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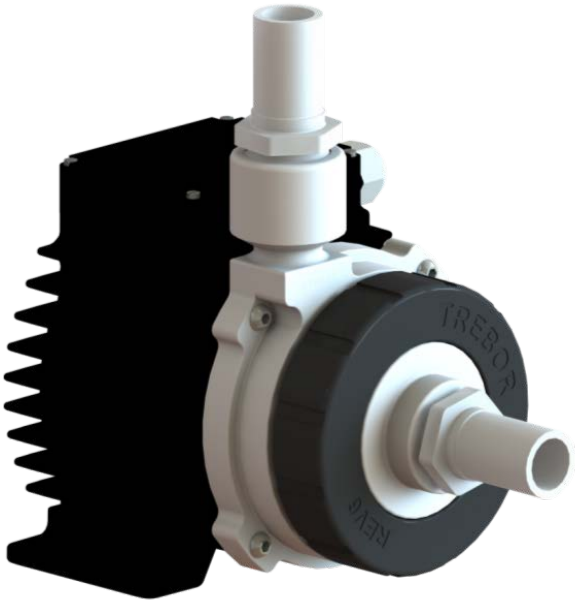
# REV6

## Operation / Maintenance Manual




*This manual contains information necessary for the safe and proper use of the Rev6. Included are specifications for the standard configurations of the pump system and instructions regarding its use, installation, operation, adjustment, inspection, and maintenance. For special configurations of the pump system, refer to accompanying information. Please familiarize yourself with the contents of the manual to ensure the safe and effective use of this product. After reading this manual, please store the manual where the personnel responsible for operating the pump system can readily refer to it at any time.*

SERIAL NUMBER (located on the product):

IDEX CORPORATION

10/04/2017 – REV6-B

# Table of Contents

# 1 SAFETY PRECAUTIONS

## CAUTION

*Do not open the motor or controller. Trebor does not assume responsibility for any damage occurring under such circumstances.*

## CAUTION

***High magnetic field strength of pump impeller***

*The pump system contains a rotor magnet with high field strength. This may alter or damage the calibration of sensitive electronic devices and measuring instruments in the immediate surroundings. Keep at a safe distance from computers, monitors and all magnetic data storage media (e.g. disks, credit cards, audio and video tapes etc.)*

## ⚠WARNING

***Hazardous voltage may be present.***

*In case of the usage of an inadequate AC/DC power supply, mains voltages may be present (even if the system is designed for 48VDC). The usage of a galvanic separated power supply, which is certified by a 3rd party (UL or CE), is highly recommended.*

*The controller must be grounded and placed in a spill protected environment. Do not under any circumstances open the powered controller. The usage of galvanic separated AC/DC supply is highly recommended.*

## ⚠WARNING

***High magnetic field strength of pump impeller***

*The pump system contains a rotor magnet with high field strength. Pacemakers may be influenced and magnetic forces may lead to contusions. Keep distance to pace makers and handle impeller with care.*

## ⚠WARNING

***TOXIC CHEMICALS may be present.***

*When using the system to pump chemicals skin contact and toxic gases may be hazardous to your health. Wear safety gloves and other appropriate safety equipment.*

# 2 SPECIFICATIONS

## 2.1 Specification of Components

Figure 1 shows the main system components. The accessories are listed below.

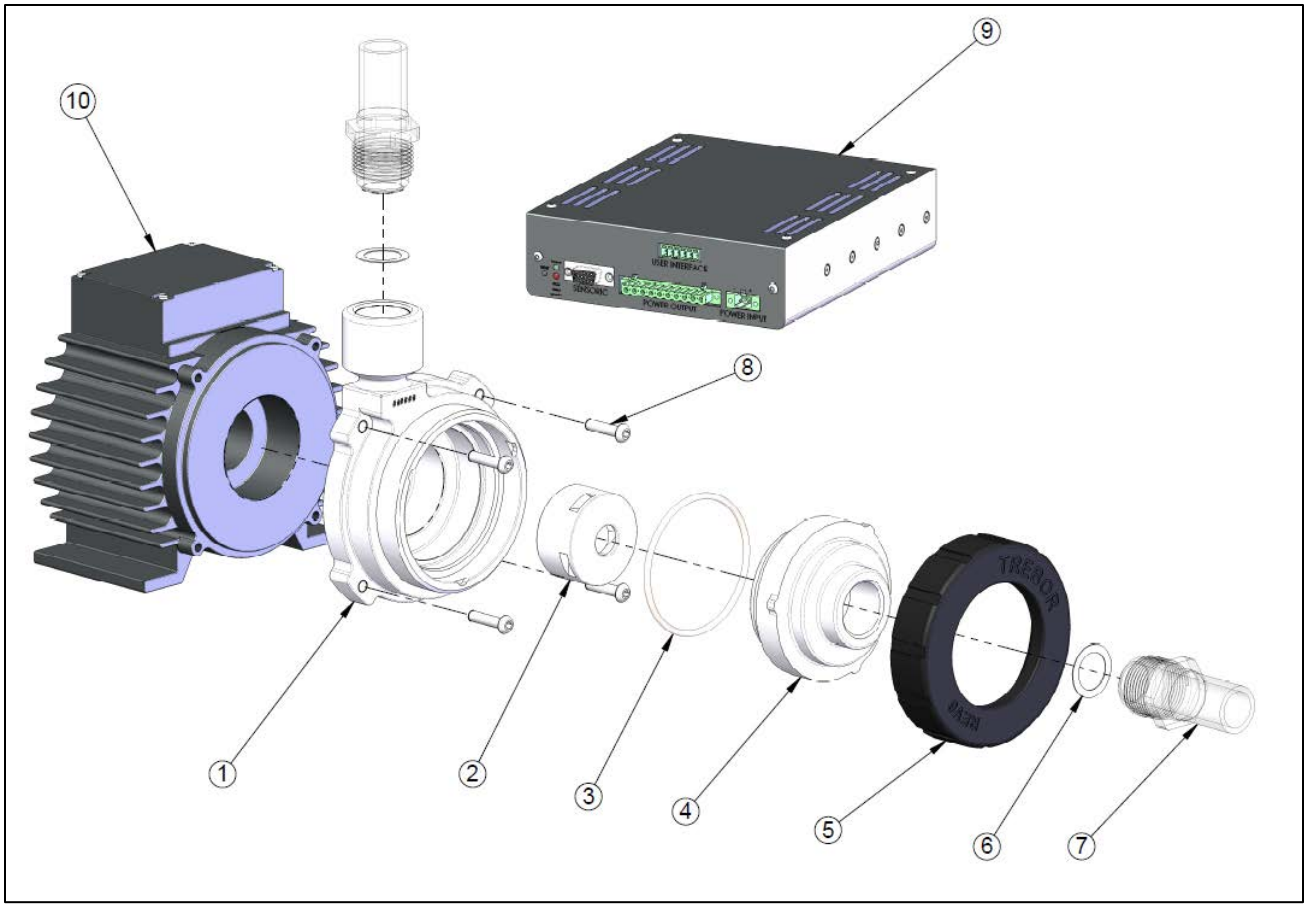



Figure 1 – Standard Components (Cables not shown)

Each Rev6 pump system is comprised of a pump, a motor, a controller, and two fluid port adapters. Table 1 lists each part:

Table 1 – Major Component Part List

| Component | Item | PN | Description | Materials of Construction |
|---|---|---|---|---|
| Pump | 1 | BM001 | Pump Casing | PTFE |
| | 2 | 98004267 | Pump Impeller | PFA flow path |
| | 3 | 98004268 | Pump Main Seal | Semiconductor grade FFKM |
| | 4 | BM002 | Inlet Housing | PTFE TFM 1600 |
| | 5 | BM003 | Union Nut | Polypropylene |
| Fluid Port Adapter | 6 | - | Seal | See Table 3 for details |
| | 7 | - | Fluid Port Adapter | |

| Component | Item | PN | Description | Materials of Construction |
|---|---|---|---|---|
| Motor Mounting Screws | 8 | 98004269 | M6x25mm<br>QTY 4 | 316 stainless steel |
| Controller | 9a | 98004271 | Standalone Controller | Standalone Controller<br>*48VDC/600W Power*<br>*Panel control for motor speed*<br>*Optional PLC control* |
| | 9b | 98004275 | Extended Controller | Extended Controller<br>*48VDC/600W Power*<br>*PLC control* |
| Motor | 10 | 98004270 | 600W Motor | Standard 3 meter cables included (not shown)<br>FEP Jacket<br>IP67 rated liquid and dust protected |

The Rev6 can be ordered as an individual pump to replace a current installation. In order to have a fully functioning unit (i.e., for a new installation) a motor, controller, connecting cables, power supply and fluid port adapters are required. The pump will not operate without a motor and controller.

**Table 2 – Standard System Configurations**

| Product | Description | Included | Additional Required Items |
|---|---|---|---|
| REV6A0 | Pump with PP union nut and 316 SS bolts (Standalone Control) | - Pump<br>- Attachment Screws<br>- Pump Manual<br>- Pump motor<br>- Standalone pump controller | - Power cable<br>- Sensor cable<br>- Power supply<br>- Fluid port adapters |
| REV6A1 | Pump with PP union nut and 316 SS bolts (Extended Control) | - Pump<br>- Attachment Screws<br>- Pump Manual<br>- Pump motor<br>- Extended pump controller | - Power cable<br>- Sensor cable<br>- Power supply<br>- Fluid port adapters |

Wide varieties of industry standard fluid interfaces are available in the fluid port adapter. The fluid port adapter assures seamless fit between plant infrastructure and the Rev6 pump. All fluid port adapters are manufactured out of ultrapure PFA for the highest chemical compatibility and purity and can be used interchangeable between any Rev6 pump.

Two seal types are available on the pump side. The first is a PTFE gasket seal to ensure chemical compatibility. The second is a semiconductor grade FFKM o-ring seal. The seal is specifically designed to maintain sealing characteristics even at elevated temperatures. The types of adapters currently available are shown below.

Table 3 – Fluid Port Adapters

| Seal Type | PN | Part Description | Plant Connection |
|---|---|---|---|
| PTFE Gasket | G12000-10 | GROUP;ADPTR;3/4IN PIPE;PTFE GSKT | 3/4” weldable pipe |
| | G12F08-10 | GROUP;ADPTR;1/2 IN FLR;PTFE GSKT | 1/2” flare |
| | G12F12-10 | GROUP;ADPTR;3/4FLR;PTFE GSKT;PVDF NUT | 3/4” flare |
| | G12F16-10 | GROUP;ADPTR;1IN FLR;PTFE GSKT | 1” flare |
| | G12P12-10 | GROUP;ADPTR;3/4 FNPT;PTFE GSKT | 3/4” female NPT |
| | G12PL12-10 | GROUP;ADPTR;3/4 PRIMELOCK;PTFE GSKT | 3/4” PrimeLock |
| | G12T12-10 | GROUP;ADPTR;3/4T;PTFE GSKT | 3/4” tube stub |
| | G12X12-10 | GROUP;ADPTR;3/4 PILLAR;PTFE GSKT | 3/4” Pillar |
| FFKM O-ring | O12000 | GROUP; ADPTR; 3/4 IN PIPE; FFKM O-RING | 3/4” weldable pipe |
| | O12F08 | GROUP;ADPTR;1/2IN FLARE;FFKM O-RING | 1/2” flare |
| | O12F12 | GROUP;ADPTR;3/4IN FLARE;FFKM O-RING | 3/4” flare |
| | O12F16 | GROUP;ADPTR;1IN FLARE;FFKM 0-RING | 1” flare |
| | O12P12 | GROUP;ADPTR;3/4IN FNPT;FFKM O-RING | 3/4” female NPT |
| | O12PL12 | GROUP;ADPTR;3/4IN PRMLCK;FFKM O-RING | 3/4” PrimeLock |
| | O12T12 | GROUP;ADPTR;3/4IN TUBE;FFKM O-RING | 3/4” tube stub |
| | O12X12 | GROUP;ADPTR;3/4IN PILLAR;FFKM O-RING | 3/4” Pillar Super 300 |
| If additional fluid connections are needed, contact your Trebor representative for options<br>All flare nuts are constructed of PVDF. PFA nuts are available on request.<br>PrimeLock and Pillar Super 300 are trademarks of Entegris, Inc. and Nippon Pillar Packing Co. LTD, respectively. | | | |

Additional components are available for the Rev6. Extension cables to pair the controller to the pump are available at several different lengths. A sensor cable and power cable are needed for each motor/controller pair. A 48V power supply is also needed for the motor and controller. The specific accessories and part numbers are listed below. See 2.2 below for descriptions and diagrams of different pump setups.

Table 4 – Additional Accessories

| Accessory | PN | Description | Comments |
|---|---|---|---|
| Power Cable | 98004272-01 | CABLE;POWER;0.5m;REV6 | PVC Jacket<br>Circular AMP and D-Sub Plastic Connectors |
| | 98004272-02 | CABLE;POWER;3m;REV6 | |
| | 98004272-03 | CABLE;POWER;5m;REV6 | |
| | 98004272-04 | CABLE;POWER;7m;REV6 | |
| | 98004272-05 | CABLE;POWER;10m;REV6 | |
| Sensor Cable | 98004273-01 | CABLE;SENSORS;0.5m;REV6 | PVC Jacket<br>Circular AMP and D-Sub Plastic Connectors |
| | 98004273-02 | CABLE;SENSORS;3m;REV6 | |
| | 98004273-03 | CABLE;SENSORS;5m;REV6 | |
| | 98004273-04 | CABLE;SENSORS;7m;REV6 | |
| | 98004273-05 | CABLE;SENSORS;10m;REV6 | |

| Accessory | PN | Description | Comments |
|---|---|---|---|
| Power Supply | 98004274 | POWER SUPPLY;48V;REV6 | TSP-600-148-M<br>(M=Modified design from Traco)<br>Output: 48 VDC, 600 W<br>Input: 85-265 VAC (auto detect)<br>CE, CB, UL, CSA, SEMI F47 |
| Air Cooling Module | 98004282 | MODULE;AIR COOLING;REV6 | PP (+40% Talc)<br>NPT 1/4" Connection<br>1-3 bar (14-43 psi) – 100 LPM @ 1 bar |

## 2.2 Standard System Configurations

### 2.2.1 Pump Only Configuration

The Rev6 pump can be purchased without a motor or controller to replace a pump in an existing installation. The Rev6 is a drop-in replacement for the Levitronix BPS-600. This configuration comes with the assembled pump and four 316 stainless steel screws to attach the pump to the motor.

### 2.2.2 Stand-Alone System Configuration

The stand-alone pump system configuration (Figure 2) consists of a controller with an integrated user panel to set the speed manually. The speed is adjusted using the buttons on the control panel and automatically stored in the internal EEPROM of the controller. As an alternative, the pump speed can also be set with an external analog signal.

