<td>12</td>
<td>22Nm</td>
</tr>
</tbody>
</table>

The class of the steel screws for «F» flange must be > 8.8

The system can only be fixed through its ISO 250 F flange. Fixing must be done according to ISO 1609 norm. Steel bolts with a strength class at least of 500 N/mm² must be used.

To connect the Turbo TM 1600 A pump to the ISO F inlet flange position the integrated inlet screen-centering ring as shown in the figure.

Then fix the two flanges with the bolts as shown in the following figures (according to Norm ISO 1609).

---

**Electrical connection/ Controls**

- Make sure that the stipulations acc. to the EMC-Directive 2004/108/EC, the EN-standards, electrical and occupational safety directives and the local or national regulations, respectively, are complied with (this is in the responsibility of the designer of the machinery into which the vacuum pump is to be incorporated; see also the note in the EC-Declaration of Conformity).

- Make sure that the power supply is compatible with the data on the nameplate of the drive motor

- Make sure that an overload protection according to EN 60204-1 is provided for the drive motor

- Make sure that the drive of the vacuum pump will not be affected by electric or electromagnetic disturbance from the mains; if necessary seek advice from the Busch service

**Installation**

**Mounting**

- Make sure that the “Installation Prerequisites” are complied with

- Set down or mount the vacuum pump at its location

**Connecting electrically**

![WARNING]

Risk of electrical shock, risk of damage to equipment.

Electrical installation work must only be executed by qualified personnel that knows and observes the following regulations:
- IEC 364 or CENELEC HD 384 or DIN VDE 0100, respectively,
- IEC-Report 664 or DIN VDE 0110,
- BGV A2 (VBG 4) or corresponding national accident prevention regulation.

**Controller description**

The dedicated controller is a solid-state frequency converter which is driven by a single chip microcomputer.

The controller can be operated by a remote host computer via the serial connection (a Window-based software is available as an option), or by the remote I/O connector.

At every power-up the controller is in “Remote Mode” of operation and accepts only commands from J1 remote I/O connector. To put it in “Serial Mode” of operation please refer to the serial command table.

**J1 – Remote I/O**

This connector carries all the input and output signals to remote control the Turbo TM 1600 A.

It is a 15-pins D type connector; the available signals are detailed in the table, the following paragraphs describe the signal characteristics and use.

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**Fore-Vacuum Pump Connection**

Dimension of the exhaust flange:
- KF 40 NW

A flange KF 40 NW is available to connect the turbomolecular pump to the fore-vacuum pump. A hose or vacuum approved pipe can be used. If a rigid pipe is used, any vibration generated by the mechanical pump must be eliminated through the use of bellows.

**NOTE:** The Turbo TM 1600 A pump is characterized by its high compression ratio also for oil vapors.

When using a mechanical oil-sealed pump, it is advisable to install a suitable trap between the turbopump and the fore-vacuum pump in order to prevent oil backstreaming.
### Signal description

- **START/STOP**: input signal to start or stop the pump. With the supplied cover connector the START/STOP (+) signal is connected to the +24 Vdc pin and the START/STOP (-) signal to the GROUND pin; in this condition the pump doesn’t start.

- **INTERLOCK**: input signal to confirm the pump rotation. With the supplied cover connector the INTERLOCK (+) signal is connected to the +24 Vdc pin and the INTERLOCK (-) signal to the GROUND pin, in this condition the pump automatically starts as soon as the controller recognises the input supply (“Plug & Pump”).

- **SPEED SETTING**: PWM input signal to set the pump speed. The PWM signal characteristics must be the following:
  - Frequency: 100 Hz +/- 20%
  - Amplitude: high level from 12 to 24 V
  - Duty cycle range: from 25% to 75% corresponding to a pump speed from 475 Hz to 555 Hz linearly (see the following diagram).

### NOTE

High Speed is the nominal rotational frequency of the pump (555Hz). Low Speed (475 Hz) corresponds to the rotational frequency for a stand by status, to preserve the bearing life. Users can set rotational frequency between these two values.

If any signal isn’t applied (no connection) the driving frequency is set to “Maximum excitation frequency” (the default value is 555 Hz; it is settable via serial line by means of window 121: see the serial command table).

The “Low Speed” function can also be activated by serial line with win.001, and the low speed value can be adjusted via serial command win.117.

Both low speed value (win.117) and high-speed value (win.120) are limited between 475Hz (can’t be set by the user) and “Maximum excitation frequency” (win.121, 555Hz default).

**NOTE:** The duty cycle percentage is referred to the low level portion of the PWM period.

**SOFT START:** input signal to activate the soft start function. This function must be activated (pin-7 shorted with pin-9) if the pump remains unused for 1 month or more, and de-activated for the next run-up. The soft Start phase is around 55 minutes long. The soft start function is factory enabled for the first system start-up. After the first pump start-up until the normal status, the soft start is automatically disabled.

**ANALOG OUTPUT:** this output signal is a voltage (from 0 to 10 Vdc) proportional to a reference quantity (frequency or power) set by the user through serial line (window 111). The default setting is the frequency (see the following example diagram). The voltage is provided between pins 14 and 15. An high impedance input should be connected to this output (> 100 kΩ).

