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Norhof LN2 microdosing systems

#600 series LN2 microdosing systems (liquid supply)
#800 series N2 microdosing systems (gas supply)
#900 series LN2 microdosing systems (liquid supply)

SERVICE Troubleshooting manual

CE

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1 The monitor software

The pump is delivered including a USB stick (or a CD-Rom for older pumps) containing the monitor software. If there is a problem with the pump, the best thing to do is to connect the pump to the PC and read out all of the behavior on screen.
The pump can be connected with the (supplied) 5 meter cable with a small black 4 pin round connector on one end, and the 9 pin subD connector on the computer side. The pump should be connected to a (serial) COM port on the PC.
If the computer does not have a COM port (such as many laptops have nowadays), you can simply use a USB to COM converter cable. (cost ab €20). With this adaptor there is created a virtual COM port on the PC.
In the hardware setup of the computer you can set this COM port to a fixed port number. The monitor software can handle port numbers from 1 to 16. When possible, assign your USB to COM port adaptor to COM1, because the monitor software starts default on COM1.

1.1 Other version software

You should use ONLY the monitor software version supplied with the pump. During the years we made changes in the pumps and the software. Only the same version number as the pump has will correspond fully. It can do no harm if you just connect an other pump to older (or newer) software to check for the version number, but you should NOT write any calibration values or feeding height into the pump with software which does not correspond to this pump. Writing in a pump with the wrong version could make the pump unusable.
Also, when a wrong version number software is connected to the pump, the readout on the screen can give numbers which incorrect. For example, the readout for the feeding height was changed somewhere in 2008. When connecting an older pump to newer software, the readout for the feeding height on screen could give for that pump 26 meters, but inside the pump the construction of this number is build in a new way. So do NOT write in this case a new value of fe. 20 cm in this pump, because probably the real feeding height in this pump was OK, but the readout with the newer software was wrong only on screen.

1.2 Firmware version number of the pump

On the right bottom in the monitor screen is the firmware version of the pump. (the firmware is the software which is inside the microprocessor in the pump). This is shown once when the software is started up or when a pump is connected. If you connect an other pump and you want to read the firmware version, you should close the monitor software and start it up again.
The firmware version should correspond with the version number of the monitor software itself (in the top blue bar, before the version date.) It will read e.g. "Norhof Monitor Program v. 7.51 21 March 2012".
The firmware version of the pump will read also : "firmware in pump: ver 7.51 12 March 2012".
The dates does not need to be the same exactly, because the date gives the date of the last change. There can have been made a small change in the same version number while not changing the version number.

1.3 Pump model

The monitor software will recognize the pump model automatically. There is one version of the monitor software which is suitable for all pump models (series #600, #800 and #900 models)
In the left part it will display the pump model, and what working mode the pump is in.
For the 800 and 900 models the working mode can be selected by yourself with the mode selector switch, mounted inside the pumphead. For the #600 models pumps there is only one fixed working mode.

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1.4 Pump drawing

On the right part is a picture of the pump in the dewar and a symbolic drawing of the application. The form of this drawing depends on in what working mode the pump is. If it is a working mode with one sensor, only one sensor is drawn on screen, but if it is a working mode with two sensors, both sensors are drawn on screen.

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2 Power connection

2.1 GENERAL, power connection

- Make sure that the pump is connected to the mains power.
- When the power is connected, the pump will start up with 9 beeps. (pumps from before 2004 does start up with one beep only)
- When rightly connected, the highest yellow LED on the pump will flash once every 5 seconds. This means that the pump has power and is in SLEEP mode.

2.2 When NO yellow LED is burning

- powersupply of the pump gives around 12 Volts AC. On the 3pDIN female connector, pin 1 and 3 (the outer pins) should give this 12V AC (or some higher when not connected to the pump). The middle pin 2 is the ground (shield)
- The pump is connected by a cable with a 3p DIN male connector to a 25 p subD female connector. The two AC leads go to pins 1=14 and 13=25 on the pump.

3 Pressure sensor (pump NOT in the LN2)

- The pump has a pressure sensor to measure the pressure in the dewar. This sensor is used the determine the pump flow and also to determine how much LN2 is in the dewar.
- For pumps up to 2007, this sensor is measuring the pressure above the LN2. With these pumps the level in the dewar is NOT visible on screen until the first pumping action has passed. For newer pumps, this pressure sensor is connected with a tube going down to the bottom of the dewar. (red tube until 2010, from 2010 a transparent tube) With these pumps the level in the dewar is visible on the monitor screen after ab. 20 seconds after putting the pump in the LN2.
- When the pump is NOT in the LN2, the LN2 level on screen should NOT be drawn and the screen should tell "level not yet determined". The "Dewar pressure" (left upper side next to the pump) should display 0 or 1 mBar.