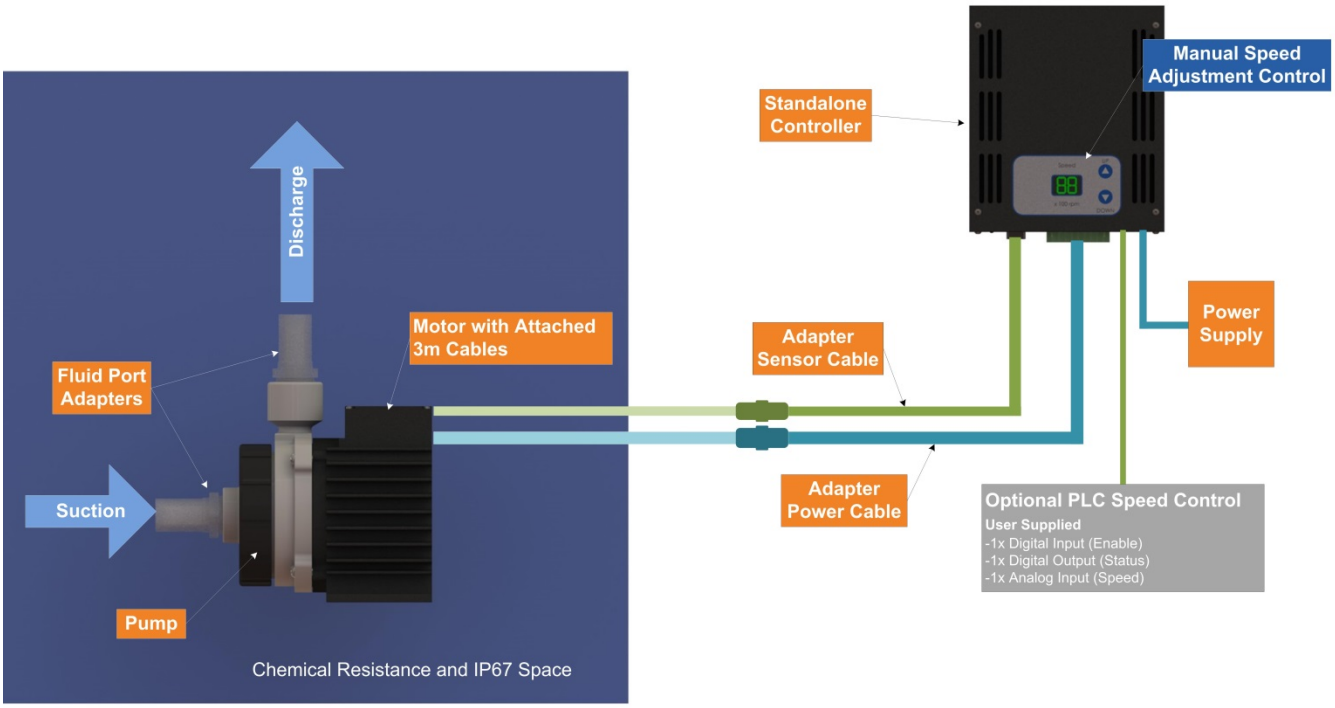



Figure 2 – Standard System Configuration for Standalone Control (Rev6A0)

All components listed in orange boxes in Figure 2 are required for an operable system. The adapter cables (sensors and power), fluid port adapters, and power supply are sold as separate line items.

### 2.2.3 Extended System Configuration

The extended version of the pump system (*Figure 3*) consists of a controller with an extended PLC interface. This allows setting the speed by an external signal and enables precise closed-loop flow or pressure control in connection with either a flow or a pressure sensor. A USB interface allows communication with a PC in connection with the *Trebor Service Software*. Hence parameterization, firmware updates and failure analysis are possible.

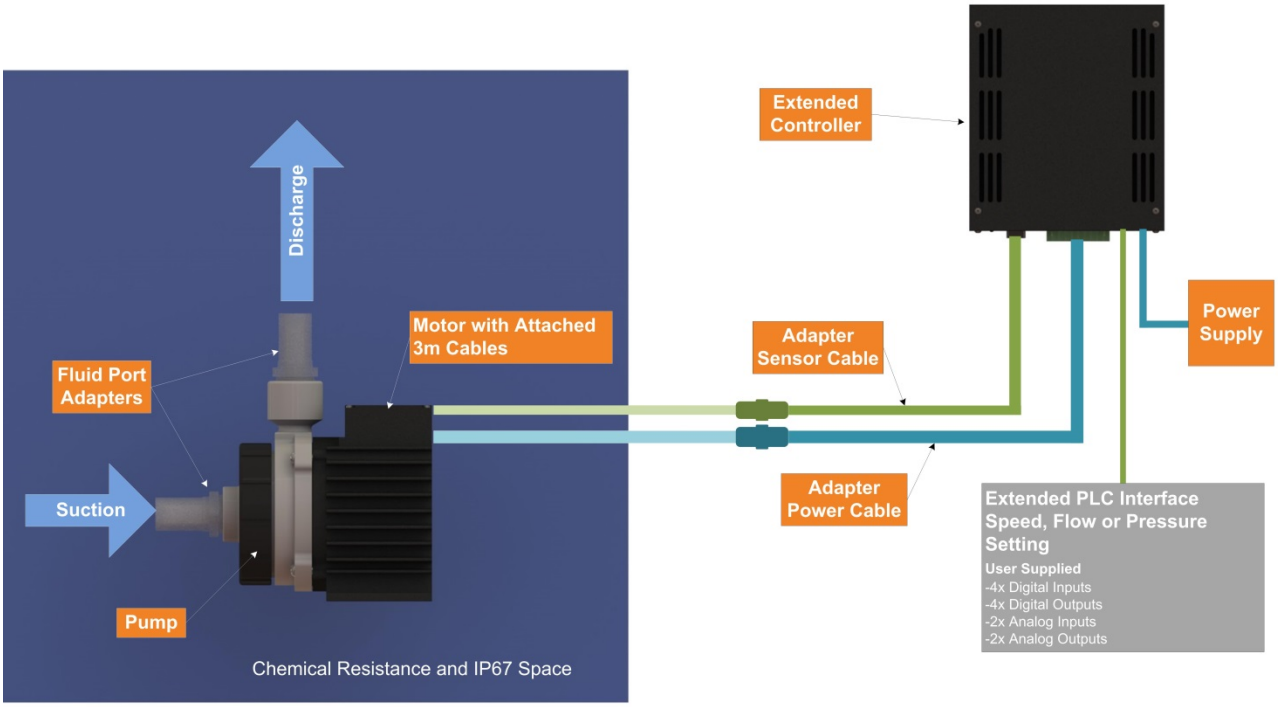



**Figure 3 – Extended System Configuration for Extended Control (Rev6A1)**

All components listed in orange boxes in Figure 3 are required for an operable system. The adapter cables (sensors and power), fluid port adapters, and power supply are sold as separate line items.

## 2.3 General Environmental Conditions

Table 5 – Environmental Conditions for Pump System

| | |
|---|---|
| **Controller usage** | Indoor |
| **Motor with pump usage** | Indoor/Outdoor |
| **Altitude** | Up to 2000 m |
| **Operating ambient temperature** | 0 to 40°C |
| **Storage ambient temperature** (Extremes for transportation) | -20 to 80°C |
| **Operating humidity range** | 15 to 95% relative humidity (non-condensing) |
| **Storage humidity range** (Extremes for transportation) | 15 to 95% relative humidity (non-condensing) |
| **Normal storage conditions** | Ambient temp.: 20 to 30 °C<br>Relative humidity: 50% (non-condensing) |
| **Acceptable DC supply fluctuations** | ±5% of nominal voltage |
| **Transient over-voltages typically present on the mains supply** | Surge immunity according to EN 61000-4-5<br>(tested together with certified AC/DC power supply) |
| **Pollution degree** | 2 |

## 2.4 Pump Performance Curves

### 2.4.1 Pressure-Flow Curves

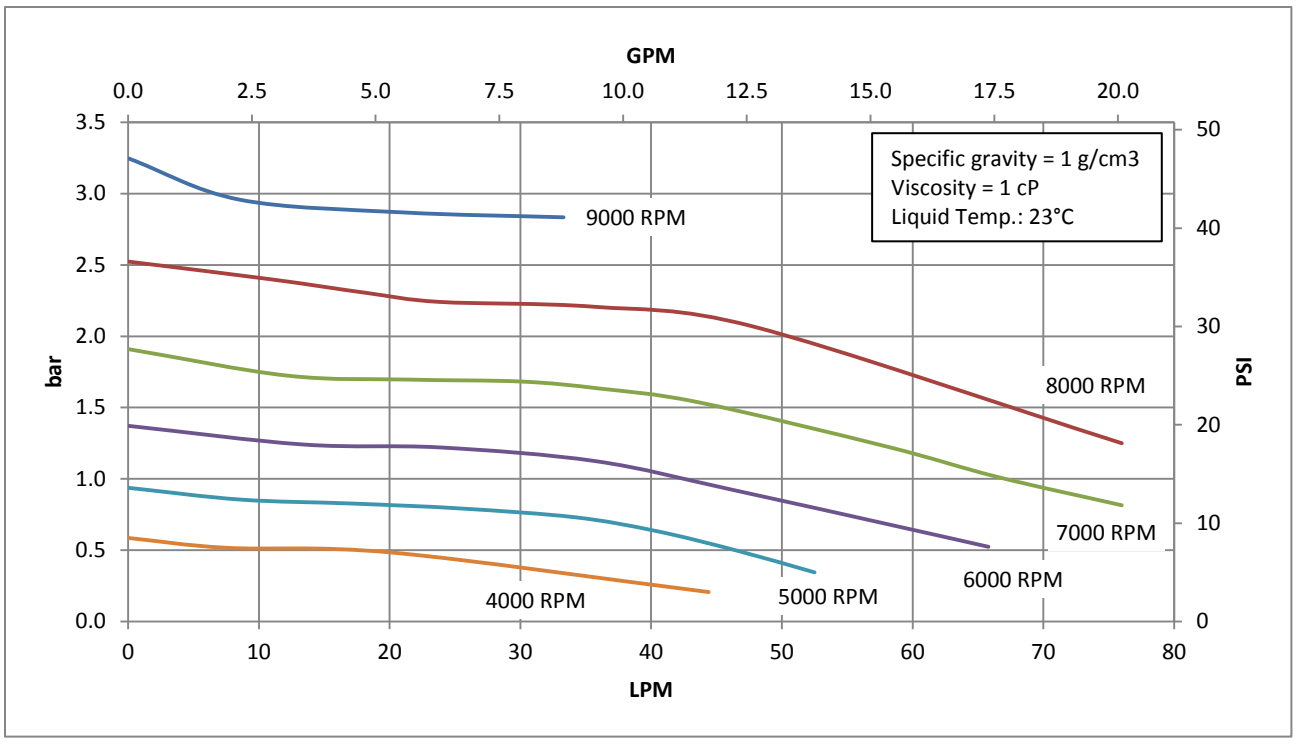



Figure 4 – Rev6 Flow vs Diff Pressure Curves

### 2.4.2 NPSHr Curves

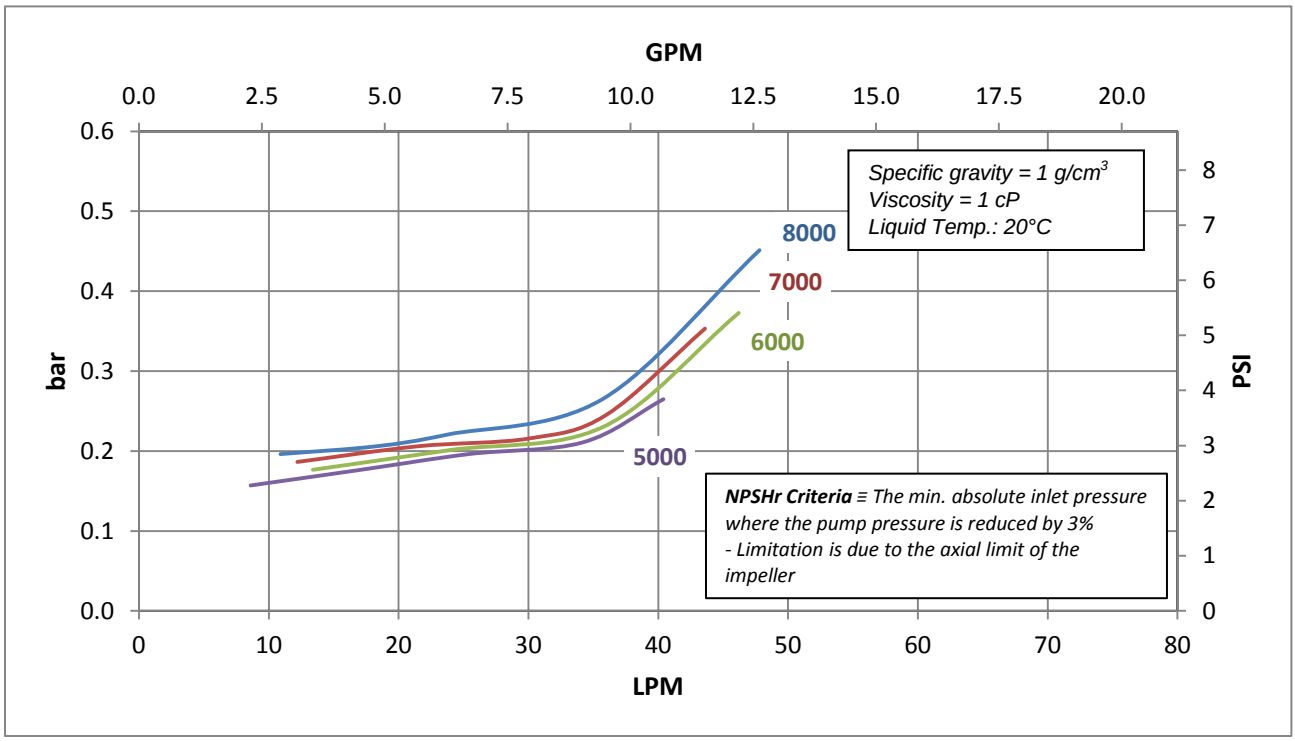



Figure 5 – NPSHr Curves

### 2.4.3 Maximum Static Pressure vs. Fluid Temperature

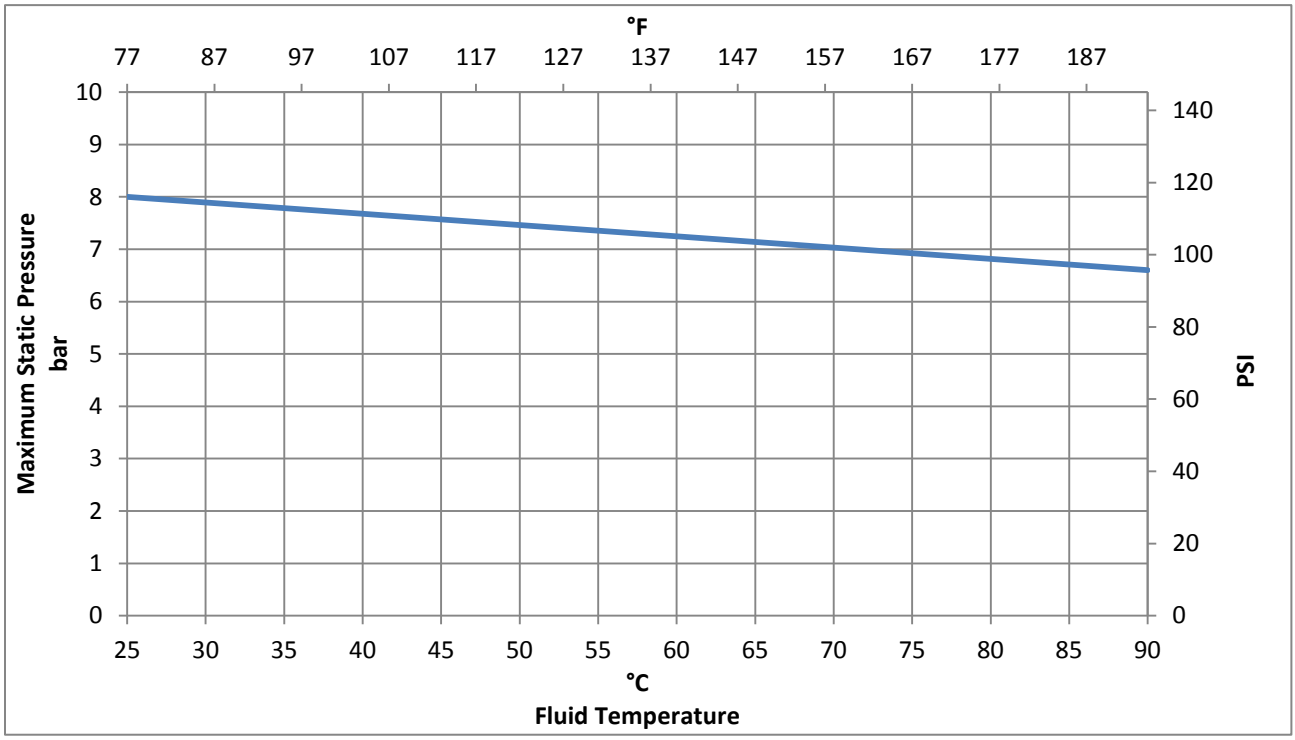



Figure 6 – Maximum Static Pressure Allowed vs. Fluid Temperature

## 2.5 Basic Dimensions of Main Components

All dimensions are given in mm and inches with the inch measurement in brackets.