![Example Diagram](image1)

### SET POINT

This relay output signal is enabled when the reference quantity chosen (frequency, current or time) is higher than the set threshold. The signal can be "active close", or "active open". Moreover, if the reference quantity is the frequency or the current drawn, it is

![Example Diagram](image2)

**FAULT:** this relay output signal is closed when any system fault condition is detected. To detect the type of failure the serial protocol is needed (see the para. *RS232-485 Communication Description*).

**SET POINT:** this relay output signal is enabled when the reference quantity chosen (frequency, current or time) is higher than the set threshold. The signal can be "active close", or "active open". Moreover, if the reference quantity is the frequency or the current drawn, it is...
Possible to set the hysteresis (in % of the threshold value) to avoid bouncing.
For example:
- reference quantity: frequency (window 101=0)
- threshold: 500 Hz (window 102=500)
- hysteresis: 1% (window 103=1)
- activation type: “active close” (window 104=1)

The set point output stays open until the frequency becomes higher than 505 Hz (that is 500 Hz + 1% of 500 Hz), then the output goes closed and stays closed until the frequency becomes lower than 495 Hz (that is 500 Hz – 1% of 500 Hz).

It is possible to mask the set point checking for a programmable mask time (window 103).
The SET POINT signal has the following default settings:
- reference quantity: controller status
- threshold: not relevant
- hysteresis: not relevant
- activation type: active close (NO)
- delay time: 0 second

NOTE: The Navigator Software ver. 3.0 (optional) or any user developed serial communication software (according to RS 232-485 Communication Protocol) allows the operator to set all the programmable feature.

When no external input-output device is available the J1 connector must be closed with the supplied mating connector that short-circuits the START and INTERLOCK inputs with the GROUND input.

**Electrical Connections Examples:**

- Start-Stop or Interlock

![Electrical Connections Example](image)

**NOTE:** Instead of switch is possible to use transistor.
- Soft Start, Speed Setting, Purge, Vent

**PURGE/VENT VALVES:** the pump integrates the “purge” and “vent” valves. The two valves are Normally Closed so if a power fail occur, the valves will remain closed.

In remote mode you can open the purge valve (N.C.) connecting pin10 of J1 to pin 9, or supplying 24 Vdc between pin 10 and pin 15. The same thing occurs for the vent valve with pin 12.

Note that the vent and purge valve can also be controlled by means of the serial connection (see the following diagram for details).
This is a 9 pin D-type serial input/output connector to control via an RS 232 or RS 485 connection the Turbo TM 1600 A.

<table>
<thead>
<tr>
<th>PIN N.</th>
<th>Signal Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RESERVED</td>
</tr>
<tr>
<td>2</td>
<td>TX (RS232)</td>
</tr>
<tr>
<td>3</td>
<td>RX (RS232)</td>
</tr>
<tr>
<td>4</td>
<td>SPARE</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
</tr>
<tr>
<td>6</td>
<td>A + (RS485)</td>
</tr>
<tr>
<td>7</td>
<td>SPARE</td>
</tr>
<tr>
<td>8</td>
<td>B - (RS485)</td>
</tr>
<tr>
<td>9</td>
<td>RESERVED</td>
</tr>
</tbody>
</table>

A serial communication kit with a serial cable and the Navigation software is available (optional).

**Serial Cable Installation**

In order to maintain the IP-54 protection level, please use a certified IP-54 connector or the one provided by Busch.
<DATA> = an alphanumeric ASCII string with the data to be written into the window. In case of a reading command this field is not present. The field length is variable according to the data type as per the following table:

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Field Length</th>
<th>Valid Characters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logic (L)</td>
<td>1</td>
<td>'0' = OFF, '1' = ON</td>
</tr>
<tr>
<td>Numeric (N)</td>
<td>6</td>
<td>'0'... '9' right justified with '0'</td>
</tr>
<tr>
<td>Alphanumeric (A)</td>
<td>10</td>
<td>From blank to ' _' (ASCII)</td>
</tr>
</tbody>
</table>

<ETX> (End of transmission) = 0x03
<CRC> = XOR of all characters subsequent to <STX> and including the <ETX> terminator. The value is hexadecimal coded and indicated by two ASCII characters.

The addressed SLAVE will respond with an ANSWER whose structure depends from the MESSAGE type.

When the MESSAGE is a reading command, the SLAVE will respond transmitting a string with the same structure of the MESSAGE.

NOTE: Some error settings are foreseen:

<table>
<thead>
<tr>
<th>Error Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x15</td>
<td>NACK foreseen with Read/Write commands</td>
</tr>
<tr>
<td>0x32</td>
<td>UNKNOWN WINDOW foreseen only with Write commands</td>
</tr>
<tr>
<td>0x33</td>
<td>BAD DATA TYPE</td>
</tr>
<tr>
<td>0x34</td>
<td>OUT OF RANGE</td>
</tr>
<tr>
<td>0x35</td>
<td>BAD OPERATION</td>
</tr>
</tbody>
</table>

NOTE: Using the RS 485 interface, the message structure remains identical to the one used for the RS 232 interface, the only difference being that the value assigned to the ADDRESS <ADDR>.