3.1 When pressure sensor is NOT on 0 or 1 mBar

- **The pressure sensor** is calibrated after manufacturing. Because of some difference in the sensors and in the electronics, this calibration value may vary. The calibration value can be read in the "service" - "show calibrate screen" at the right side below at "internal pressure sensor". The calibrate value is in gray and will read somewhere between 30 and 50.
- When this value is in this range, and the pressure reads zero or 0.56mBar , probably the calibration is still OK.
- When the pump is all warmed up, and dry, you may continue here below. Otherwise you should first warm up the pump and perhaps dry it (see later)
- When the pressure here reads some higher, or if you have the feeling that it reads lower (but the readout is always 0 or positive), you may recalibrate this value by clicking on the "calibrate 0 mBar " button. After this, a new calibration value will be visible (after 5 seconds) and the actual pressure now should read 0 or 0.56 mBar.
- If the calibration value is out of this range of 30 to 50, this is an indication for that OR the measuring tube is frozen or blocked, or that the sensor may be broken. For a frozen pressure measuring tube see below. If the sensor is broken, the pump should be returned to us. (the sensor may break if there has been a too high pressure on this sensor, fe. when used pressed air and blown into the measuring tube. In normal use, this sensor could not be broken.

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4 Internal TMB sensor and level sensors

4.1 The pump has 3 built-in sensors, the TMB and two low level sensors. While the pump is still out of the LN2, these sensors can be read out in the "service" screen. This will show two bars. The top bar is the TMB sensor and the bottom bar is for a set of two low level sensors inside the dewar.

4.2 **The TMB sensor.** The TMB (thermal moisture barrier) sensor is mounted in the pumphead inside the rise tube for the LN2. This sensor is warmed up by current to have a temperature of ab. 49-55 C when the pump is NOT pumping. This warmth will block water vapor going into the rise tube when the pump is not active. So the value of the bar should be 49 C, and will shortly show 46 and 49 C. When connecting power, this value starts at ab 20C and will go up to 49 C in about 20 seconds when the pump is at room temperature. You may look at this sensor temperature also during pumping. It will be at -196C when the pump is fully pumping LN2. If this sensor is broken, the pump will give a "broken TMB sensor" alarm when the pump is in ACTIVE mode. This sensor can not be replaced by yourself. The pump then should be send to us for repair. (but this never happens)

4.3 **The two low level sensors.** The bottom bar shows the set of two low level sensors. When the pump is out of the LN2, the temperature will show around +25 C to +40C. The sensors will be at room temperature, but they are warmed up by some electric current to make a better difference between cold gas and LN2. This set of sensors is a set of two, one mounted in the heater spring, and one mounted at 7 cm from the bottom of the dewar. They are connected in serial, so the result of these sensors will show the temperature of the warmest sensor.

4.4 It is possible to calibrate these sensors when the pump is in the LN2. In the LN2, these sensors should read exactly -196. The default calibration value is probably 237 and 637. But if the sensors reads totally different than at room temperature around 28 C and in LN2 -196, there is something else wrong.

5 External sensors

5.1 When the pump is in a working mode in which a sensor(s) should be connected, while the sensors are NOT connected, the sensor readout on the right will show " >125 C".
Please now connect the sensor(s). The sensor readout will show around +30 to +50 C when the sensor(s) is at ambient temperature.

5.2 Sensor type, level sensor or temperature sensor:
On screen, on the right side next to the pump , close to the sensor LEDS is written the sensor type.
The sensor type was selected when you installed the pump, or was preset by us.
The sensor type depends on jumper settings and calibration and can show two possibilities.
When the sensor(s) are used for level control, it will show "type=LevelSensor 33mA."
When the sensor is used for temperature control, it will show "type= TempSensor 1 mA."
If the sensor is a type Temperature sensor (on 1 mA.), it should show exactly the temperature of the sensor.
If the sensor is a type Level sensor, it will show the temperature of the sensor, PLUS 20 to 30 degrees, because the sensor is in self heating mode (with 33 mA), so that the sensor itself is 20 to 30 C warmer than the air around it. Only when the sensor is fully submerged in the LN2, it will show the correct temperature of -196C.

5.3 Broken sensor:
The sensor element itself is a glass sensor of 1.6 mm diameter and 8 mm long, mounted in a blue Teflon hose on two wires. This glass element is very fragile and can not be bend. The blue Teflon hose may be bend to suit your application, but the last 20 mm may NOT be bend.
If a sensor is broken, the pump will give and "external sensor x" broken alarm, and a set of 8 or 16 beeps when the pump is switched to "ACTIVE".

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A correct sensor should have a resistance of ab. 112 ohm at 20 C. If a sensor is broken, mostly the sensor would measure a resistance higher than 1 MegaOhm, or when the wires of the sensor makes short circuit, it would measure lower than 10 Ohm.
Eventually you can try to measure this on pin 1 and 2 of the 4 pin round connector.

6 Place pump in the Dewar, so in the LN2

Now you can place the pump in the dewar

6.1 **Dewar Pressure** . After ab. 20 seconds the level of LN2 will be drawn on the screen, and the corresponding dewar pressure will be shown. (note that for pumps from before 2007 the dewar level is NOT shown before the first pumping action)

6.2 The dewar pressure should correspond with the height of the LN2 inside the dewar. For an empty dewar it will be 0. For a half filled dewar it should be around 14 mBar (for a 35 liter dewar), and for a completely full dewar it should be around 27 mBar (for a 50 liter dewar 31 mBar)
For pumps from before 2007, the dewar pressure here gives the value above the LN2, so the read out should be 0 or 1 mBar.