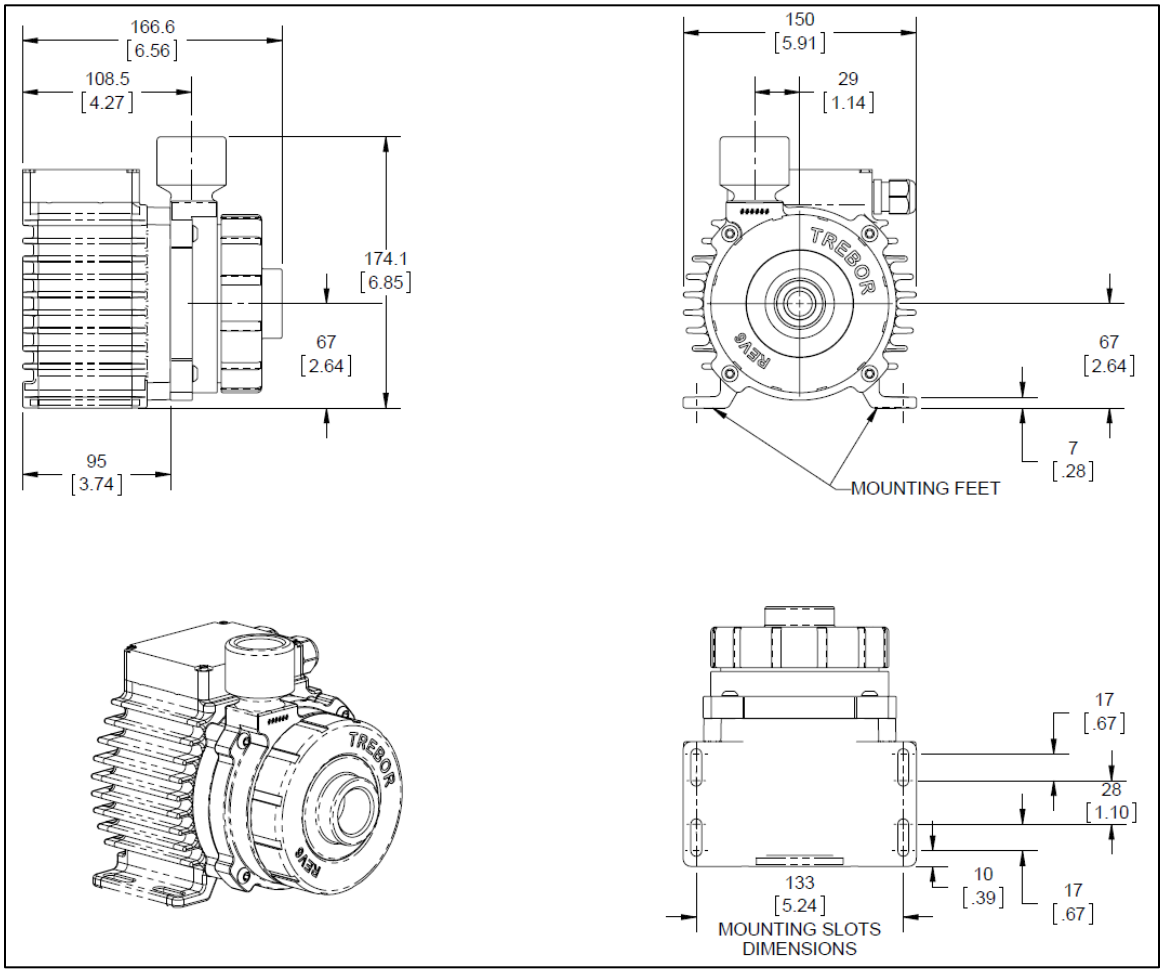



Figure 7 – Basic Pump Dimensions

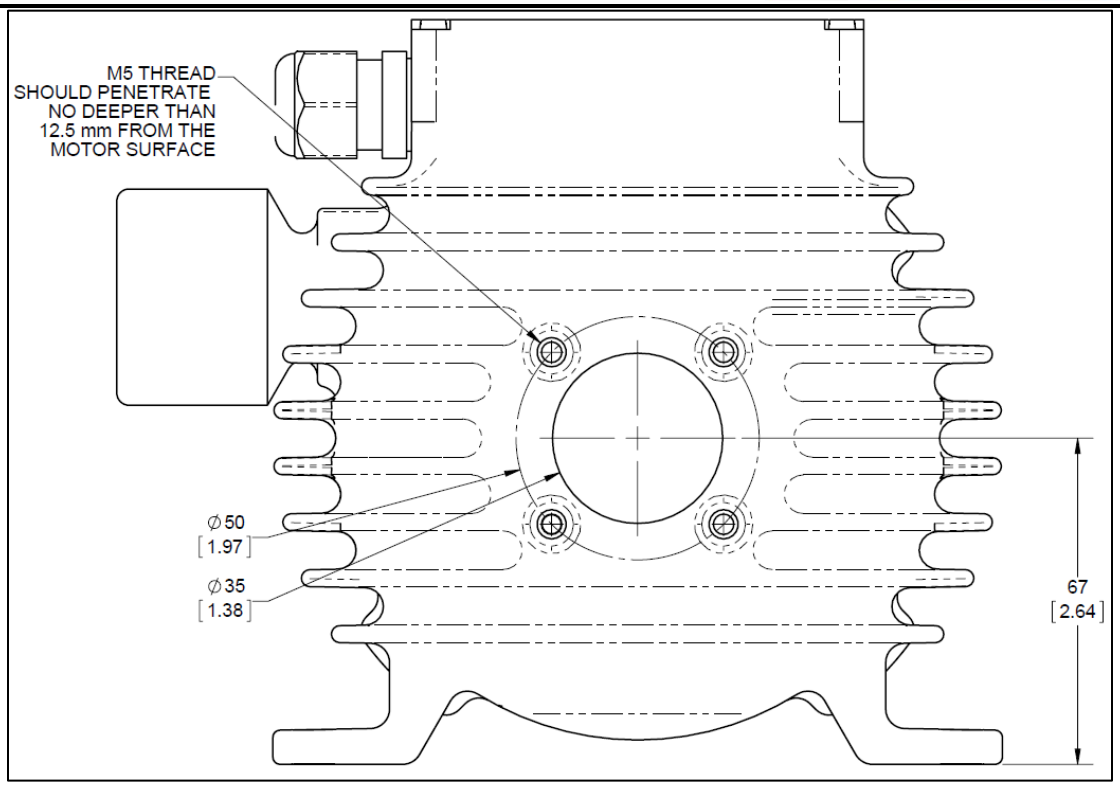



Figure 8 – Alternative Mounting Position

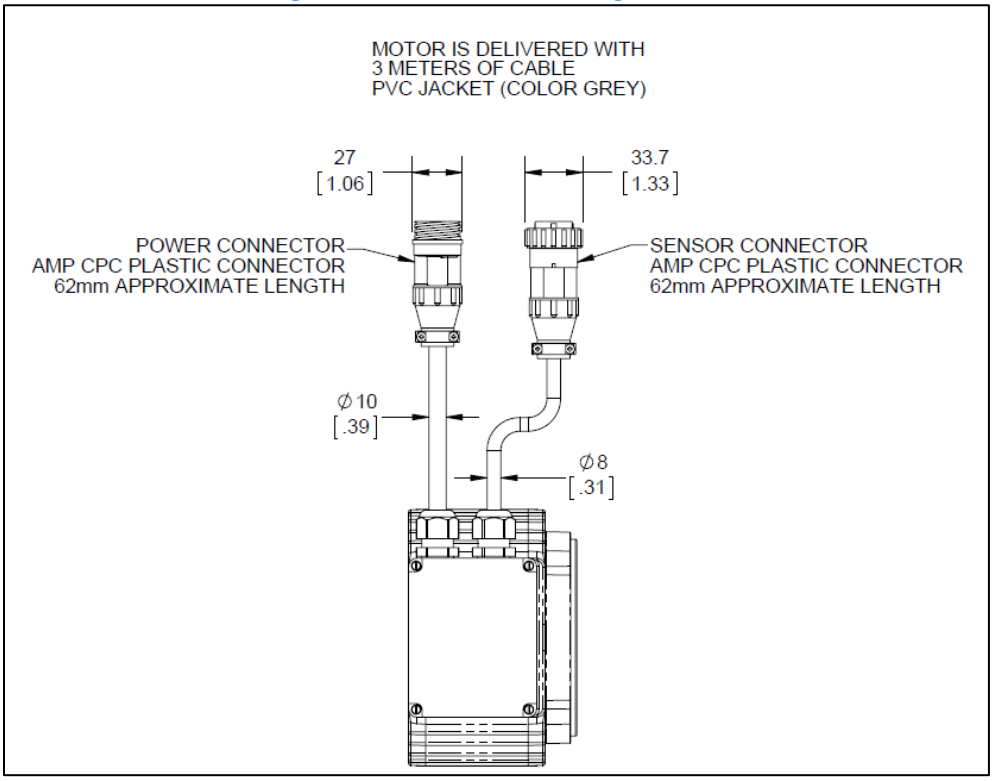



Figure 9 – Cable and Connector Specifications

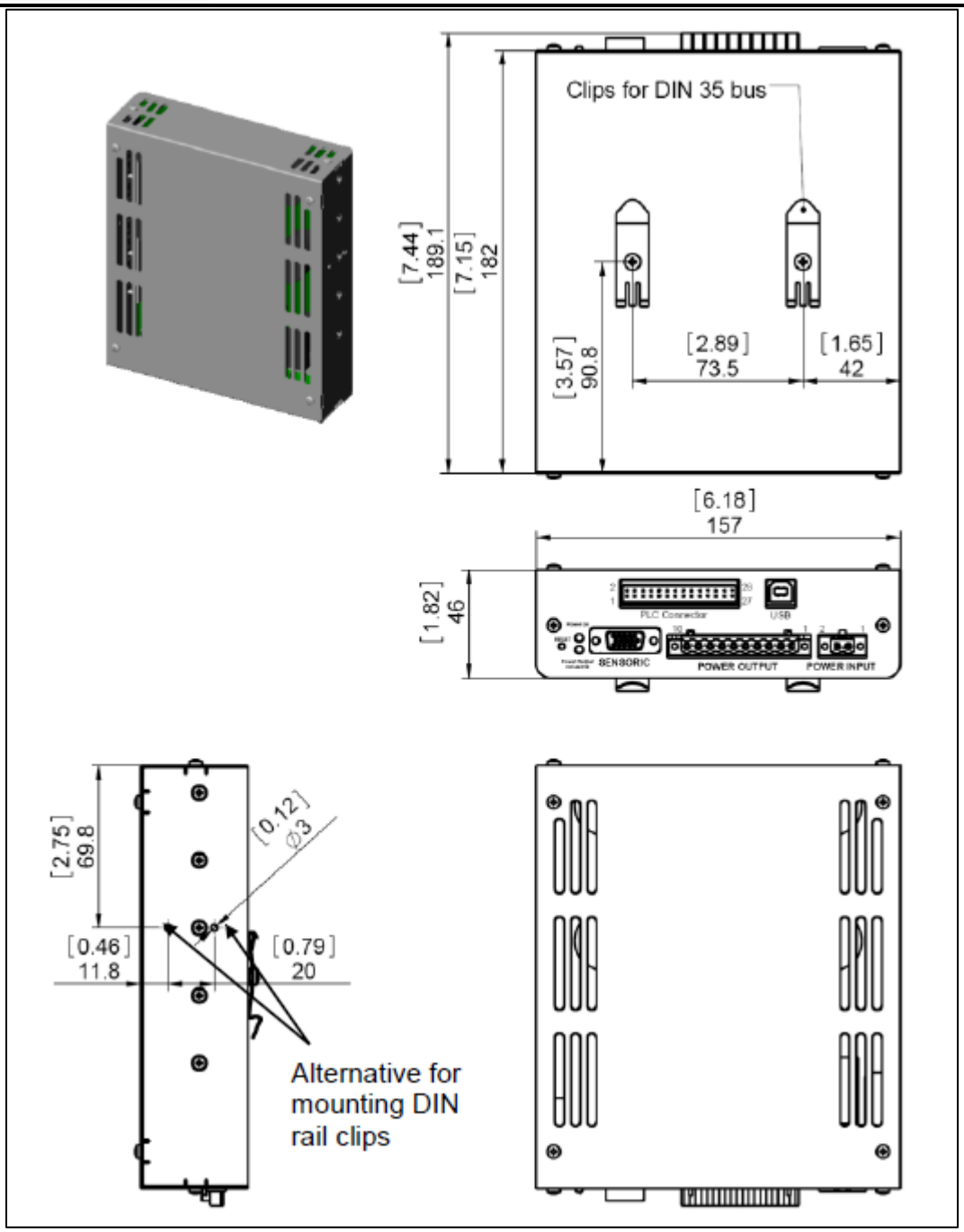



Figure 10 – Controller Basic Dimensions

## 2.6 Air Cooling Module

The motor can be cooled by using the air-cooling module. This module attaches to the back of the pump motor with four bolts. Section 3.4.1 gives more information on motor cooling requirements. Figure 11 shows the dimensions of the motor with the attached air-cooling module.