The controller can answers with the following response types:

<table>
<thead>
<tr>
<th>Type</th>
<th>Length</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logic</td>
<td>1 byte</td>
<td>-</td>
<td>After a read instruction of a logic window</td>
</tr>
<tr>
<td>Numeric</td>
<td>6 bytes</td>
<td>-</td>
<td>After a read instruction of a numeric window</td>
</tr>
<tr>
<td>Alphanumeric</td>
<td>10 bytes</td>
<td>-</td>
<td>After a read instruction of an alphanumeric window</td>
</tr>
<tr>
<td>ACK</td>
<td>1 byte</td>
<td>(0x6)</td>
<td>The command execution has been successfully completed</td>
</tr>
<tr>
<td>NACK</td>
<td>1 byte</td>
<td>(0x15)</td>
<td>The command execution has been failed</td>
</tr>
<tr>
<td>Unknown Window</td>
<td>1 byte</td>
<td>(0x32)</td>
<td>The specified window in the command is not a valid window</td>
</tr>
<tr>
<td>Data Type Error</td>
<td>1 byte</td>
<td>(0x33)</td>
<td>The data type specified in the command (Logic, Numeric or Alphanumeric) is not accorded with the specified Window</td>
</tr>
<tr>
<td>Out of Range</td>
<td>1 byte</td>
<td>(0x34)</td>
<td>The value expressed during a write command is out of the range value of the specified window</td>
</tr>
<tr>
<td>Win Disabled</td>
<td>1 byte</td>
<td>(0x35)</td>
<td>The specified window is Read Only or temporarily disabled (for example you can't write the Soft Start when the Pump is running)</td>
</tr>
</tbody>
</table>

NOTE : The RS 485 is a 2-wire (gnd optional) half-duplex communication link.

Examples:

**COMMAND: START**
Source: PC

```
02 80 30 30 30 31 31 03 42 33
STX ADDR WINDOW WR ON ETX CRC
```

**Source: Controller**

```
02 80 06 03 38 35
STX ADDR ACK ETX CRC
```

**Command: STOP**
Source: PC

```
02 80 30 30 30 31 30 03 42 32
STX ADDR WINDOW WR OFF ETX CRC
```

**Source: Controller**

```
02 80 06 03 38 35
STX ADDR ACK ETX CRC
```

**Command: SOFT-START (ON)**
Source: PC

```
02 80 31 30 30 31 31 03 42 33
STX ADDR WINDOW WR ON ETX CRC
```

**Source: Inverter**

```
02 80 06 03 38 35
STX ADDR ACK ETX CRC
```

**Command: SOFT-START (OFF)**
Source: PC

```
02 80 31 30 30 30 31 30 03 42 33
STX ADDR WINDOW WR OFF ETX CRC
```

**Source: Inverter**

```
02 80 06 03 38 35
STX ADDR ACK ETX CRC
```

**Command: READ PUMP STATUS**
Source: PC

```
02 83 32 30 35 35 30 03 38 37
STX ADDR WINDOW RD ETX CRC
```

**Source: Controller (with address=3)**

```
02 83 32 30 35 35 30 03 38 37
STX ADDR WINDOW RD ETX CRC
```
Source: Controller (with address=3 in stop status)

<table>
<thead>
<tr>
<th>STX</th>
<th>ADDR</th>
<th>WINDOW</th>
<th>DATA (STATUS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td>83</td>
<td>32 30</td>
<td>35 30 30 30 30</td>
</tr>
</tbody>
</table>

Command: READ SERIAL CONFIGURATION

Source: PC

Destination: Controller (with address=3 in 485 mode)

<table>
<thead>
<tr>
<th>STX</th>
<th>ADDR</th>
<th>WINDOW</th>
<th>RD</th>
<th>ETX</th>
<th>CRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td>83</td>
<td>35 30</td>
<td>34</td>
<td>30</td>
<td>03</td>
</tr>
</tbody>
</table>