6.3 If the readout does NOT correspond with the LN2 level, the pressure tube can be blocked or frozen, or the pressure sensor can be damaged. (see below for warming up and drying the pump)

6.4 **TMB sensor**. The TMB sensor (show in the "service" screen), should read again 46 to 55 C.

6.5 **The low level sensors**. The low level sensors (shown in the "service" screen), now should show exactly -196 C, when the level of LN2 in the dewar is higher than 7 cm. If the level is lower than 7 cm, the temperature here will show some higher. If the liquid level is under the highest sensor, the low level warning is generated. If the liquid level is also under the lowest sensor, the "EMPTY" alarm is generated.

6.6 **The required pumping flow**. The pumping flowrate as you (for the #800 and #900) have adjusted with the white thumbwheel on the pump housing (0-7) , or for the #600 the fixed value, adjusted in the calibration screen, is displayed on the left side of the pump in the square with "required pumping flow xx mBar"
This is the pressure the pump will build to create the required flowrate. The total pressure in the dewar during pumping will be the sum of :

- **the pre-pressure**. This is the pressure needed to lift the LN2 to the pumphead.
  This pre-pressure value is fixed for the pumps from after 2007 and is at 27 mBar for 35 liter dewar or 31 mBar for 50 liter dewars.
  For older pumps, this pre-pressure value is determined during the first pumping action.
- the pressure for the **feeding height**. This is the value depending on how high you have set the feeding height. If the application is on the table, probably the feeding height is still on 20cm.(above the outlet of the pump), and is on 8 mBar.
  If you have your application on 100 cm above the pump outlet, the value will be around 40 mBar.
  Note that this value is NOT exactly the relative weight of the liquid (0,8). Because of the boiling effect of the LN2 when it is in the fill line, the added pressure is about half the value corresponding with the weight of the LN2 coulomb when it would be solid.
- The **required pumping flow**. This is the adjustment made by the white thumbwheel on the side of the pumphead (for #800 and #900), or (for #600) the flowrate adjusted in the calibration screen.
  Note that for 910 and 915 pumps this value also can be set by RS232 commands or 0-5 Volt signals, depending on in which working mode the pump is. (working mode above 7)
  Note: When this thumbwheel is on 0 (zero), NO pumping pressure will be build.

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7 Pumping action

Now we are going to try to pump, while watching all behavior on screen

7.1 **Press the green button** on the pump housing once. The pressure release valve will close.

7.2 Now the pump will start building pressure, but this is depending on in what working mode the pump is, and what the temperature of the sensor(s) is. Let us presume that the sensor temperature is so, that the pump should start pumping liquid.
The **heater** (below in the dewar on screen), which was on 0% all the time, now will start at 5% and will increase every second. Meanwhile the dewar pressure will rise, making the LN2 to rise in the rise pipe of the pump. The pressure will rise up to the pre-pressure value (27 of 31 mBar) to have the liquid at the bottom of the pumphead, and some higher to reach the TMB sensor. After that the heater will go lower again, waiting for the TMB to be cold.

7.3 If you watch the **TMB** sensor , you will see that at the start the temperature was 49-55 C. During pumping, while the LN2 in the rise pipe is rising, the cold gas from the LN2 will cool down the TMB sensor. The TMB temperature will go lower than -23C when this sensor is touched by the liquid.

7.4 **Frozen alarm 1**. If the TMB does not reach the -23 within 10 seconds that the pressure is above the pre-pressure value, the frozen alarm is set.
This frozen alarm will occur when the liquid can not go freely in the fill tube, or when the rise tube or fill tube is blocked, or when the application is too much air tight.
As the user manual explains, if this alarm occurs often because of the application is more airtight, the length of the fill hose can be set some longer, because a longer fill tube will have also some more resistance for the gas. If the length of the fill tube is set some longer, the pressure on which this temperature of -23 is checked, will be some higher. So then this alarm then is less sensitive.
Frozen alarm 2 Also the frozen alarm will be set if the pressure measuring tube is frozen. If during pumping the temperature of the TMB is below -150C, and the dewar pressure is below the pre-pressure, this alarm is set.
This indicates that the pump is pumping, while the dewar pressure measured is not higher than the pre-pressure. Of course that can never happen, so the measured dewar pressure is too low.
An ice clog in the measuring tube will let the dewar pressure measure too low.

7.5 The **heater** value will go again higher after the checking procedure for the blocked alarm has passed. The heater value will increase every second until it is on 100%. During all this, the dewar pressure will rise again, until the "total required" value is reached. (left upper corner next to the pump drawing)

7.6 After the total required value of dewar pressure is reached, the heater will switch off (0%), and again ON (95%) when the pressure drops a little. It will then be switched ON with a little lower capacity (95%) each time, so that after a minute this will be a stable situation and the heater will switch ON and OFF at 30% to 50 %, depending of how much LN2 is really pumped.
(On screen the visibility is slower than it is in real. This value is sampled on screen every 1 second only, to limit data transfer. This is also for many other values on screen, because the monitor is just for indication)

7.7 The **release valve** may open when the dewar pressure is too high, or when the requested flow is readjusted (by hand or automatic) or after the pump is switched to ACTIVE or SLEEP again.