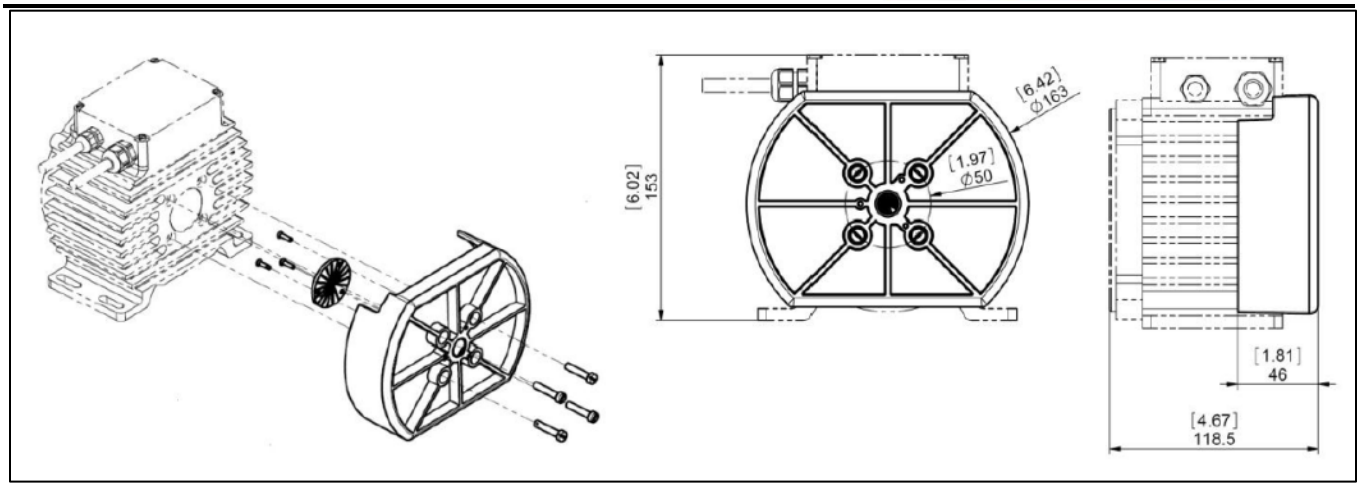



Figure 11 – Motor dimensions with attached air-cooling module.

## 2.7 Cable Minimum Bend Radius

| Cable Jacket | Sensor Cable OD | Power Cable OD | Minimum Bending Radius Permanent Installation | Minimum Bending Radius Occasional Cable Movement |
|---|---|---|---|---|
| FEP | 6.6mm | 8.4mm | 7x Cable OD | 15x Cable OD |
| PVC | 7.2mm | 10.0mm | 6x Cable OD | 12x Cable OD |

# 3 ENGINEERING INFORMATION

## 3.1 Sealing and Material Concept

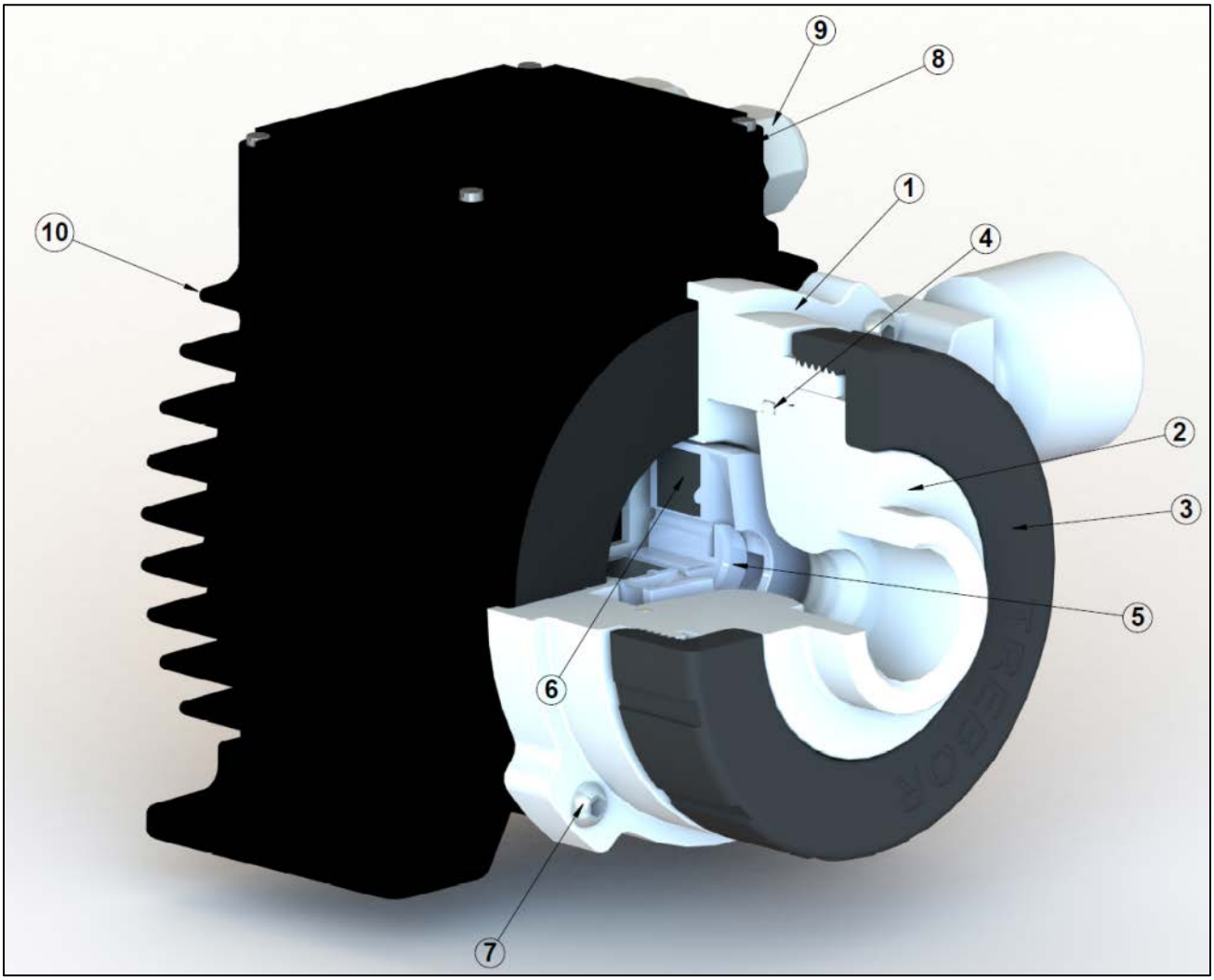



Figure 12 – Sealing and Material Concept

Table 6 – Materials Used in the Pump and Motor

| System Component | Item | | Materials |
|---|---|---|---|
| | No | Description | |
| Pump | 1 | Pump Casing | PTFE |
| | 2 | Inlet Housing | PTFE |
| | 3 | Union Nut | Polypropylene |
| | 4 | Static Sealing O-ring of Pump Casing | FFKM |
| | 5 | Impeller | PFA |
| | 6 | Rotor Magnet | NdFe (rare-earth material) |
| | 7 | 4 screws for pump-motor housing | 316 stainless steel |

| System Component | Item | | Materials |
|---|---|---|---|
| | No | Description | |
| Motor | 8 | Flat gasket for motor housing | FKM (FPM) |
| | 9 | Cable strain relief bushing | PVDF, cable jacket is PVC |
| | 10 | Motor housing | ETFE coating, waterproof (IP-67)<br>Coils and electromagnetic circuit potted with an epoxy compound (UL94 V0). |

## 3.2 Power Consumption

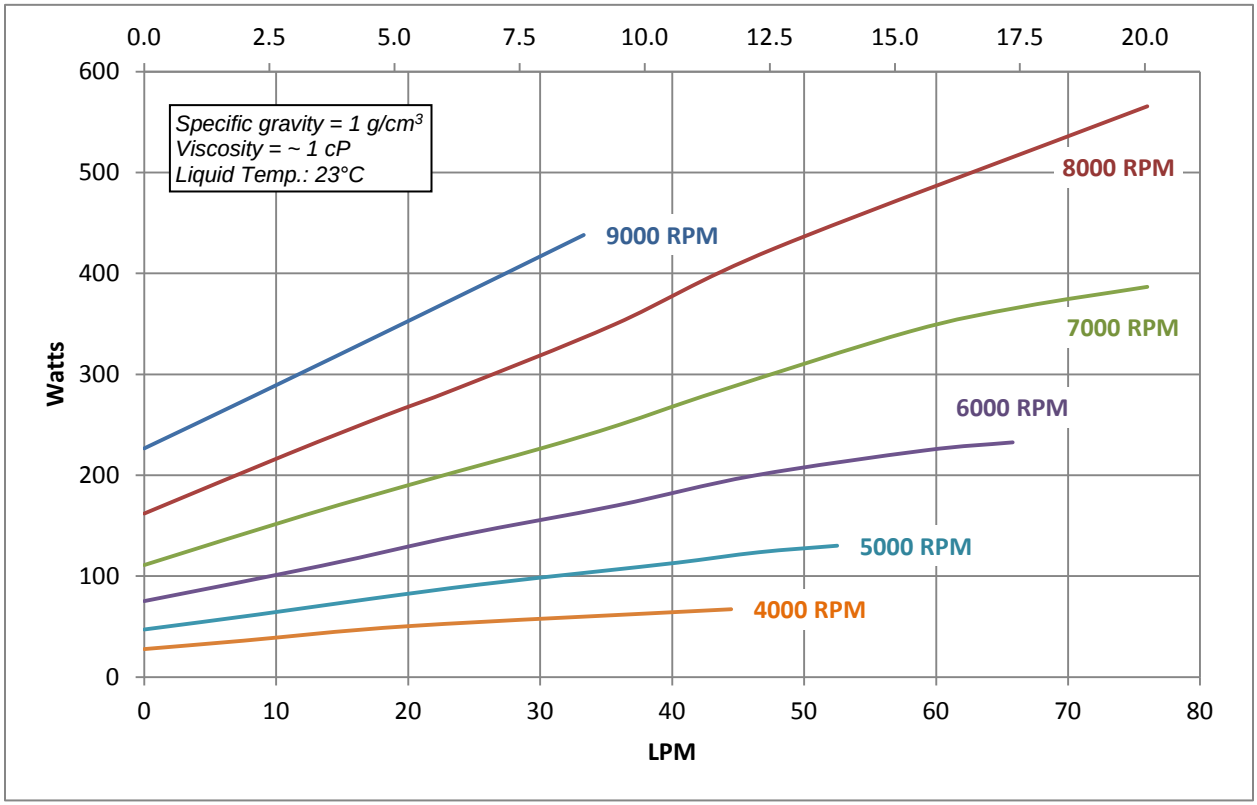



Figure 13 – Electrical Power Consumption

## 3.3 Temperature Monitoring

To avoid overheating of the system, the controller and motor temperatures are monitored. If the controller temperature exceeds *70°C (158°F)* or the motor temperature *90°C (194°F)* for longer than 10 minutes, the system goes into an error state and the pump stops. At *80°C (176 F)* controller temperature or *100°C (212°F)* motor temperature, the system immediately stops.

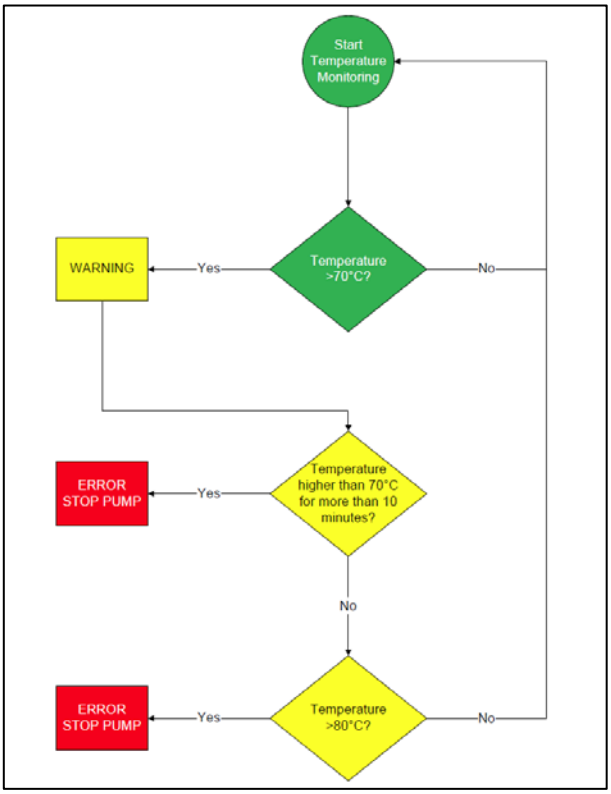



Figure 14 – Controller Temperature Monitoring

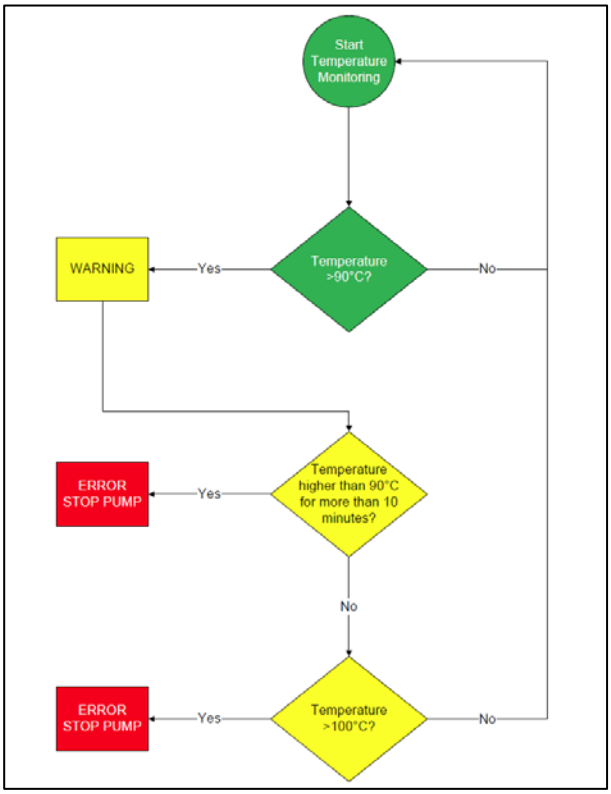



Figure 15 – Motor Temperature Monitoring

## 3.4 Thermal Management

### 3.4.1 Motor Temperature

The motor temperature depends on the ambient and liquid temperature, as well as on the hydraulic operation point. Figure 16 and Figure 17 illustrate the temperature characteristics of the motor depending on these parameters. For higher fluid temperatures and hydraulic operating points, active cooling is recommended. The air-cooling module is available from Trebor for this purpose.