Source: Controller

Destination: PC

<table>
<thead>
<tr>
<th>STX</th>
<th>ADDR</th>
<th>WINDOW</th>
<th>RD</th>
<th>DATA</th>
<th>ETX</th>
<th>CRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td>83</td>
<td>35 30</td>
<td>34</td>
<td>30</td>
<td>31</td>
<td>03</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STX</th>
<th>ADDR</th>
<th>WINDOW</th>
<th>RD</th>
<th>DATA</th>
<th>ETX</th>
<th>CRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td>83</td>
<td>35 30</td>
<td>34</td>
<td>30</td>
<td>31</td>
<td>03</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STX</th>
<th>ADDR</th>
<th>WINDOW</th>
<th>RD</th>
<th>DATA</th>
<th>ETX</th>
<th>CRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td>83</td>
<td>35 30</td>
<td>34</td>
<td>30</td>
<td>31</td>
<td>03</td>
</tr>
<tr>
<td>N.</td>
<td>Read / Write</td>
<td>Data Type</td>
<td>Description</td>
<td>Admitted Values</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>--------------</td>
<td>-----------</td>
<td>-------------</td>
<td>-----------------</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 000 | R/W L        | Start/Stop (in remote mode the window is a read only) | Start = 1  
Stop = 0 | |
| 008 | R/W L        | Remote (default) or Serial configuration | Remote = 1  
Serial = 0 (default = 1) | |
| 100 | R/W L        | Soft Start (write only in Stop condition) | YES = 1  
NO = 0 | |
| 101 | R/W N        | Set Point type | 0 = Frequency  
1 = Current  
2 = Time (default = 0) | |
| 102 | R/W N        | Set Point threshold (expressed in Hz, mA or s) (default = 500) | |
| 103 | R/W N        | Set Point mask: time between the pump start and the set point check (seconds) | 0 to 99999 (default = 0) | |
| 104 | R/W L        | Set Point signal activation type: the signal can be “N.O.” or “N.C.” | 0 = active close (N.O.)  
1 = active open (N.C.) (default = 0) | |
| 105 | R/W N        | Set point hysteresis (in % of threshold) | 0 to 100 (default = 2) | |
| 108 | R/W N        | Baud rate | 600 = 0  
1200 = 1  
2400 = 2  
4800 = 3  
9600 = 4 (default = 4) | |
| 109 | W L          | Pump life / cycle time / cycle number reset | To reset write ‘1’ | |
| 110 | R/W L        | Interlock type (default = 1) | Impulse = 0  
Continuous = 1 | |
| 111 | R/W L        | Analog output type: output voltage signal proportional to frequency or power | 0 = frequency  
1 = power (default = 0) | |
| 114 | R/W N        | Purge gas type | 0 = N. | |
| 115 | R/W L        | Threshold flowmeter | sccm | |
| 117 | R/W N        | Low speed setting (Hz) | 475 to win. 121 (default = 475) | |
| 118 | R/W L        | Body thermistor enable | 0 = NO  
1 = YES | |
| 120 | R/W N        | High speed setting (Hz) | 475 to win. 121 (default = 555) | |
| 121 | R/W N        | Maximum excitation frequency in Hz (active only in Stop condition) | 475 to 555 (default = 555) | |
| 122 | R/W L        | Set vent valve open/ close (N.C.) | 1 = open  
0 = close (default = 0) | |
| 123 | 124 | Reserved to Busch service | | |
| 125 | R/W L        | Valves operating mode | 0 = auto (default)  
1 = on command (see win. 146) | |
| 126 | R/W N        | Vent valve opening delay (expressed in 0.2 sec) | 0 to 65535  
(corresponding to 0 to 13107 sec) (default = 15) | |
| 130 | Reserved to Busch service | | | |
| 145 | R/W L        | Set purge valve open/ close | 0 = close  
1 = open (default = 0) | |
| 146 | R/W L        | Set valves command source | 0 = Serial  
1 = Remote (default = 0) | |
| 147 | R/W N        | Vent Valve Opening Time (expressed in 0.2 sec) | 0 to 65535 bit  
(0 = infinite, 1 = 0.2 sec, max = 13107 sec) (default = 0) | |
| 152 | R/W L        | HPS enable | 0 = OFF  
1 = ON (default = 0) write only in STOP | |
<table>
<thead>
<tr>
<th>155</th>
<th>R</th>
<th>N</th>
<th>Power limit applied</th>
<th>Watt</th>
</tr>
</thead>
<tbody>
<tr>
<td>157</td>
<td>R/W</td>
<td>L</td>
<td>Gas load type</td>
<td>0 = Ar, 1 = N₂, (default = 0)</td>
</tr>
<tr>
<td>158</td>
<td>R/W</td>
<td>N</td>
<td>Max foreseen water cooling temperature (Twater, max)</td>
<td>°C, min = 15, max = 35, (default = 34)</td>
</tr>
<tr>
<td>159</td>
<td>R/W</td>
<td>N</td>
<td>Water cooling hysteresys</td>
<td>% (default = 1)</td>
</tr>
<tr>
<td>164</td>
<td>R</td>
<td>N</td>
<td>Tbody, lim: body temperature corresponding to Twater, max</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>R</td>
<td>N</td>
<td>Pump current in mA dc</td>
<td></td>
</tr>
<tr>
<td>201</td>
<td>R</td>
<td>N</td>
<td>Pump voltage in Vdc</td>
<td></td>
</tr>
<tr>
<td>202</td>
<td>R</td>
<td>N</td>
<td>Pump power in W (pump current x pump voltage duty cycle)</td>
<td></td>
</tr>
<tr>
<td>203</td>
<td>R</td>
<td>N</td>
<td>Driving frequency in Hz</td>
<td></td>
</tr>
<tr>
<td>204</td>
<td>R</td>
<td>N</td>
<td>Pump temperature in °C</td>
<td>0 to 70</td>
</tr>
<tr>
<td>205</td>
<td>R</td>
<td>N</td>
<td>Pump status</td>
<td>Stop = 0, Waiting intlk = 1, Starting = 2, Auto-tuning = 3, Braking = 4, Normal = 5, fail = 6</td>
</tr>
<tr>
<td>206</td>
<td>R</td>
<td>N</td>
<td>Error code</td>
<td>Bit description: see the following figure</td>
</tr>
<tr>
<td>211</td>
<td>R</td>
<td>N</td>
<td>Controller temperature n. 1</td>
<td>°C</td>
</tr>
<tr>
<td>216</td>
<td>R</td>
<td>N</td>
<td>Pump body temperature</td>
<td>°C</td>
</tr>
<tr>
<td>222</td>
<td>R</td>
<td>N</td>
<td>Controller temperature n. 2</td>
<td>°C</td>
</tr>
<tr>
<td>223</td>
<td>R</td>
<td>N</td>
<td>Flow meter reading</td>
<td>sccm</td>
</tr>
<tr>
<td>300</td>
<td>R</td>
<td>N</td>
<td>Cycle time in minutes (zeroed by the reset command)</td>
<td>0 to 999999</td>
</tr>
<tr>
<td>301</td>
<td>R</td>
<td>N</td>
<td>Cycle number (zeroed by the reset command)</td>
<td>0 to 9999</td>
</tr>
<tr>
<td>302</td>
<td>R</td>
<td>N</td>
<td>Pump life in hours (zeroed by the reset command)</td>
<td>0 to 999999</td>
</tr>
<tr>
<td>303</td>
<td>R</td>
<td>N</td>
<td>High Power Start cycles number</td>
<td></td>
</tr>
<tr>
<td>304</td>
<td>R</td>
<td>N</td>
<td>High Power Start tries number of last 9</td>
<td></td>
</tr>
<tr>
<td>310 to 399</td>
<td></td>
<td></td>
<td>Reserved to Busch service</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>R</td>
<td>A</td>
<td>CRC EPROM (QE)</td>
<td>QE8XXXX (where “XXXX” are variable)</td>
</tr>
<tr>
<td>402</td>
<td>R</td>
<td>A</td>
<td>CRC Param. (PA)</td>
<td>PA8XXXX (where “XXXX” are variable)</td>
</tr>
<tr>
<td>500</td>
<td></td>
<td></td>
<td>Reserved to Busch service</td>
<td></td>
</tr>
<tr>
<td>503</td>
<td>R/W</td>
<td>N</td>
<td>RS 485 address</td>
<td>0 to 31, (default = 0)</td>
</tr>
<tr>
<td>504</td>
<td>R/W</td>
<td>L</td>
<td>Serial type select</td>
<td>0 = RS 232, 1 = RS 485, (default = 0)</td>
</tr>
</tbody>
</table>