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8 The pressure release valve

This valve is drawn left next to the pumphead drawing on screen. This valve is normally open when the pump is not ACTIVE. With this valve all over pressure from the dewar is released. During pumping this valve closes, to allow the dewar to build up pressure.
This valve is mounted in the pumphead, inside the 20x20mm square aluminum tube. It is a solenoid coil connected to a plunger to close a small 3 mm hole. The expanding N2 gas will enter the pump housing, warmed by the solenoid.
(for pumps from after 2009, there is a black plastic cap on top of the aluminum square tube, and there is a hole in the pump housing to let the gas expand through the pump housing downwards to the flange. This cap can be removed to observe the solenoid working)
During the pumping, while the pressure is not yet the wanted pressure, this valve opens very shortly every 4 seconds. This is possible to hear, because it will make a small noise. When the wanted pressure is reached, this opening every 4 seconds stops. The mechanical movement every 4 seconds is made to better settle the plunger on the O-ring every time.
The valve should NOT leak any gas during pumping, except this every 4 seconds (very) short opening.
If the valve leaks, this is clear to hear. When the valve is leaking, probably there will be dirt in the solenoid, which should be removed. This is better when the pump is send to us to do that, but if you yourself want to do that, see below.

Removing the solenoid is not so easy, because the trick is to adjust it properly after it is cleaned.

- For pumps from before 2009 (with NO black plastic cap on top), the solenoid housing (the square aluminum tube) can be demounted, after which the solenoid can be loosened and taken out.
- For pump from after 2009 (with the plastic cap on), the housing also holds the PCB. For these pumps the solenoid can bee loosened by the two screws on the front of the aluminum tube, and taken out upwards.

Cleaning the solenoid

The solenoid has one or two plastic rings and a rubber O-ring and a M3 nut + spring ring + OR a M3 nut, or a M3 six sided block, on it. (Notice that the movement of the core can be 2,8 to 3 mm.)
These should be removed. After that, the core of the solenoid can be taken out.
Polish the coil with scotch brite or very fine sanding paper, and also polish the 3 mm hole inside, by cutting a piece of scotch brite small enough to enter the 3 mm hole.
After all is clean and dry, mount the core in the solenoid again. Then put the rubber O-ring on, then the one or two plastic rings, and then mount the M3 nut, the spring ring and then OR the M3 nut OR the M3 six sided block.
Mount is so, that there is 2,8 to 3 mm play. So the core should be movable over 2,8 to 3 mm.
Clean the Teflon plunger and the spring, and look if the small rubber O-ring is in place

- For pumps from after 2009, make sure the Teflon plunger and spring are in the right place, and put the solenoid back into the housing . Mount the two M3 screws with spring rings, and then put 12 Volts DC on the solenoid to make it active. In active state, lower the two M3 screws a little, and push on the coil downwards so that the plunger is firmly into the rubber O-ring. (400 gram force). Then tighten the two screws to fixate this position. Now it should be possible to push on the core, and after it has reached the O-ring, you could push it about 0,5 mm further into the rubber. The free way of movement is now 2,3 to 2,5 mm, and with a higher force it can go 0,5 mm deeper while forcing the rubber O-ring. This is the correct adjustment.
  You may let the black plastic cap off for now, so that you can observe the solenoid movement when the pump is in working later. Do not forget to put on the cap after all is finished
- for pumps from before 2009, mount the solenoid into the aluminum housing and mount the two M3 screws with spring rings loosely. Put the Teflon plunger on, holding the housing upside down. Position the solenoid so, that the flat part of the plunger which will come on the O-ring (so NOT the tip), is 0,5mm below the housing, and 2,5 mm above the housing when the core is pushed (active). The 2,5 mm is the important size.
  After this, measure if the six sided block is exactly in the middle of the square tube, while the core is pushed (active). The size between the six sided block and the side of the tube should be around

8,8 mm exactly the same on both sides. Then fixate the two screws. Now the housing can be put back on the pump.

During pumping, when the solenoid is active, it should be possible to push on the coil and force it about 0,5 mm deeper into the rubber Oring. This is the correct adjustment. Of course now during pumping, it should NOT leak any gas.