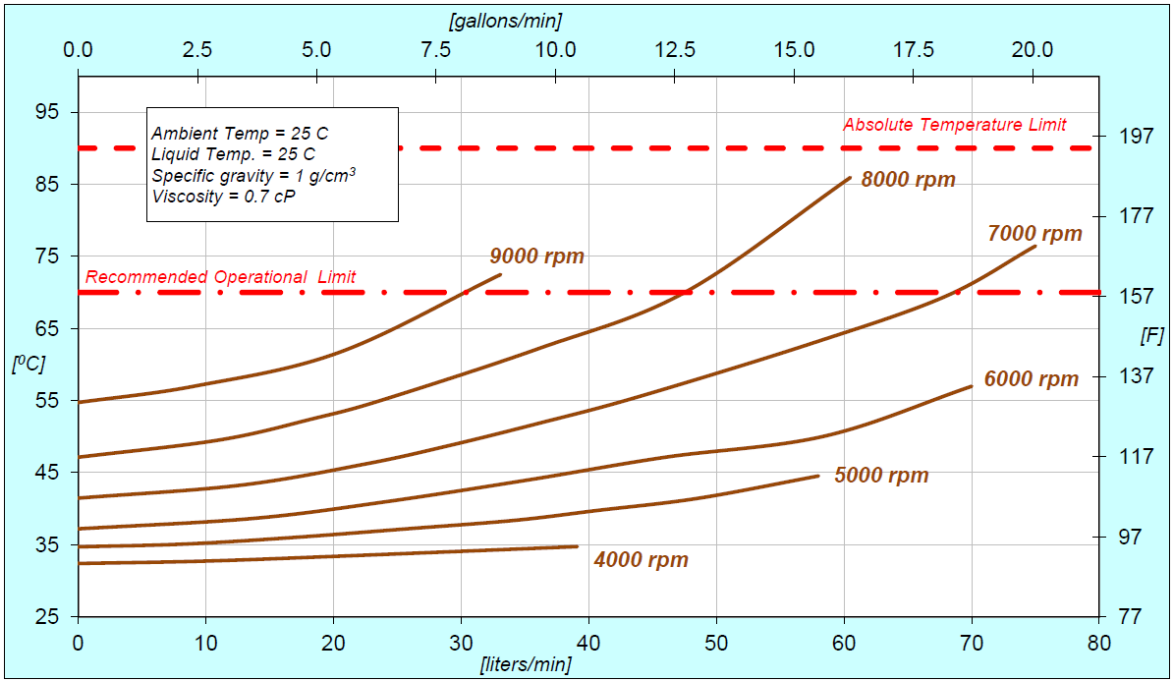



**Figure 16 - Temperature Curves of the Motor for 25°C Fluid Temperature**
**(Temperature is measured inside of the motor, contact temperature of surface is below this temperature)**

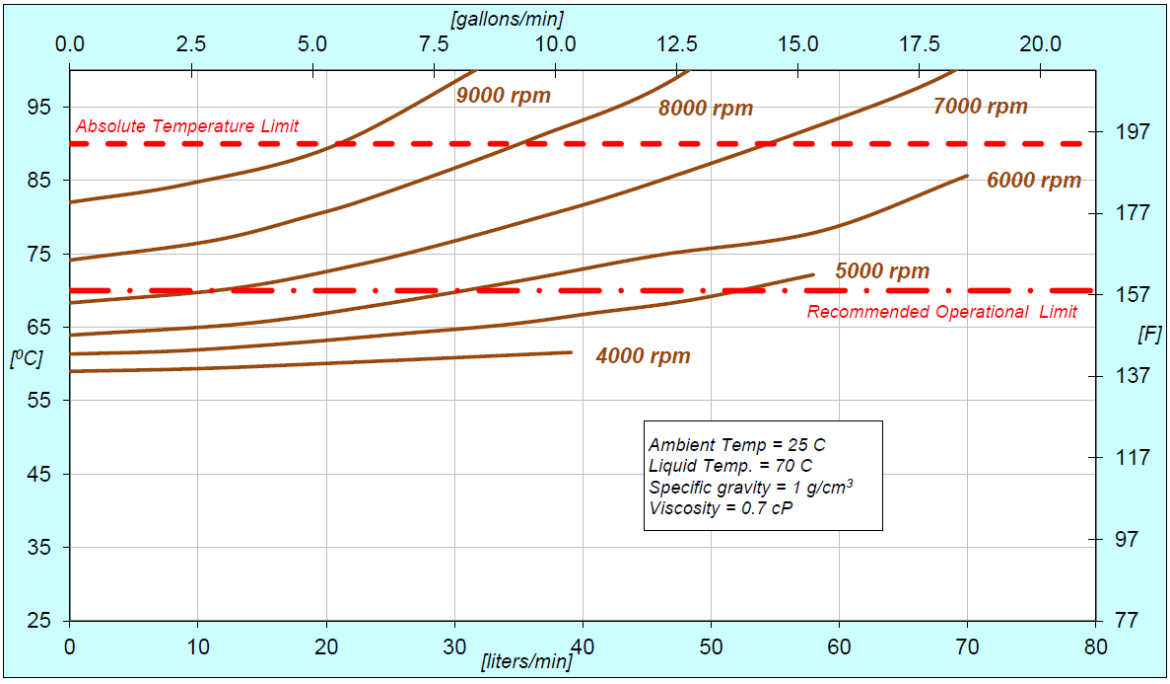



**Figure 17 - Temperature curves of the Motor for 70°C Fluid Temperature**
**(Temperature is measured inside of the motor, contact temperature is below this temperature)**

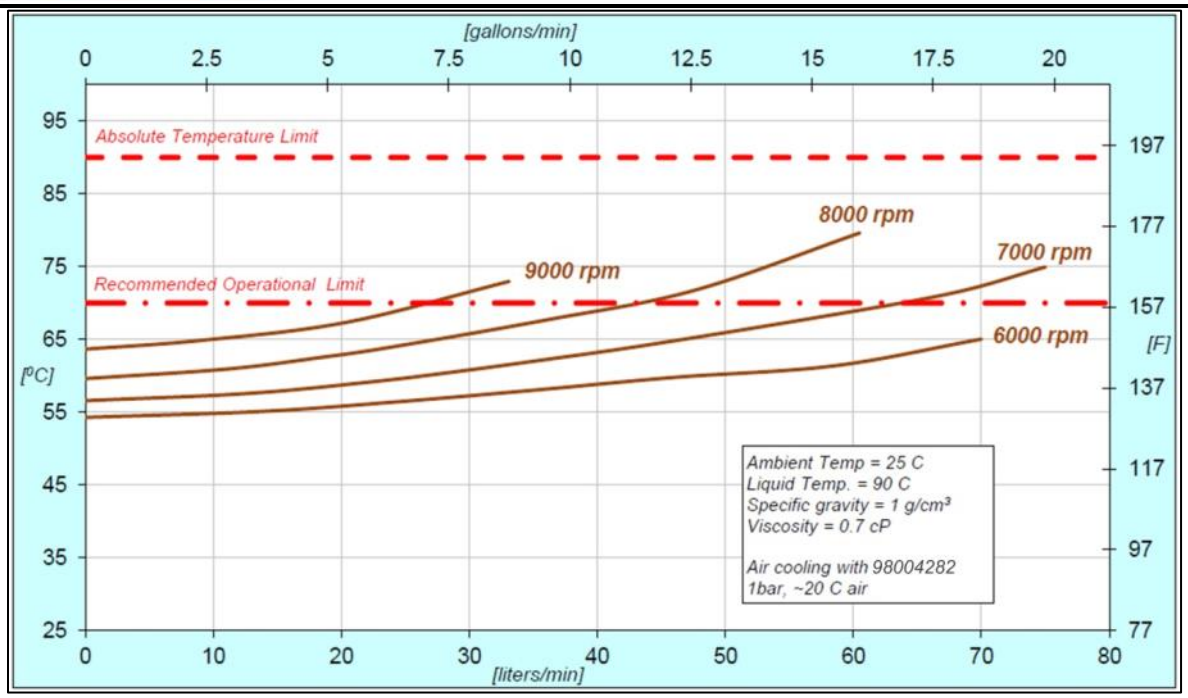



**Figure 18 – Temperature Curves of Motor with Air Cooling Module (98004282)**

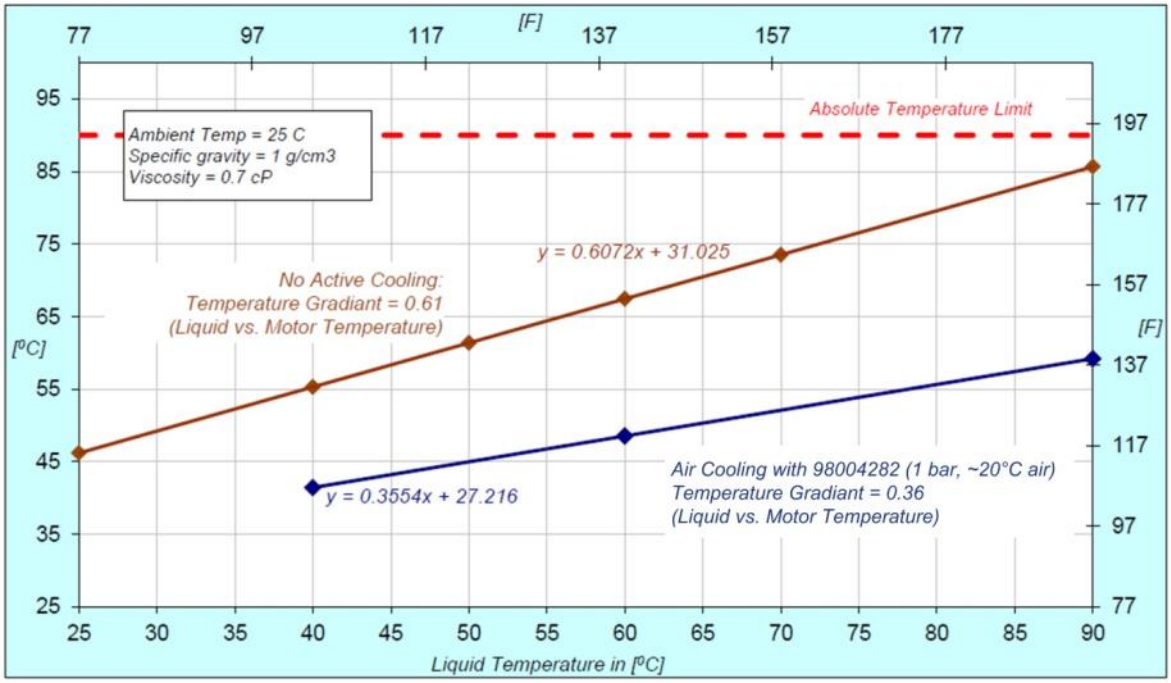



**Figure 19 – Fluid Temperature Influence on Motor Temperature**

*(Measurement at 7000 RPM, 23 LPM but gradients are representative for other operational points)*

The above curves are measurements of the motor temperature at certain liquid and ambient temperatures. Equation 1 shows how to calculate the motor temperature for other liquid and ambient temperatures based on these curves.

$$T_M(T_F, T_A) \approx \underbrace{T_M(T_F = 25°C, T_A = 25°C)}_{see\ Figure\ 15} + (T_F - 25°C) \cdot \underbrace{tg_{LM}}_{see\ Figure\ 18} \cdot (T_A - 25°C)$$

$T_M = Motor\ Temperature$ $\quad T_F = Fluid\ Temperature$

$T_A = Ambient\ Temperature$ $\quad tg_{LM} = Temperature\ Gradient\ Liquid/Motor$

**Equation 1**

In order to account for thermal variations (like ambient temperature, closed chemical cabinets or corners without ventilations) and to not significantly reduce the MTBF of the motor it is recommended to keep about 20°C safety margin to the absolute thermal limit of the motor (90°C) when designing the thermal concept of the pump system.

### 3.4.2 Controller Temperature

Depending on the ambient temperature and the placement of the controller, additional cooling may be required (see Figure 20). To improve cooling of the controller, place the device into a moving air stream. If the controller is mounted in a compact area or adjacent to additional heat sources (e.g. a 2nd controller), ensure that there is sufficient ventilation.

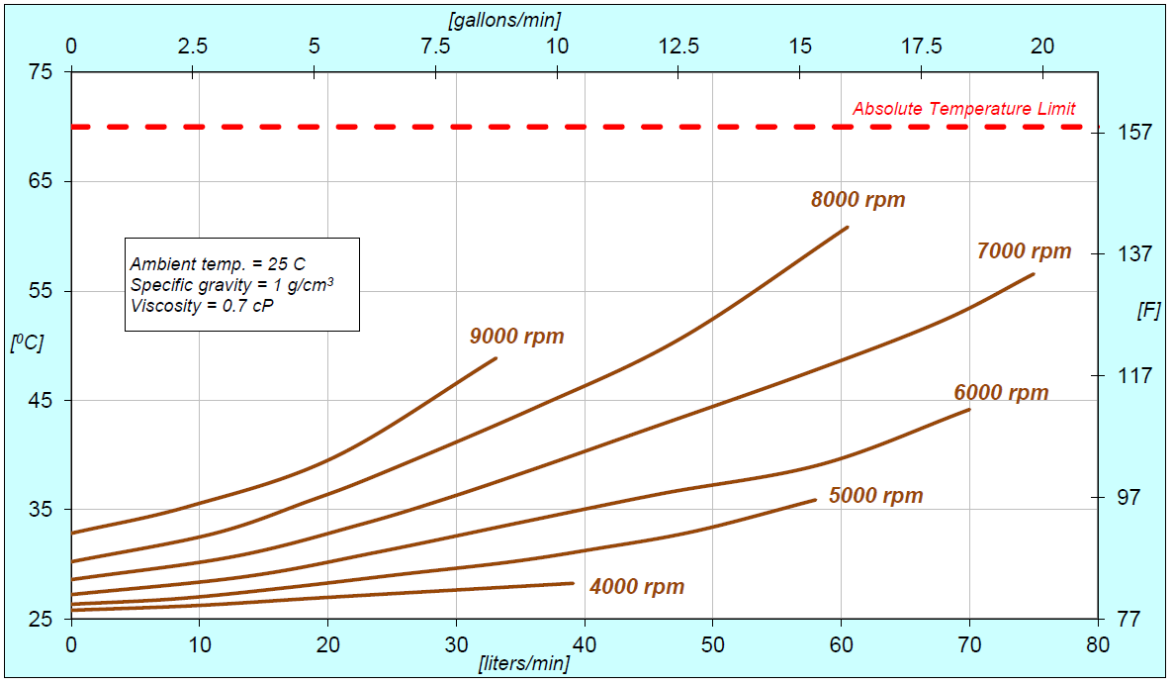



**Figure 20 - Temperature Curves of Controller vs. Flow and Speed**

The above curves are measurements of the controller temperature at 25°C ambient. Equation 2 shows how to calculate the controller temperature for other ambient temperatures based on this curve.

$$\boldsymbol{T_C(T_A) \approx T_C\,\underbrace{(T_A = 25°C)}_{See\ Figure\ 19} + (T_A - 25°C)}$$

$\boldsymbol{T_C = Controller\ temperature}$

$\boldsymbol{T_A = Ambient\ Temperature}$

**Equation 2**

## 3.5 Hydraulic Circuit Design

Follow these general design rules for the hydraulic circuit will yield more robust pump operation and optimum priming:

1. The general rule for optimum priming behavior is to minimize the pressure drop in the inlet circuit and avoid negative pressure at the inlet of the pump.
2. Minimize tubing length and maximize the tubing ID at the inlet of the pump. This reduces the pressure drop and the tendency of cavitation.
3. Avoid any restrictions, valves, elbows, bended tubing and sharp edges at the inlet circuit of the pump, which could potentially cause cavitation resulting in gas bubble collection in the pump and potential priming loss.
4. Place the pump at the lowest point of the hydraulic circuit. Optimum is as much as possible below a tank or reservoir. This optimizes priming behavior and removal of gas bubbles.
5. Keep the liquid level in the reservoir as high as possible, which increases the inlet pressure of the pump and minimizes fluid heating.
6. In general, the pump system placement and circuit shall be designed such that gas bubbles can leave the pump housing so the pump remains primed.
7. To minimize fluid heating, the overall pressure drop in the hydraulic circuit should be reduced as much as possible.
8. Deadhead operation (pump operation when the discharge valve is closed) should be avoided. It can cause heat-up of the liquid.
9. Optimization of the fluid circuit becomes more important as the fluid temperature increases due to the higher cavitation tendency of the liquid.