Window N. 206 Bit Description
MoniTorr

An integrated MoniTorr card is suitable for the Turbo TM 1600 A. This feature allows the pump’s vibration spectra acquisition and download. The necessary hardware is totally integrated into the controller and consists of one PCB card and one accelerometer fixed on the controller’s side.

The MoniTorr card allows to:
- perform programmed maintenance on the turbopump
- continuously monitor the turbopump operating conditions
- identify the wear conditions of one or two bearings.

Powering on the MoniTorr

At pump’s power-on, the POWER LED comes on and the system proceeds with its self-configuration routine. Data acquisition and processing will be automatically activated at the moment in which the turbo pump reaches its maximum speed (Normal Operation). The MoniTorr card is powered from the controller.

Operation

At predefined intervals, the Monitorr will also acquire the data related to the vibration spectrums, power and temperature in addition to other data detected by the Turbo controller. All the data must be transferred to a PC (by means of the “File Download” program) where are stored and where can be analyzed by Busch’s specialised personnel.

Maintenance

The MoniTorr card doesn’t require any maintenance. Any intervention must be carried out by authorised personnel.

In case of failure, the Busch Repair Service is available or Advanced Exchange Service that provides you with a regenerated controller in replacement of the faulty one.

MoniTorr Installation on the Network and on the Main PC

The RS-485 interface allows connecting more than one system in network (up to 32). In this way it is possible to download all the spectrums data with a single PC through a protocol converter (not yet available) which operate as a gateway from 485 to 232 link.

The controller provides the serial address of the MoniTorr option. Every controller must therefore have a different serial address so as to avoid conflicts on the network. Every controller has “0” default serial address. So the user must set the controller’s address.

The following figure shows the connection of the MoniTorr to the RS485 network.

NOTE: The protocol converter is not strictly needed for MoniTorr operation. It is also possible to use the standard RS232 to RS485 converter and the standard optical to RS232 converter.

In order to install and operate the MoniTorr card of the Turbo-V 2K-G it’s necessary to get the Monitor Connectivity Kit (P/N 969-9260). The user should install it on any windows based PC with at least one RS232 port.

MoniTorr Connectivity Kit Installation Procedure

- Install the File VT Serial Address Configurator on PC (launch VT-SAC\setup.exe on CD Rom)
- Connect the RS232 cable between the PC serial port and the first TV 2KG serial port

- Launch the VT Serial Address Configurator program
- Set the Serial Communication as following:
  - Baudrate 9600
  - COM Port = Your PC COM Port Number (generally COM1)
  - Numeric: a different address for each pump (0..1..2…..31)
  - Click on “Set the new address” button

- Close the VT Serial Address Configurator program
- Repeat all operations from the point 2 choosing a new address for each pump
- Install the MoniTorr File Download Program PC (FileDW\Setup.exe on CD rom); see Installing the File Download Software paragraph
- Connect the RS232 cable from PC to Protocol Converter
- Connect the RS485 cable between the protocol converter and the network connector of each pump
Operation Notes

Application

**CAUTION**
The turbomolecular pump is designed for operation under the conditions described below.

In case of disregard risk of damage or destruction of the vacuum pump!

Risk of Injury!
The turbomolecular pump must be operated under the conditions described below.