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9 warming up and drying the pump

Notice: when cleaning the pump, <u>always remove the pump from mains</u> during cleaning procedure

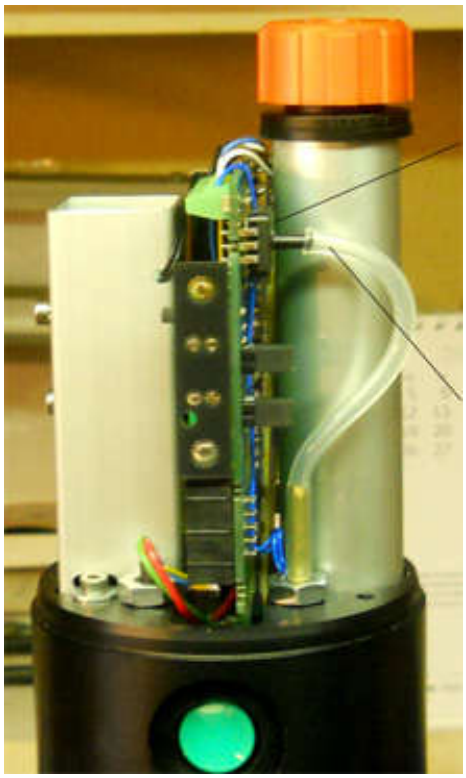
If you have the feeling that the risepipe or the pressure measuring tube is frozen, you need to warm the pump up to room temperature, and maybe dry the rise pipe and measuring tube.
Please put the pump in its floorstand, or lay the pump on a table and wait for all ice and condense water has disappeared. You may help a little by warming it with a electrical hairdryer. But be careful. The protection pipe, around the heater and rise pipe, is made of PVC, and will deform at temperatures above 70 C.

Blocked exhaust:

After all condense water is disappeared, it could be possible to see if there is an ice block in the rise pipe. The most obvious place is high in the risepipe, almost at the pumphead. So this may not be easy to see.
You may blow with dry air from the fill line into the pump, to blow the last water downwards out of the rise pipe. Of course the air should flow freely through this when the ice block is removed.

Frozen pressure measuring tube:

Second place of freezing is the pressure measuring tube. (red tube of 3,3 mm for pumps from before 2011, or transparent tube for pumps after 2011)
At the bottom, next to the heater, there is a set of two small resistors mounted in this pressure tube. These resistors evaporate LN2 during pumping, to make sure this pressure tube is fully filled with N2 gas all the time.
If the pump is out of the LN2, condense water may occur here, which will turn into ice when the pump is replaced in the LN2 before it was dried. If done many times, some ice may appear here, and even some water can go upwards in this tube. To make really sure that all water is out, you may careful blow with dry air from above trough this tube. Here for, the silicon tube in the pumphead could be removed from the pressure sensor on the PCB. Then you can blow in the silicone tube downwards through this pressure tube. Watch if any water comes out, and blow until there is no water left.



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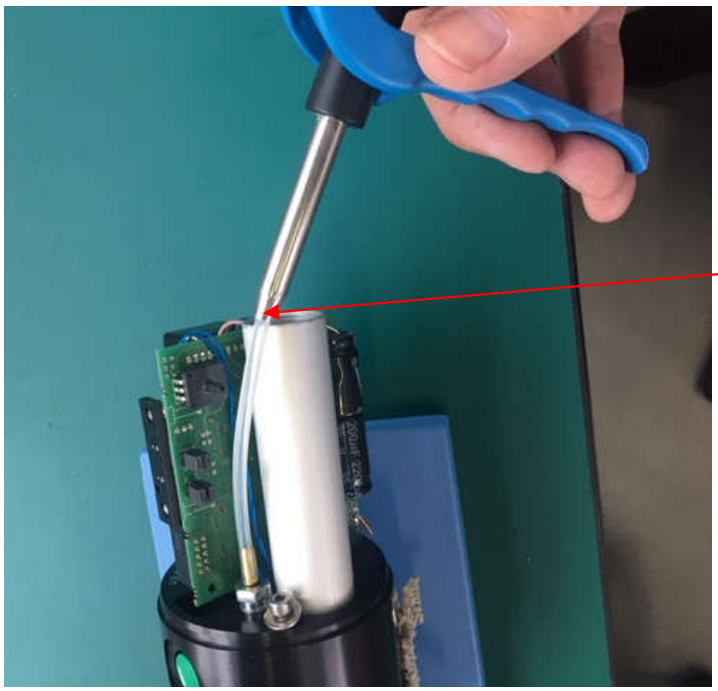

Blow some dry air through the pressure tube to remove the moisture.
Do not build up any pressure in the tube because it can damage the tube internally.

NOTE:
When the pump warms up while laying on a table, water can run into the risepipe and/or pressure measuring tube. When laying on a table, it can take quite a long time before all water is dried out. It is highly recommended to let the pump warm up while it is standing upright, so in its floorstand. In that position most water will fall out, in stead of going into the pipes

NOTE: When the pump is in the LN2, the power should be kept on the pump. When the power is OFF, the leading hose of the pump may freeze because water vapor will enter the pump slowly and freeze the exhaust. There is a small heater element in the pumphead to prevent this. If the pump is longer (several hours) without power, the pump could internally freeze. Only solution then is to warm up the pump completely.

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10 Appendix E: calibration

Usually the system will work as mentioned above and you do not have to do any adjustments.
If the system is recently delivered, all calibration is already done at the factory.
However, if you change the setup, or have the feeling that the sensors may not give the accurate temperature, you may calibrate the internal pressure sensor and internal and external sensor(s).
This procedure is very simple.

In the monitor program, there is a button to go to the 'service' screen. There in the bottom is a button to go to the 'calibrate' screen.
On the left are some buttons to make a 'rough' calibration, to select what type of external sensors are connected. In the right part is the fine calibration.