Contact Trebor (see Section 8) for additional considerations and support on the hydraulic circuit design.

# 4 INSTALLATION

## 4.1 Electrical Installation of Controller

### 4.1.1 Overview

The Rev6 standalone controllers have signal processor controlled power converters with four switched inverters for the drive and the bearing windings of the motor. The signal processor allows precise control of pump speed and impeller position. Figure 21 shows the interfaces of the standalone controller with standalone and minimal PLC functions.


Figure 21 – Overview of the Standalone Controller Interface

Table 7 – Interface Description of Standalone Controller

| Item | Interface | Description | |
|---|---|---|---|
| 1 | "SENSORIC" | Position, field and temperature sensor signals from motor<br>Torque spec. for tightening of connector screws: Min. = 0.4Nm, Max. = 0.6 Nm | |
| 2 | "USER INTERFACE" | 1 Digital Input | Galvanic isolation with optocoupler<br>Lowest input voltage for high level detection: min. 5 V; typical 24 V / 16 mA; maximum 30 V / 20 mA<br>Highest input voltage for low-level detection: max. 0.8 V<br>Minimum input resistance: RIN = 2.2 kΩ |
| | | 1 Digital Output | Galvanic isolation with relay<br>Relay: 1A / 30VDC, 0.3A / 125 VAC |
| | | 1 Analog Input | Analog current input: 4 – 20 mA<br>450 Ω shunt input |
| 3 | "POWER OUTPUT" | Drive and bearing currents of the motor<br>Torque spec. for tightening of connector screws on motor side: Min. = 0.5 Nm, Max. = 0.6 Nm | |
| 4 | "POWER INPUT" | DC power input<br>Torque spec. for tightening of connector screws on motor side: Min. = 0.5 Nm, Max. = 0.6 Nm | |

| Item | Interface | Description |
|---|---|---|
| 5 | “Power on” Green LED | LED is on if supply voltage of signal electronics is present. |
| 6 | “Power Output not active” Red LED | Red LED is off if the switched output stage of the controller is enabled. If the LED is on, the bearing and drive coils of the motor carry no current. |
| 7 | “RESET” Button | Reset button of the controller stage. The button is recessed and can be activated using a small pointed object. |
| 8 | 2-Digit Display “Speed” | Rotational speed display in 100 RPM |
| 9 | “UP” Button | Button for speed increasing |
| 10 | “DOWN” Button | Button for speed decreasing |
| 11 | “Firmware” Label | Firmware version and revision number |

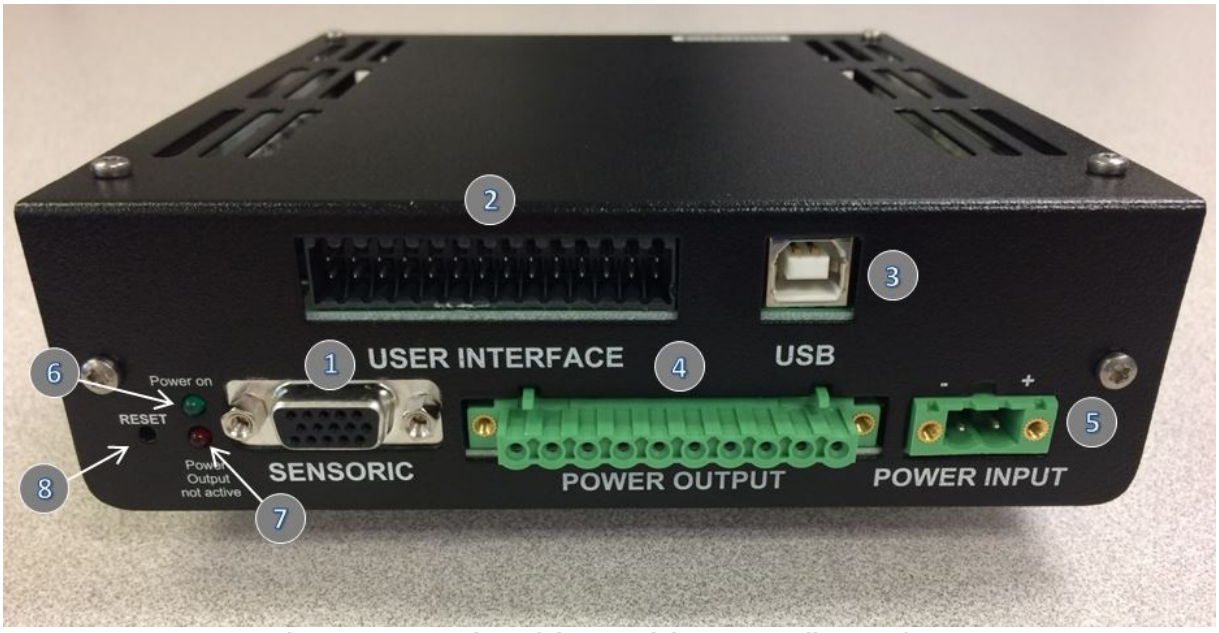



Figure 22 – Overview of the Standalone Controller Interface

Table 8 – Interface Description of Extended Controller

| Item | Interface | Description | |
|---|---|---|---|
| 1 | “SENSORIC” | Position, field and temperature sensor signals from motor<br>Torque spec. for tightening of connector screws: Min. = 0.4, Max. = 0.6 Nm | |
| 2 | “USER INTERFACE” | 2 Analog Input | - Analog current input: 4 – 20 mA - 450 Ohm shunt input |
| | | 2 Analog Input | - Analog voltage input 0 – 10 V - Direct connection, no galvanic isolation - 7.8 k□ input resistance |
| | | 2 Analog Output | - Analog voltage output: 0 – 5 V - Direct connection, no galvanic isolation - Max. Output current: 2mA |
| | | 4 Digital Input | - Galvanic isolation with optocoupler<br>- Lowest input voltage for high level detection: min. 5 V Typical 24 V / 16 mA, maximal 30 V / 20 mA<br>- Highest input voltage for low level detection: max. 0.8 V<br>- Minimum input resistance: RIN = 2.2 k□ |
| | | 4 Digital Output | - Galvanic isolation with relay - Relay: 1A / 30VDC, 0.3A / 125 VAC |
| 3 | “USB” | USB interface | |
| 4 | “POWER OUTPUT” | Drive and bearing currents of the motor. Torque spec. for tightening of connector screws on motor side: Min. = 0.5 Nm, Max. = 0.6 Nm | |

| Item | Interface | Description |
|---|---|---|
| 5 | “POWER INPUT” | DC power input Torque spec. for tightening of connector screws on motor side: Min. = 0.5 Nm, Max. = 0.6 Nm |
| 6 | “Power on” Green LED | LED is on if supply voltage of signal electronics is present. |
| 7 | “Power Output not active” Red LED | LED is off if the switched output stage of the controller is enabled. If the LED is on, the bearing and drive coils of the motor carry no current. |
| 8 | “RESET” Button | Reset button of the controller stage |

### 4.1.2 General Installation Instructions

**⚠WARNING**

***Hazardous voltage may be present.***

*Always isolate the electrical power supply before making or changing connections to the unit.*

*In case of the usage of an inadequate AC/DC power supply, mains voltages may be present (even if the system is designed for 48VDC). The usage of a galvanic separated power supply, which is certified by a 3rd party (UL or CE), is highly recommended.*

**⚠WARNING**

***Hazardous voltage may be present.***

*The controller housing must be properly grounded and placed in a spill protected environment. Use one of the DIN-rail screws on the back side of the controller housing.*

*Do not use different and longer screws, which may result in short-circuits within the controller.*

1. The controller casing must be grounded. The screws of the DIN-rail bracket can be used for grounding.
2. Connect the two motor connectors (“POWER OUTPUT” and “SENSORIC”) to the controller.
3. Connect the controller type specific connectors: see Section 4.1.3 for standalone operation with the Standalone Controller and Section 4.1.4 for Extended operation with the Extended Controller.
4. The pump system requires 48 VDC supply voltage at a maximum power of 600 W. Depending on the desired hydraulic operational point, smaller power supplies may be used. Also, a larger supply may be used to power several pump systems simultaneously. Figure 13 shows the power consumption depending on the pressure and flow rate. Contact Trebor for additional information on a power supply solution.
5. Connect the DC power supply connector with the cable (included with the controller). Make sure that the polarity is correct (see Figure 21) and that AC/DC power supply is off.
6. To secure the connectors, tighten all retaining screws according to the torque specifications in Table 7 for he standalone controller and Table 8 for extended controller.

### 4.1.3 Electrical Installation of Standalone Operation

For standalone operation, the controller is disabled when power is turned on. It can be enabled manually by pressing the “UP” button on the display. If the controller will be enabled automatically when power is applied, the “ENABLE” pin on the “USER INTERFACE” connector (see Table 9) has to be active (typically 24V).

### 4.1.4 Electrical Installation of Standalone Controller for Extended Operation

If the *REV6A0* shall be controlled with external signals the “USER INTERFACE” can be used with the PIN designations described in Table 9.

**Table 9 – Description of “USER INTERFACE” Connector**

| Pin | Pin Number | Function | Name | Levels | Note |
|---|---|---|---|---|---|
| Signal | 5 | Analog In | Reference Speed | 4-20 mA = 0-10000 rpm<br>Upper Speed Limit = 9000 rpm ≈ 18.4 mA<br>Lower Speed Limit = 300 rpm | Direct connection, no protection. Galvanic isolation on the user side is required. |
| Ground | 6 | | | | |
| Signal | 3 | Digital In | Enable | 24 V → active<br>0 V → not active | Needed to enable the system with an external signal. |
| Ground | 4 | | | | |
| Signal | 1 | Digital Out | Status | Relay closed → active, system on<br>Relay open → not active, system off | This signal indicates if the system is active. |
| Ground | 2 | | | | |

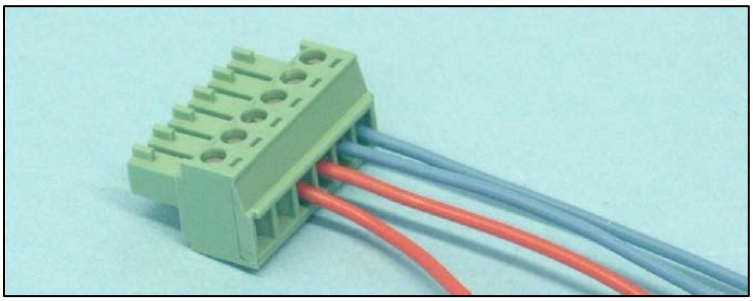


**Figure 23 – “USER INTERFACE” Connector**
- **Delivered with Controller**
- **Connector Type: AK1550/06-3.81-Green**


**Figure 24 – “USER INTERFACE” Pin Numbering**

### 4.1.5 Installation of PLC Interface for Extended Controller

To operate the pump system with a PLC, a minimum set of two digital inputs and one analog input is needed. The digital and analog outputs can be used to monitor the pump status and operating parameters.

**CAUTION**

*The analog inputs and outputs are not galvanic isolated from the controller electronics. To avoid ground loops and mal-functions, use floating analog signals.*

**1.** Detach the PLC connector from the controller

**2.** Connect the designated wires of a cable the pins of the detached connector according to Table 10. Assignment and functions of the I/Os can be changed with the controller firmware version (refer to according firmware documentation).

**3.** Connect the PLC connector (Figure 25) to the controller.

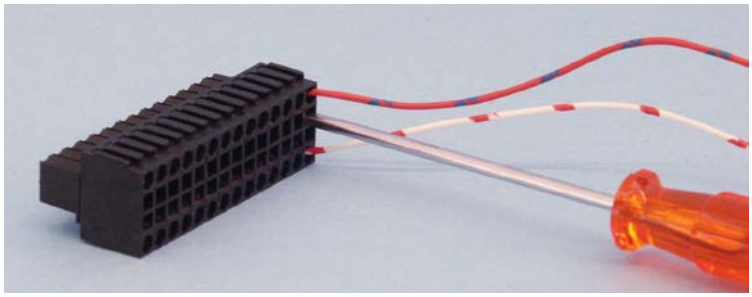


**Figure 25 - PLC Connector**
**- Delivered with controller**
**- Supplier: Weidmüller**
**- Connector Type: B2L 3.5/28 SN BK BX**