**CAUTION**
Make all electrical an pneumatic connections before the use of the system.

While heating the vacuum chamber, the temperature of the inlet flange must not exceed 80°C.

While operating the pump the rotor temperature must never exceed 120°C. The user must be sure to set the correct gas mode, according to the pumped gas : 1 for N₂ and lighter gases, 0 for Argon (default). See the chapter "Window Meanings" for details.

**CAUTION**
Never use the turbopump when the inlet flange is not connected to the vacuum chamber or is not blanked.

Do not touch the turbopump or any of its accessories during the heating process. The high temperatures may cause burns.

**CAUTION**
Avoid impacts, oscillations or harsh movements of the pump when in operation. The bearings may become damaged.

Use air or inert gas free from dust or particles for venting the pump. The pressure at the vent port must be less than 1 bar (above atmospheric pressure).

For pumping aggressive gases containing particulate or aggressive pollutants for the bearings, these pumps are fitted with a special port to allow a steady flow of inert gas (like N₂, He) for pump bearing protection (see the chapter "Pump Used with Corrosive Gases").

**CAUTION**
Never use the pump with corrosive gases or vapor to avoid damage to the internal materials of the pump.

**CAUTION**
When employing the pump for pumping toxic, flammable, or radioactive gases, please follow the required procedures for each gas disposal.

Do not use the pump in presence of explosive gases.

The pump is designed to pump high throughput of N₂, Ar and lighter gas. Should you need to pump gases heavier than Ar, please contact Busch technical support for information.

---

- Check if Baud Rate of protocol converter is fixed at 115K2 (switch between 9 position and F position)
- Connect the power supply to protocol converter
- Launch the file download software
- Select menu File/Download Mode and check the following fields:
  - Trigger 1
  - Mode: Number of file (# file)
- Select menu File/Archive Time and select the number of days for a periodical file download to be sent (for example 7 days)
- Read the Archive Saving Method Procedure Paragraph
- Start the system

**NOTE:** The computer must be always connected to the MoniTorr. Please, be sure that the PC hasn’t automatically Standby or Suspend procedure active.
Switching on
Before starting the system, please check that the mating I/O connector is unplugged. If the system is connected to a remote I/O, make sure the stop signal (see para. “J1-REMOTE I/O”) is given.

To start the system please follow the following steps:
- unplug (if present) the system mating I/O connector
- plug on the mains
- pump the vacuum chamber down to 0.1 mbar
- give the Turbo-V 2K-G a start signal by one of the following methods:
  - connecting the provided mating I/O connector
  - giving a remote start signal through the I/O connector (see chapter “J1-REMOTE I/O”)
  - giving a remote start signal via the serial RS 232/485 interface (see chapter “RS232/RS485 Communication Description”).

WARNING
When power is supplied and factory default 15 pin mating connector is inserted, the Turbo TM 1600 A will start automatically.

CAUTION
The controller is furnished already mechanically and electrically connected to the pump. Detaching of the controller from the pump must be carried out by authorized Busch Vacuum Technologies personnel only.

NOTE: When you run the Turbo TM 1600 A for the very first time, the control unit automatically starts the system with a special procedure which protects the bearings from possible damages (SOFT START). The system is launched step by step at full speed in a time variable from 10 mins up to 1 hour. After the system has reached the full speed, the soft start procedure is disabled and following starts are performed in the normal way.

NOTE: In order to maintain the IP-54 protection level you must use only the connectors provided with the pump. Use connectors PN: 969-9957 or 969-9958 for the power cable and fix it to the controller by means of the suitable retaining bracket (see the following figure). Use this power cord and plug in conjunction with a properly grounded power socket to avoid electrical shock and to satisfy CE requirements.

The system is provided with a green status led signal. The green LED located on the Turbo TM 1600 A base front panel indicates with its flashing frequency the system operating conditions:
- with no flashing: the pump is normally rotating;
- slowly flashing (period of about 400 ms): the system is in ramp, or in braking, or in Stop, or in “Waiting for interlock” status;
- fast flashing (period of about 200 ms): error condition.

Turbo pump, switching off
To stop the pump you can use one of the following methods:
- unplugging the provided mating I/O connector
- giving a remote stop signal through the I/O connector (see para. “J1-REMOTE I/O” of annex “Technical Information”)
- giving a remote stop signal via the serial RS 232/485 interface (see chapter “RS232/RS485 Communication Description”).

Emergency Stop
To immediately stop the Turbo TM 1600 A in an emergency condition it is necessary to remove the mains. It must be however noted that this operation, in addition to cutting off the pump power, also cuts off all other controller functions, such as Purge and Controlled Vent management and the capability of communicating with the system in which the pump is integrated via I/Os, Serial or Profibus.

Furthermore, this operation may not ensure the immediate stopping of the rotor. Rotation speed of the rotor will decrease according to the degree of vacuum present in the system.

Inlet Screen Installation

The inlet screen mod. 969-9138 prevents the blades of the pump from being damaged by debris greater than 5.2 mm diameter.

The inlet screen, however, does reduce the pumping speed by about 10%.

The inlet screen is fitted in the upper part of the pump, as shown in the figure.

It is welded to the center ring of the ISO 250 F viton gasket.

The screen can be removed as shown in the following figure.
The following figure shows the ISO 250 F pump flange section with the protection screen fitted on it. As you can see, the overall dimensions do not change as the inlet screen remains inside the pump profile.