SELECTION OF EXTERNAL SENSOR TYPE
Standard two external sensors are supplied with each system. This sensor is a PT100 element. The sensor itself is a 1.6 mm ceramic sensor, in a blue Teflon tubing of 2,8 mm. (the tip is very fragile). You also could use other sensors yourself, as long as it is a PT100 element.
If the sensors are used for level-detection, the sensors are heated continuously by a small current (33 mA) to heat the sensor approx. 20 degrees Celsius above the environment temperature. So if the sensor is in the N2 gas, the temperature measured is a little higher than for real. If the sensor is touched by the liquid, it will cool down to the liquid temperature. In this way it is possible to have an accurate level detection.
If the sensors are used for temperature-measurement, the sensors can be switched with a much lower current (1 mA), so that the sensor will not be heated up by the current, to make the temperature accurate over all the range.
To select this current, some jumpers should be set corresponding the choice of sensor working.
On this screen a little drawing gives the position of the jumpers corresponding the wanted working.
Once the jumpers are set, you may press a corresponding button to enter the 'rough' calibration values into the pump. This is enough for good working, but the real temperature may vary one ore two degrees for small manufacturing differences in the sensors and electronics. (default for 33mA. = 137 and 470, for 1mA. = 90 and 478)

Also it is possible to connect a dual sensor (two PT100 sensor serial on only two wires). This could be convenient for using mode 4 (one point level control) and with this dual sensor having in fact a two point level control, and having only one cable to connect. If so, use the rough calibration to let the pump know that this type of sensor is connected.

FINE CALIBRATION
After the rough calibration is entered into the pump, you may use the fine calibration to calibrate the sensor more accurate. In the right side of this screen you see the fine calibration buttons.

External sensors
For the external sensors, you can read the actual temperature in the middle.
When the sensors are at room temperature, after switching the mains power on the pump, of after connecting the sensor, the sensor would be at ambient temperature (about 20 degrees). If the value is much lower ore higher, you may press the '20 degrees' button to enter this value into the pump. When the sensor is connected some time longer, the temperature rises (when the sensor is at 33 mA, because of the self-heating). If you want a very accurate calibration, you may put the sensor in a glass of water, and heat the water up to 30 degrees (with a heat gun?) and then press the '30 degrees' button. Note that this temperature does not need to be absolute accurate when the sensor is only used for level control. For level control the sensor is used at –196 up to –172 only, so if the top temperature is some degrees too high or low, it has almost no influence.(default calibration for the 33 mA sensor is 470, 1mA = 478)

What is important, is the calibration for the 'cold' value. Therefor the sensor must be put into LN2. Make sure that the sensor is deep into the LN2, and look at the temperature on screen that it is not dropping any longer (one or two minutes). If the reading is not exactly –196, press the '-196' button to enter this value

into the pump. Now the reading should be –196 exactly. (default calibration for the 33mA sensor is 137, for 1 mA sensor 90)
Calibration is now ready, but before use, the pump should be reset (power off and on) to work with the new values.

Internal pressure sensor
Inside the pump is an internal pressure sensor which measures the pressure in the dewar, 2cm from the bottom, so UNDER the LN2. Calibration of this is very simple. The pump should be out of the LN2, so in open air.

If the reading on screen is not 0 mBar (+_ 0.5 mBar), you may click the '0 mBar' button to enter this value. Now the reading should give 0 mBar +- 0,5 mBar. After the pump is placed back in the LN2, the LN2 level should correspond with the actual LN2 level. (default may vary between 32 and 52, was factory calibrated)

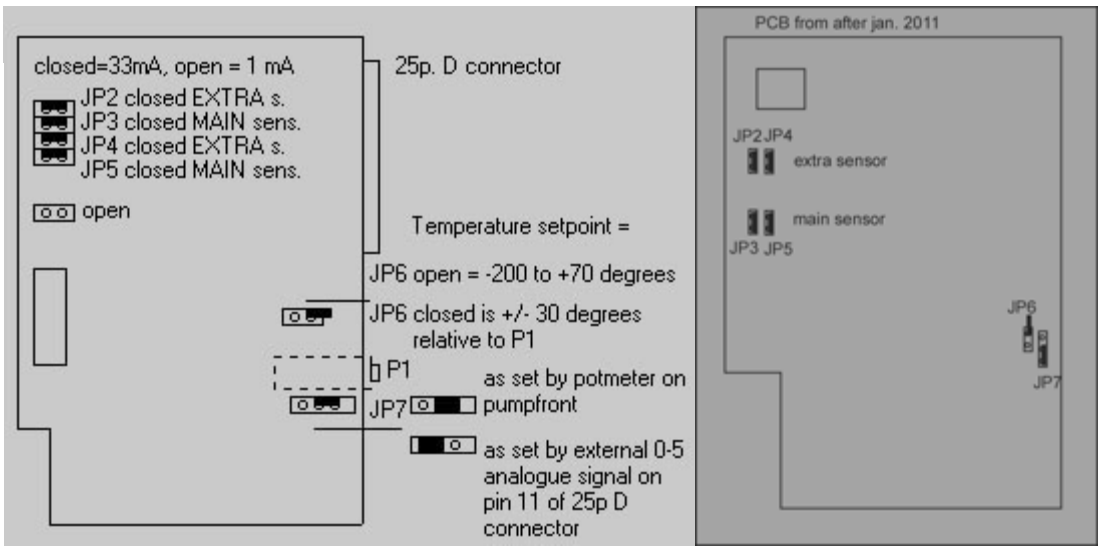
Internal vessel sensor. (in service screen)
Inside the pump , down in the dewar, there is a set of sensors to measure the level in the dewar. If the pump is in room temperature, the reading should be around +30 degrees (due to heating because of 33 mA through these sensors also)
When the pump is in the LN2, and there is more than 10 cm LN2 in the dewar, the reading should be –196 degrees. If not, you may click the '-196 button' to calibrate this value. (default = 237 and 637)