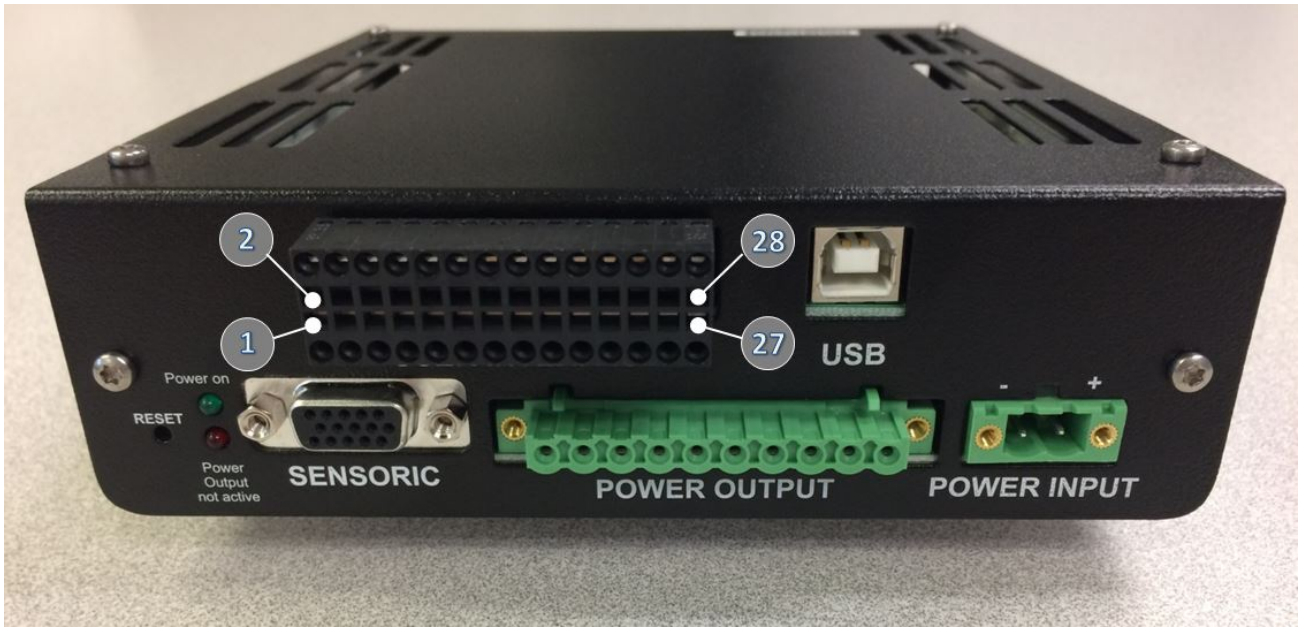



**Figure 26 – Mounted PLC connectoer and Pin Numbering**

| Pin Name | Connect Pin # | Designation | Levels | Note |
|---|---|---|---|---|
| Analog In1, (Signal) | 18 | *Actual Process Control Value (Current Input)* | 4..20 mA = 0..100% | - Grounds are internally connected<br>- Direct connection, no protection. Galvanic isolation on the user side is required.<br><br>- Default input settings: Current inputs selected. Voltage input can be selected with EEPROM–editor in Service Software (consult detailed firmware specification Service Software Manual). |
| Ground Analog In1 | 17 | | | |
| Analog In2, (Signal) | 20 | *Ref Value (Current Input)* | 4..20 mA = 0..10000 rpm *(speed mode)*<br>-> Speed Limit = 9000 rpm<br>-> Cut-off (min.) speed = 300 rpm<br><br>4..20 mA = 0..100% *(process mode)* | |
| Ground Analog In2 | 19 | | | |
| Analog In3, (Signal) | 22 | *Actual Process Control Value (Voltage Input)* | 0..10 V = 0..100 % | |
| Ground Analog In3 | 21 | | | |
| Analog In4, (Signal) | 24 | *Ref Value (Voltage Input)* | 0..10 V = 0..10000 rpm<br>-> Speed Limit = 9000 rpm<br>-> Cut-off (min.) speed = 300 rpm<br>0..10 V mA = 0..100% *(process mode)* | |
| Ground Analog In4 | 23 | | | |
| Analog Out1, (Signal) | 26 | *Actual Process Control Value* | 0..5 V = 0..100% | Direct connection, no protection. Galvanic isolation on the user side is required.<br><br>5V is given by firmware, hardware allows up to 10V output voltage. |
| Analog Out2, (Signal) | 28 | *Actual Speed* | 0..5 V = 0..10000 rpm | |
| Com. Ground Analog Out | 25, 27 | -- | -- | |
| Digital In1, (Signal) | 2 | *Process mode* | 24 *V* => active<br>0 *V* => not active | Switches between process mode and speed mode |
| Ground Digital In1 | 1 | | | |
| Digital In2, (Signal) | 4 | *Enable* | 24 *V* => active, system on<br>0 *V* => not active, system off | The Enable signal switches the pump system on and off. |
| Ground Digital In2 | 3 | | | |
| Digital In3, (Signal) | 6 | *Reset* | 24 *V* => active<br>0 *V* => not active | Resets error state |
| Ground Digital In3 | 5 | | | |
| Digital In4, (Signal) | 8 | *Not used* | -- | -- |
| Ground Digital In4 | 7 | | | |
| Digital Out1 | 10 | *Warning* | Relay closed => not active, system o.k.<br>Relay open => active, system not o.k. | The warning signal indicates if a system fault has been detected. The warning signal indicates a system fault but the system does not shut down |
| Ground Digital Out1 | 9 | | | |
| Digital Out2 | 12 | *Status* | Relay closed => active, system on<br>Relay open => not active, system off | This signal indicates the state of the pump system. |
| Ground Digital Out2 | 11 | | | |
| Digital Out3 | 14 | *Error* | Relay closed => not active, system on<br>Relay open => active, system off | When active, the system drives the impeller to zero rpm and shuts down. With a reset pulse the system can be re-initialized. |
| Ground Digital Out3 | 13 | | | |
| Digital Out4 | 16 | *Not Used* | - | - |
| Ground Digital Out4 | 15 | | | |

**Table 10 - *Signals of the PLC connector for standard firmware D8.48***

***- For other configurations of PLC Inputs and Outputs refer to alternate firmware documentation***

***- Configurations can be done with Trebor Service Software***

## 4.2 Mechanical Installation of the Pump/Motor

- The motor can be fixed with four screws on the motor feet (see Figure 7)
- As an alternative the motor can be mounted with four screws on the back (see Figure 8)
- The motor can be mounted in either the horizontal or the vertical position
- Each motor is identified with a unique serial number. This serial number consists of a series of 6 digits where the 5$^{th}$ and the 6$^{th}$ digit represent the manufacturing year.

## 4.3 Mechanical Installation of the Controller

**⚠WARNING**

***Hazardous voltage may be present.***

*In order to avoiding fluid spills shorting mains or other voltages within the controller, place the controller in a spill-protected environment (for example protected electronic cabinets).*

*If explosive flammable gases are present, place the controller in an explosion-proof cabinet.*

**CAUTION**

*Make sure the controller is mounted in a position that allows free air circulation around the controller. A minimum distance of 10cm (4") to other objects above or below the controller casing is recommended.*

- Use the Din-Rail bracket to mount the controller.
- If no forced air-cooling is used, mount the controller in upright position.
- The Din-Rail brackets can also be mounted on the controller side according to Figure 10

**CAUTION**

*Use only 3.5 x 6.5mm self-tapping screw for the fixation of the Din-Rail brackets. The controller may be damaged if other screws are used!*

## 4.4 Mechanical Installation of Adapter/Extension Cables

For connecting the motor to the controller, use adaptor cables 98004272-## (for power cable) and 98004273-## (for sensor cable) (see Table 4 for details).

# 5 OPERATION

## 5.1 System Operation with Standalone Controller

### 5.1.1 State Diagram of Standalone Controller

The standalone controller allows operation with manual speed setting (Button Control Mode) as well as extended operation with analog speed setting (Analog Control Mode). Figure 27 shows the state diagram, which can be controlled with the manual buttons and the signals on the “USER INTERFACE” connector. The operation mode can be chosen by pressing the “UP” and “DOWN” buttons simultaneously for five seconds. The default setting from the factory is “Button Control Mode”.

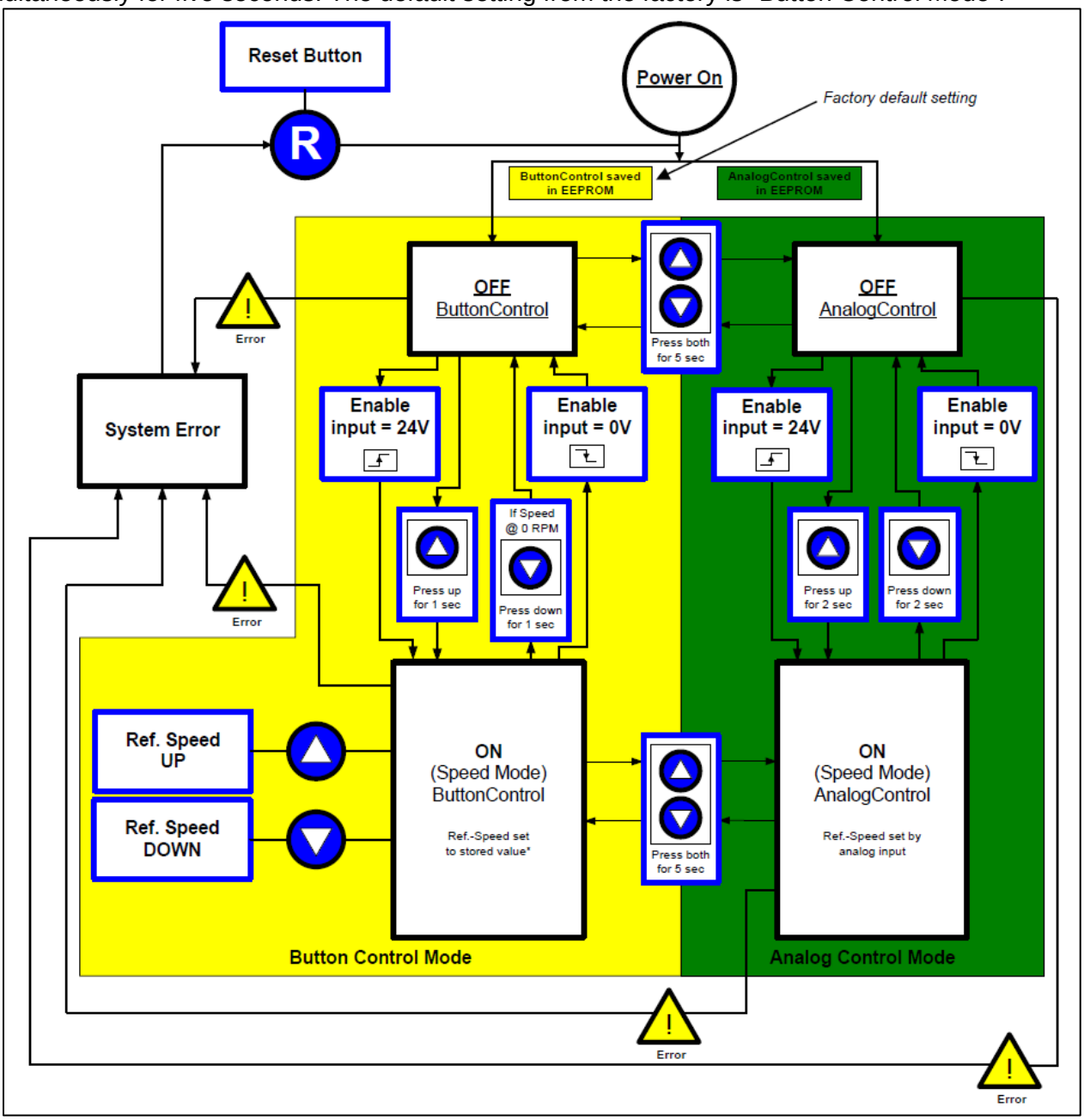



**Figure 27 - State Diagram for Standalone Controller Operation**

*(Description is for firmware D6.25 with Revision > 01, for other configurations refer to alternate firmware documentation)*

### 5.1.2 Standalone Operation (Button Control Mode)

- When applying power the system defaults into the *"Button Control Mode*" and goes into the status *"OFF Button Control"* according to Figure 27. Levitation is disabled and the display indicates *"OF"*.
- Levitation can be enabled by pressing the *"UP"* button for 1 second (display shortly indicates *"ON"*) or by activating (typically 24V) the *"ENABLE"* pin on the *"USER INTERFACE"* connector (see Table 9). The system goes then into the status *"ON Button Control"* and is running at the speed, which is stored in the EEPROM.
- The speed can be changed by pressing accordingly the *"UP"* and *"DOWN"* buttons. As long as the digits on the display are blinking, the "set speed" is shown. As soon as blinking stops the actual speed is shown and the "set speed" is stored in the EEPROM of the controller.
- The system can be disabled by pressing the *"DOWN"* button until 0 rpm is achieved. Pressing further 1 second the *"DOWN"* button the system disables levitation and shows *"OF"* on the display. The system can also be disabled by deactivating (0 V) the *"ENABLE"* pin on the *"USER INTERFACE"* connector (see Table 7). Before disabling the system, the speed is automatically reduced to 0 rpm and the impeller is properly touched down without grinding the wall.
- In case of an error the *"RESET"* button (see Figure 21) can be used to restart the system or the power can be switched off and on.
- For error analysis, the codes described in Table 11 are displayed (blinking between *"Er"* and the according code number).
- If the system shall be enabled automatically, when power is applied the *"ENABLE"* pin on the *"USER INTERFACE"* connector (see Table 7) has to be active (typically 24V). When switching on the power the system is running with the stored speed.
- For monitoring purposes, a digital output on the *"USER INTERFACE"* connector (see Table 7) indicates the status of the system. When the impeller is rotating the digital output *"Status"* turns active.

The digital input *"ENABLE"* is normally edge-triggered to allow control by digital input and buttons in order to enable/disable systems simultaneously. An exception is, when the system is powered up or a system reset occurs: than the system checks the level of the digital input and switches to the desired state. Hence, on startup, a high level of the digital input *"ENABLE"* is sufficient to switch on the system and a transition from low to high is not required.

### 5.1.3 Extended Operation (Analog Control Mode)

- In order to be able to control the pump with external signals, the mode "Analog Control Mode" has to be set with the display buttons. Press the "UP" and "DOWN" buttons simultaneously for 5 seconds. The display should show the mode change by blinking between the stored speed value and "An". The chosen mode is then stored in the EEPROM of the controller. After startup, the system returns to the operation mode selected previously.
- The system and levitation can be enabled/disabled with the digital input on the "USER INTERFACE" connector (see Table 9). When disabling the running system the speed is automatically reduced to 0 rpm and the impeller is properly touched down without grinding the wall. The display is blinking between "An" and "OF". Alternatively "UP" button is also able to switch the system on. Pressing the "DOWN" button will switch the system off.
- The speed can be set with an analog signal on the "USER INTERFACE" connector according to Table 9. It is strongly recommended to use galvanic separated signal values.
- For monitoring purposes, a digital output "Status" on the "USER INTERFACE" connector (see Table 9) indicates the status of the system. When the impeller is rotating the digital output "Status" turns active.