**Water Cooling Connection**

The pumping system is supplied with a metallic model water cooling kit.

Two 9-10 mm internal diameter rubber or plastic tubes from the water supply must be fitted to the two dedicated nozzles.

**NOTE:** These tubes must be held on the respective nozzles using hose clips to avoid that the tube(s) gets loose or disconnected during operation.

Cooling may be carried out either through an open circuit with eventual discharge of the water, or using a closed circuit cooling system.

The water temperature must be between +10°C and +35°C, with an inlet pressure between 3 and 5 bar. In any case the water flow must not be less than 3.5 l/min.

The customer can alternatively order the 90°C bend water cooling kit, plastic model (969-9348) or metallic model (696-9338).

**NOTE:** The water electrical conductance must be ≤ 500 µS/cm. When the conductance is higher, in closed water circuit, the use of up to 20% of Ethyl-Glycole is suggested.

**Pump Purging and Venting**

The Turbo TM 1600 A pump is equipped with an integrated purging and venting valve device. Both valves are fed through a single gas port, with 1/8 NPT thread or Swagelok connector.

**Purge and Vent Installation**

To install the gas purge and vent line it is necessary to unscrew the purge/vent port cover, and then connect the gas line.
Removal from Service
Dismantling and Disposal
Recommissioning

CAUTION

Only authorised personnel may carry out dismantling work on the vacuum pump. Before work begins, the operator of the turbomolecular pump must fill in a form or a «Declaration of Decontamination» that provides information on possible dangers and appropriate measures.

If this form has not been filled in completely and signed, the vacuum pump may not be dismantled.

CAUTION

During dismantling of the turbomolecular pump protective equipment and clothing must be worn.

◆ dispose of the turbomolecular pump as scrap metal
— dispose of the different components of the turbomolecular pump in compliance with applicable regulations

Meaning of the "WEEE" logo found in labels

The following symbol is applied in accordance with the EC WEEE (Waste Electrical and Electronic Equipment) Directive. This symbol (valid only in countries of the European Community) indicates that the product it applies to must NOT be disposed of together with ordinary domestic or industrial waste but must be sent to a differentiated waste collection system. The end user is therefore invited to contact the supplier of the device, whether the Parent Company or a retailer, to initiate the collection and disposal process after checking the contractual terms and conditions of sale.

According to the best knowledge at the time of printing of this manual the materials used for the manufacture of the turbomolecular pump.
The following figure shows the Turbo TM 1600 A outlines (dimensions are in mm).

### Dimensions

**Turbo TM 1600 A**

Upper View:
- Flange ISO 250 F
- Eyebolt
- Purge & Vent
- SwageLock Pipe 1/8
- Controller
- Front Panel
- Inlet Screen with Center-Ring
- Water Cooling for Rubber Tube Dia 9.0
- Foreline KF 40

Bottom View:
- Dimensions in mm:
  - Diameter: 335
  - Height: 245
  - Width: 335

Dimensions in mm:
- 95
- 162.8
- 164
- 245
- 265
- 335
Throughput and power curves for Argon (power limit 350 W) - Data with 80 m³/h primary pump.

Throughput and power curves for Nitrogen (power limit 400 W) - Data with 80 m³/h primary pump.
Spare parts

**NOTE:** when ordering spare parts or accessories acc. to the table below please always quote the type and the serial no. of the vacuum pump. This will allow Busch service to check if the vacuum pump is compatible with a modified or improved part.

The exclusive use of genuine spare parts and consumables is a prerequisite for the proper function of the vacuum pump and for the granting of warranty, guarantee or goodwill.

This parts list applies to a typical configuration of the standard vacuum pump. Depending on the specific order deviating parts data may apply.
## Technical data