FLOWPOTMETER RANGE
On the side of the pump is the thumbwheel to set the wanted pressure in the dewar to reach a corresponding flow. It is scaled from 0 to 7, working is a logarithmic way. For most applications, a middle range flow setting of about 3 should be sufficient, which is about 50 mBar, when the pump is delivered.
The standard range at delivery is 0 to 270 mBar for this thumbwheel. (for the #905, #910 and #915 liquid pumps). For gas pumps 0-70 mBar.
However, if you want, you may rescale this range, to adjust it more for your application.
In the middle of the calibration screen, on the bottom, there is a selection box in which you may select an other range.
If you select an other range, and write it into the pump, you may prevent the user in setting a too high flow for your application.
NB. For most filling applications a pressure of ab. 50 mBar is sufficient. Start with the thumbwheel on 3 (= ab. 50 mBar) and allow the fill-line to cool down and observe the flow after 3 minutes.

TEMPERATURE POTMETER RANGE (#910, #915, #810, #815)
On the front of the pump is the potentiometer for setting the wanted temperature, in case of a temperature regulation mode.
Standard the range is from –190 to ab. +70 degrees Celsius.
On the PCB in the pump housing is a jumper JP6, which is normally open. If this jumper is put ON (closed), the range of the temperature can be set by the blue potentiometer P1, and with the potentiometer on the front of the pump, this can be varied plus or minus about 30 degrees.
For this a different temperature scale is needed on the pump. You may request an other scale from us, or make it yourself.

NB. There is a drawing of the jumpers in the monitor software, in the 'view all modes' button, with a separate button.

NB. There is a pin connection diagram in the monitor software, in the 'view all modes' button, at the bottom of mode 15



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11 Appendix F: detailed working of the pumping

When the pump is not standby, there is NO overpressure in the dewar and the small release valve is open. This release valve is a small hole to connect the dewar to the outside. It is closed when overpressure is needed.
When the pump is switched to 'STANDBY' , the pump uses a heater element in the bottom of the dewar to create gas to build a small overpressure. Because the fill hose is in fact coming from the bottom of the dewar, when a small overpressure is inside the dewar, the liquid will raise in this fill hose. When the pressure is enough, the liquid will reach the highest point, and will flow out of the fill hose. You can imagine, that how higher the pressure is, the higher the flowrate is. Note that there is NO valve in the fill hose, it is just a hose coming from the bottom of the dewar, going to the application.
So, when switched to STANDBY, the release valve will close and the heater will build some pressure to create some LN2 flow.

There can be 3 situations of the pump:
1 SLEEP the pump is doing nothing, except keeping an internal small heater warm to prevent the pumphead from freezing
2 STANDBY a small overpressure is used to keep the pump standby for the next pumping action (most working modes)
3 PUMPING a pressure is used to realize the requested flow of LN2

Pumping Pre-pressure
For pumping, the pumping pressure consists of 3 variable values.
* First, a certain pressure is needed to get the level high enough to reach the pumphead. This is called the 'pre-pressure'.
Since the pressure is measured in the bottom of the dewar, the pressure needed here is not depending of the dewar level. Only when the dewar is more empty, it may take some more time to reach that pressure.
This pre-pressure is fixed and adjusted to the dewar height. (27 mBar. for 35 Liter dewar, or 32 mBar. for a 50 liter dewar)
* The second value is the pressure to reach the highest point in the fill hose. You can imagine that if the fill hose goes 1.5 meters high, that a higher pressure is needed to let the LN2 come out of the fill hose. This can be set in the monitor program with the 'feeding height compensation'. The value for 20 cm feeding height is 8 mBar, needed to rise from the bottom of the pumphead to the outlet, keeping the level at 20cm lower than the highest point..
* The third value is the pressure wanted to have a flow suitable for your application. This is adjusted by the thumbwheel on the side of the pump. The higher this pressure is set, the faster the LN2 comes out of the fill hose. Begin with a small flowrate, of 50 mBar (thumbwheel on 3).