### 5.1.4 Error Display on the Integrated Panel

| Error Source | Errors | Error Code on Display |
|---|---|---|
| Motor | No motor | *Er 01* |
| Motor | Motor cable (power wires) not connected to controller | *Er 02* |
| Motor | Motor cable (sensor wires) not connected to controller | *Er 03* |
| Motor | No impeller | *Er 04* |
| Controller | Short circuit | *Er 05* |
| Controller | Over current in the bearing coils | *Er 06* |
| Controller | Over current in the drive coils | *Er 07* |
| Controller | DC-Link voltage out of range (< 40 or > 54 V DC)<br>If the voltage is out of range the system starts to reduce the speed and a warning is generated. When reaching 0 rpm and the voltage is still out of range the system is disabled and an error is generated. In case the voltage is again within the range during speed reduction the system switches to normal operation and no Error is generated. | *Er 08* |
| Controller | Communication problems EEPROM Controller | *Er 09* |
| Motor | Communication problems EEPROM Motor | *Er 10* |
| Controller | Controller temp. over 80°C or more than 10 minutes above 70°C | *Er 11* |
| Motor | Motor temp. over 100°C or more than 10 minutes above 90°C | *Er 12* |
| Pump | Dry running of pump circuit:<br>-> Pump keeps running on reduced speed (5000 rpm) -> The system accelerates to the original speed value when the pump is refilled with liquid. -> Note that the speed is only reduced during dry running if the pump speed was ≥ 6000 rpm. | *Blinking dots on display* |

**Table 11 - Errors and Warnings with Indication on Standalone Controller Display**

- ***In case of an error the system can only be restarted with a reset or a power supply restart***
- ***For other configurations of error codes refer to alternate controller or firmware documentation***

## 5.2 System Operation with Extended Controller (REV6A1)

### 5.2.1 State Diagram of the PLC Interface

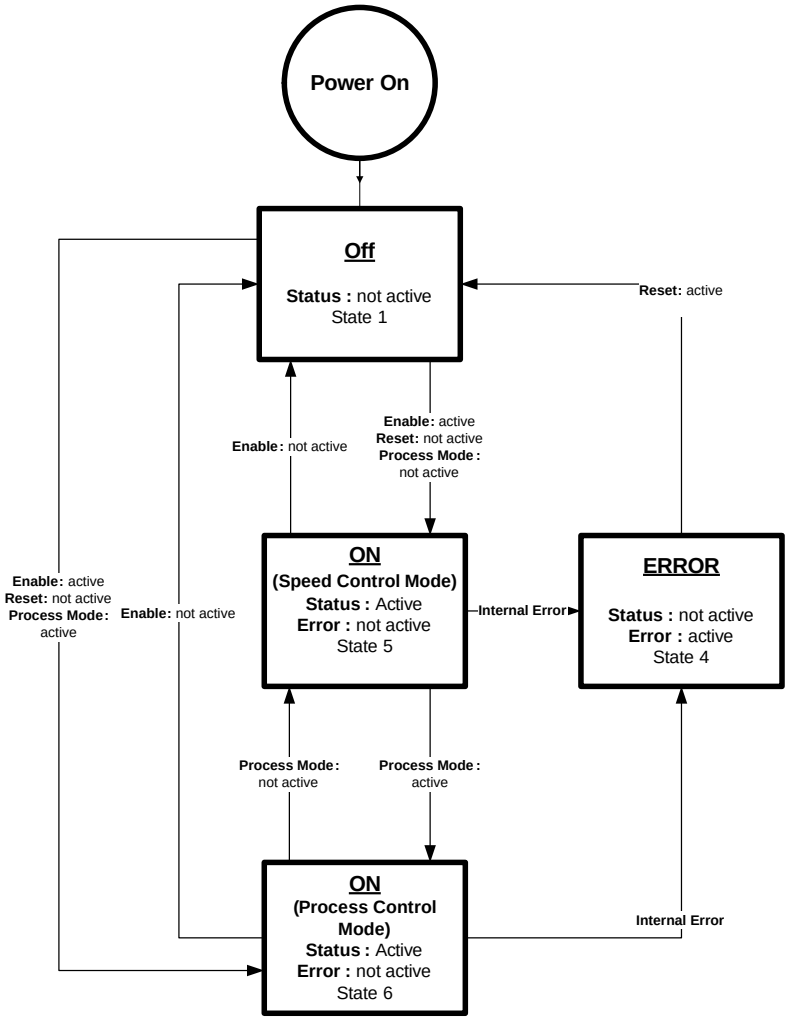



Figure 28 – PLC Interface State Diagram

***State "Off":***
The pump system is switched off and the motor has no power. In this state, Trebor Service Software has full control.

***State "ON" (speed control mode):***
The pump system is switched ON and the impeller is rotating with the referenced speed. The motor has electrical power when in this state.

***State "ON" (process control mode):***
The pump system is switched ON and the impeller is rotating with the priming speed. The motor has electrical power when in this state.

***State "Error":***
If an error according to Table 12 occurs in the pump system, the system defaults to the *Error* state. The designated digital output on the PLC Interface is activated. The pump system is switched OFF. By activating the "*Reset*" input the system gets back to the "*Off*" state.

| Error Source | Errors | Effect on Designated Digital Output of the PLC |
|---|---|---|
| Motor | No rotor | *Error = relay open* |
| Motor | Temperature over 100°C | *Error = relay open* |
| Motor | Temperature was higher than 90°C for more than 10 minutes. | *Error = relay open* |
| Motor | Temperature more than 90°C | *Warning = relay open* |
| Motor | No motor temperature signal | *Warning = relay open* |
| Motor | Motor power cable not connected with controller | *Error = relay open* |
| Motor | Motor sensor cable not connected with controller | *Error = relay open* |
| Controller | Over-current | *Error = relay open* |
| Controller | Power channel interrupted | *Error = relay open* |
| Controller | Temperature over 80°C | *Error = relay open* |
| Controller | Temp. was higher than 70°C for more than 10 minutes. | *Error = relay open* |
| Controller | DC link (supply voltage) out of range (< 40 or > 54 V DC)<br>If the voltage is out of range the system starts to reduce the speed and a warning is generated. When reaching 0 rpm and the voltage is still out of range the system is disabled and an error is generated. In case the voltage is again within the range during speed reduction the system switches to normal operation and no Error is generated. | *Error = relay open* |
| Controller | Temperature over 70°C | *Warning = relay open* |
| Controller | Dry Running Detection<br>-> Pump keeps running on reduced speed (5000 rpm) -> The system accelerates to the set speed value when the pump is refilled with liquid -> Note that the speed is only reduced during dry running if the pump speed was ≥ 6000 rpm | *Warning = relay open* |
| Controller | Trend warning (actual speed too high) | *Warning = relay open* |

**Table 12 – Possible Errors and Warnings with Indication on PLC Interface**

# 6 INSPECTION AND MAINTENANCE

## 6.1 Impeller Replacement Interval

The impeller has a limited lifetime depending on the type, concentration, and temperature of the fluid being pumped. Therefore, a preventive periodical exchange of the impeller is recommended. Contact the *Trebor Technical Service Department* (see Section 8) for further information on replacement times.

## 6.2 Impeller Replacement Procedure

### 6.2.1 Preparation

Before starting the impeller replacement procedure, understand the placement and function of the parts and tools shown in Figure 24 and Figure 25. The rebuild kit contains these parts and tools shown in Figure 25. Please verify that you have the right impellers, and O-rings.

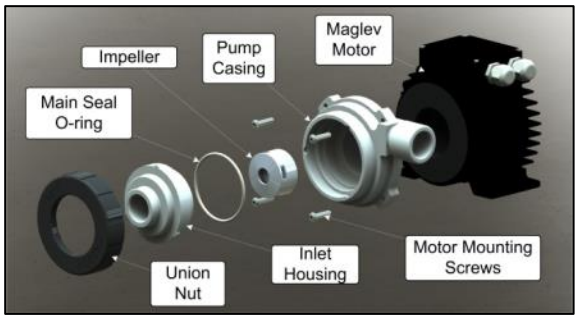



Figure 29 – Labeled Exploded View of Pump


Figure 30 – Rev6 Rebuild Kit

The following warnings and cautions should be read carefully before starting the replacement of the impeller.

**⚠WARNING**

*The impeller could splash TOXIC or CORROSIVE CHEMICALS because of the strong magnetic forces. Flush the pump housing before opening it.*

**⚠WARNING**

***HARMFUL CHEMICALS may be present.***

*Skin contact and toxic gases may be hazardous to your health. Wear safety gloves and other appropriate safety equipment.*

**⚠CAUTION**

*The rotating impeller could cause injury. Do not run the pump system when opening the pump head.*

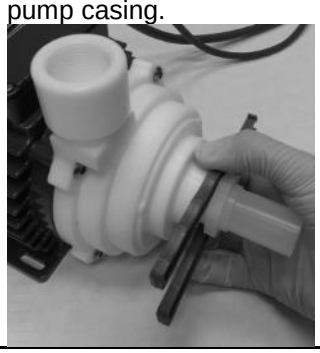
**⚠CAUTION**

*Pay attention to the magnetic forces when handling the impeller. The attraction of magnetic parts and particles should be avoided in order to keep the impeller and the pump head clean and free of contamination.*

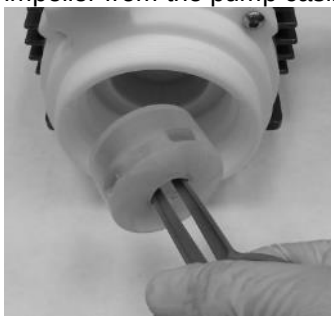
### 6.2.2 Instructions for Replacement

1. Power down the pump system and remove the AC power. If necessary, allow the motor housing to cool down to a workable temperature.
2. Unscrew and remove the union nut. Trebor provides a tool (T0180 - Tool; Union Nut; Socket; Rev6) to loosen the union nut or a strap wrench may be used.

3. Loosen the fluid port adapter enough to insert the Impeller Removal Tool. Use the tool to pull the inlet housing and main seal o-ring from the pump casing.



4. Gently slide the nose of the Impeller Removal Tool into the center hole of the impeller. Squeeze the handle of the tool and pull the impeller from the pump casing.



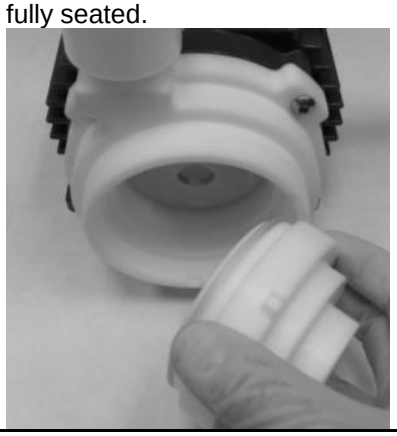
5. Inspect the wet area of the pump head carefully. In case of material damage, replace the pump casing and inlet housing.
6. Place the new impeller into the pump casing using the Impeller Removal Tool
7. If necessary, remove the existing O-Ring and gently press the new O-Ring into the shoulder of the inlet housing.

**CAUTION**

*Use the correct O-Ring type for your process. If necessary, consult your Trebor representative.*

*Do NOT twist or roll the O-Ring as this may cause leaking to occur.*

8. Align the tabs on the inlet housing with the slots in the pump casing. Press the inlet housing into the pump casing. Ensure the housing is fully seated in the casing. The top edge of the inlet housing should be ~2.5mm (0.1in) above the casing when fully seated.



9. Carefully tighten the union nut. Tighten by hand until the union nut is flush with the surface of the inlet housing. Add an additional 1/8 turn or 8-9 Nm (70-80 in-lbs.) of torque.
10. Start up the system and check if the impeller is rotating properly and the pump head does not leak.
11. If the pump head leaks, inspect that the housing and o-ring are properly pressed into the bottom of the pump casing. If the o-ring has been damages, it may be necessary to replace it.

# 7 TROUBLESHOOTING

## *7.1* Troubleshooting for Operation with Standalone Controller

For troubleshooting and failure analysis with the stand-alone controller the following procedure is recommended:

- Check the status of the LEDs. The specific LEDs are described in Table 7
- Use the ERROR codes on the display. The specific error codes are described in Table 11.
- A digital output on the “USER INTERFACE” connector (“Status”) indicates if the system is active. However, the source of an error cannot be identified by this signal.

## *7.2* Troubleshooting for Operation with Extended Controller

The integrated *PLC* provides a Warning and an Error signals according to Table 12. However, the source of error cannot be identified by these signals.

For more detailed analysis the *Trebor Service Software* can be used with a PC and a USB interface to the controller.

## *7.3* Troubleshooting with Service Software

The *Trebor Service Software* allows communication with the pump system in connection with a PC and a USB interface. The software can be used for performing detailed troubleshooting. For usage of the Service Software refer to the *Service Software User Manual.* Contact Trebor International Technical Support (see under *Section 8*).

**Note:** the Service Software cannot be used with the standalone controller (*REV6A0).*

# 8 TECHNICAL SUPPORT

For troubleshooting, support and detailed technical information contact

**TREBOR**
8100 South 1300 West
West Jordan, Utah 84088 USA
Tel: (801) 561 0303
Toll Free: (800) 669 1303
Fax: (801) 255 2312

# 9 APPENDIX

## 9.1 Regulatory Status

### 9.1.1 CE Marking

Machinery Directive 2006/42/EC (Safety)
EMC Directive 2004/108/EC Electromagnetic Compatibility

The *Rev6 pump*, in its various configurations as listed below, is in conformity with the above-mentioned European Directives.

| Part Name | Description |
|---|---|
| Rev6A0 | Pump casing consisting of various fittings and o-rings<br>See F0117C |
| 98004270 | Bearingless motor<br>See DC-4003-03, Rev05 |
| 98004271 | Standalone Controller with 48 VDC, 600 W supply inputs (galvanic separated from high voltage side)<br>See DC-4003-03, Rev05 |
| Accessories | Motor controller adapter cables of various lengths, air-cooling module, and others.<br>See DC-4003-03, Rev05 |

**Machinery Directive 2006/42/EC:**

The machinery directive essentially has been followed by a risk analysis, according mitigation actions and a user manual for safe operation. For design and testing, the following standards are used as a guideline:

EN 809 Pumps and pump units for liquids: basic requirements are followed.
EN 12162 Liquid Pumps – Safety Requirements - Procedure for hydrostatic testing: used for maximum static pressure testing of pump.
ISO 12100 Safety of machinery – principles for risk assessments: used for system risk analysis.

**EMC Directive 2004/108/EC:**

The following standards of the EMC directive are tested and confirmed at a certified laboratory:

EN61000-6-2 Generic standards, Immunity for industrial environments
EN61000-6-4 Generic standards, Emission standard for industrial environments
Test Laboratory: Hochschule für Technik Zürich
EMV Labor, Technoparkstr. 1
CH-8005 Zurich, Switzerland
Swiss certification number = STS 404

## 9.2 Symbols and Signal Words

| Symbol / Signal Word | Description | Type | Source |
|---|---|---|---|
| DANGER | Indication of an imminently hazardous situation that, if not avoided, will result in death or severe injury. Limited to the most extreme situation | Signal word | SEMI S1-0701 |
| WARNING | Indication of a potentially hazardous situation, which if not avoided, could result in death or severe injury. | Signal word | SEMI S1-0701 |
| CAUTION | Indication of potentially hazardous situations, which if not avoided, could result in moderate or minor injury. Also, alert against unsafe practice.<br>Without safety alert indication of hazardous situation which, if not avoided, could result in property damage. | Signal word | SEMI S1-0701 |
|  | Safety alert for “Warning” and “Caution” | Safety alert | SEMI S1-0701 |
|  | Safety alert for “Danger” | Safety alert | SEMI S1-0701 |
|  | Caution (refer to accompanying documents) (is used on article labels for reference to manual) | Refer to manual | ISO 3864 |
|  | Toxic material, poison | Hazard identification | IEC 61310 |
|  | Corrosive material, corrosion | Hazard identification | IEC 61310 |
|  | Cut/sever hand, sharp object | Hazard identification | ANSI Z535.3 |
|  | Strong magnetic field | Hazard identification | SEMI S1-0701 |
|  | Danger: electricity, electrical hazard | Hazard identification | IEC 61310, ISO 3864 |
|  | Wear safety gloves | Hazard avoidance Mandatory action | IEC 61310 |
|  | Wear face shield | Hazard avoidance Mandatory action | SEMI S1-0701 |
|  | Unplug power line | Hazard avoidance Mandatory action | SEMI S1-0701 |
|  | No pacemakers | Hazard avoidance Prohibition | SEMI S1-0701 |