<table>
<thead>
<tr>
<th>Technical data</th>
<th>Turbo TM 1600 A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumping speed (without inlet screen) m³/h N²:</td>
<td>5760</td>
</tr>
<tr>
<td>Compression ratio</td>
<td>5 x 10⁻³</td>
</tr>
<tr>
<td>Compression ratio Ar:</td>
<td>6 x 10⁻³</td>
</tr>
<tr>
<td>Base pressure with recommended fore-pump hPa (mbar)</td>
<td>5 x 10⁻³</td>
</tr>
<tr>
<td>Inlet flange, nominal diameter ISO 250-F</td>
<td></td>
</tr>
<tr>
<td>Foreline flange, nominal diameter KF 40 NW</td>
<td></td>
</tr>
<tr>
<td>Rotational speed min⁻¹</td>
<td>33000</td>
</tr>
<tr>
<td>Start-up time minutes</td>
<td>&lt; 7</td>
</tr>
<tr>
<td>Recommended forepump m³/h</td>
<td>&gt; 40</td>
</tr>
<tr>
<td>Operating position</td>
<td>Any</td>
</tr>
<tr>
<td>Operating ambient temperature °C</td>
<td>+5°C...+40°C</td>
</tr>
<tr>
<td>Max. flange temperature °C</td>
<td>no process: 80°C</td>
</tr>
<tr>
<td>Max. rotor temperature °C</td>
<td>process: 50°C</td>
</tr>
<tr>
<td>Max. rotor temperature °C</td>
<td>120</td>
</tr>
<tr>
<td>Vibration level µm</td>
<td>&lt; 0.01 at inlet flange</td>
</tr>
<tr>
<td>Lubricant</td>
<td>Permanent lubrication</td>
</tr>
<tr>
<td>Cooling requirements</td>
<td>Water</td>
</tr>
<tr>
<td>Coolant water</td>
<td></td>
</tr>
<tr>
<td>Minimum flow I/min</td>
<td>3.5</td>
</tr>
<tr>
<td>Temperature °C</td>
<td>+10...+35</td>
</tr>
<tr>
<td>Pressure bar</td>
<td>3...5</td>
</tr>
<tr>
<td>Noise level (EN ISO 2151) dB(A)</td>
<td>&lt;45 (at 1 meter)</td>
</tr>
<tr>
<td>Power supply:</td>
<td></td>
</tr>
<tr>
<td>Input voltage : Vac</td>
<td>208-240</td>
</tr>
<tr>
<td>Input frequency : Hz</td>
<td>50-60</td>
</tr>
<tr>
<td>Max input power : VA</td>
<td>850</td>
</tr>
<tr>
<td>Stand-by power : W</td>
<td>30 to 35</td>
</tr>
<tr>
<td>Max operating power</td>
<td>400 W using Nitrogen or lighter gases</td>
</tr>
<tr>
<td>Protection fuse (Navigator Controller) A</td>
<td>2 x 8</td>
</tr>
<tr>
<td>Power cable With European or NEMA plug 3 meters long (optional)</td>
<td></td>
</tr>
<tr>
<td>Serial communication (Navigator kit) RS232 cable with a 9-pin D type male connector and a 9-pin D female connector, and Navigator software (optional)</td>
<td></td>
</tr>
<tr>
<td>Installation category Il</td>
<td></td>
</tr>
<tr>
<td>Pollution degree</td>
<td>2</td>
</tr>
<tr>
<td>Max. altitude 2000 m MSL</td>
<td></td>
</tr>
<tr>
<td>Storage temperature °C</td>
<td>-20°C to +70°C</td>
</tr>
<tr>
<td>Environment protection</td>
<td>IP54</td>
</tr>
<tr>
<td>Weight kg</td>
<td>35</td>
</tr>
</tbody>
</table>

**NOTE:** When the Turbo TM 1600 A has been stored at a temperature less than 5°C, wait until the system has reached the above mentioned temperature before starting the pump.
EC Declaration of Conformity

NOTE: This Declaration of Conformity and the -mark affixed to the nameplate are valid for the vacuum pump within the Busch-scope of delivery. When this vacuum pump is integrated into a larger machinery the manufacturer of the larger machinery (this can be operator, too) must conduct the conformity assessment process acc. to the Directive Machinery 2006/42/EC for the larger machine, issue the Declaration of Conformity for it and affix the -mark.

We
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declare that the vacuum pumps Turbo TM 1600 A

in accordance with the European Directives
“Machinery” 2006/42/EC,
“Electromagnetic Compatibility” 2004/108/EC

have been designed and manufactured to the following specifications:

<table>
<thead>
<tr>
<th>Standards</th>
<th>Title of the standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harmonised standards</td>
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</tr>
<tr>
<td>UNI EN 292-1</td>
<td>Fundamental concepts, general design principles - terminology, basic methodology; Part 1</td>
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<tr>
<td>UNI EN 292-2</td>
<td>Fundamental concepts, general design principles - Specifications and technical principles; Part 2</td>
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<tr>
<td>EN 55011CI.A</td>
<td>Industrial, scientific and medical (ISM) radio-frequency equipment - Radio disturbance characteristics - Limits and methods of measurement</td>
</tr>
<tr>
<td>EN ISO 13857</td>
<td>Safety of machinery - Safety distances to prevent hazard zones being reached by upper and lower limbs</td>
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<tr>
<td>EN 1012-2</td>
<td>Compressors and vacuum pumps - Safety requirements - Part 2</td>
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<tr>
<td>EN 61010-1</td>
<td>Electrical equipment of machines - Part 1:</td>
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<tr>
<td>EN 61000-4-2</td>
<td>Electromagnetic compatibility (EMC) – Electrostatic discharge immunity test; Part 2</td>
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<tr>
<td>EN 61000-4-3</td>
<td>Electromagnetic compatibility (EMC) – Radiated, radio-frequency, electromagnetic field immunity test; Part 3</td>
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<tr>
<td>EN 61000-4-4</td>
<td>Electromagnetic compatibility (EMC) – Testing and measurement techniques - Electrical fas transient/burst immunity test ; Part 4</td>
</tr>
<tr>
<td>EN 61000-4-5</td>
<td>Electromagnetic compatibility (EMC) – Testing and measurement techniques - Surge immunity test; Part 5</td>
</tr>
<tr>
<td>EN ISO 2151</td>
<td>Acoustics - Noise test code for compressors and vacuum pumps - Engineering method (grade 2)</td>
</tr>
</tbody>
</table>

Manufacturer                       Mandatory within the EC:                        Person authorised to compile the technical file

Christian Hoffmann  General director  [Signature]       [Signature]                              Gerd Rohweder
                                                                 General director                        Product manager