Dewar level detection and pre-pressure

SLEEP mode:
When the pump is connected to the power, 9 beeps sounds, and the pump will begin in SLEEP mode (yellow LED flashing slowly every 5 seconds)
When the pump is started for the first time, the LN2 level in the dewar is unknown to the pump. During SLEEP (when all is OFF) the pump measures the pressure in the bottom of the dewar, and after some seconds, when this is stable, the LN2 level will be drawn on the screen.
Since this LN2 level can only be detected when the pump is in SLEEP, this drawing on screen can be some inaccurate during PUMPING, but it will NOT influence pumping behavior. After pumping is done and the pump is in SLEEP mode, the drawing on screen of the LN2 level is accurate again.
The warning for that the dewar is almost empty, or really empty, is measured with other sensors, so this is always accurate.
STANDBY / PUMPING mode:
When the green button is pushed, the pump switches ON, depending of what working mode and sensor temperature(s).

When in a mode with no sensors, or when sensor(s) are not yet cold enough, the pump will go into PUMPING mode. (Yellow LED burning)
When the sensor(s) are cold, or the temperature is reached, the pump will go into STANDBY mode. (yellow LED flashing every 1 sec.)

STANDBY mode:
In the standby mode, a small overpressure is used to raise the LN2 level in the rise pipe to the bottom of the pumping head, to make it as fast as possible to respond on a pumping request later. The pump will create the pressure equal to the "pre-pressure", depending on the height of the dewar. (for a 35 liter dewar this is ab. 27 mBar, equal to a level of 13 cm under the dewar top.)
This is kept until the pump goes into PUMPING mode. (for working mode 3, in STANDBY, NO pre-pressure is used)

PUMPING mode:
When starting pumping, the pump starts to build up pressure. You can see this in the monitor program at the HEATER. It will start at 5% and increases every 3 seconds, up to 100%. It will increase pressure until the pressure is equal to the requested total pressure, depending on 3 values.
1. The pre-pressure (to reach the bottom of the pumphead, for a 35 Liter dewar ab. 27 mBar)
2. The pressure to reach the highest point in the fill line. (8 mBar for the 13 cm. to reach the outlet of the pump, PLUS the pressure needed to reach the highest point, if set)
3 The real pumping pressure (set by the thumbwheel on the side of the pump)

In working modes which just switches ON and OFF the pumping, this total pressure will be kept during PUMPING.
In working modes which regulates flow or temperature, the percentage of the last (3) part of the pressure may depend on temperature changes and/or level sensor temperatures. If more cold seems needed, the pressure will be higher, but when a temperature is almost reached, the pressure will be lower.

If this pressure is reached, the heater shuts OFF, until the pressure is too low again. It will then be switched ON with a little lower capacity (95%) each time. In the end this will be a stable situation and the heater will switch ON and OFF at 30% to 50 %, depending of how much LN2 is really pumped.
(On screen the visibility is slower than it is in real. This value is sampled on screen every 1 second only, to limit data transfer. This is also for many other values on screen, because the monitor is just for indication)

After the pump has finished pumping (depending on what mode the pump is in) and the pump is in STANDBY, the dewar pressure is released to the pre-pressure. This means that the LN2 is in the rise pipe at the bottom of the pumphead.. This is to have the fastest response for when again LN2 is needed again. (for working mode 3, in STANDBY, NO pre-pressure is used)

FREEZE PROTECTION:
If the pump is OFF (in sleep mode), a small heater element in the top of the rise pipe will be heated up to 55 degrees, to block the water vapor which could go into the pump and freeze the risepipe.
Therefore, the pump should not be IN the LN2 and disconnected from the mains power in the same time. If mains power is disconnected, the pump should NOT be in the dewar. (for some hours it is no problem, but for a night long, it can be too long and the pump could freeze) This also depends on the humidity of that moment, and on the length of the fill hose. If the fill hose is long, it takes more time for the water vapor to go into the tube and reach the pumphead.

BLOCKED (frozen) alarm:
The pump checks if the LN2 is really going out of the rise pipe, counting on that the exhaust of the LN2 is in the free air. When the pressure in the dewar is higher than 60 mBar, and the temperature measured in the exhaust of the pump is still higher than -23 C., the "exhaust blocked" alarm is set.
If the application is too much airtight, thus the exhaust is blocked too much, this could also cause a ‘blocked exhaust’ alarm. This is the same as a frozen exhaust. The application should have an opening

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wide enough to let expand all the gas. If the pump gives this alarm often, the value for the length of the fill hose could be set some longer, to prevent this alarm. This value only sets the sensitivity of the alarm. It has further NO influence on any pumping behavior

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12 Appendix G: detailed working of the delayed switching off

In mode 2,3,4 and 5, the switching OFF of the filling has an (adjustable) delay responding time.
The sensor is in self-heating mode, so the sensor is warmed a little by electric current. This means that the sensor itself is some warmer than the surrounding air, but when the sensor is IN the LN2, the sensor shows the right temperature of -196 C. In this way the difference between gas and real liquid is detected.

This is an extra mechanism for making sure that the application is fully filled before the filling shuts off.
This is done by looking to the sensor, and lowering the flowrate when the sensor comes below the setpoint of -181 C.
In the right upper corner of the monitor software is the "flow allowed" bar. During filling this is on 100%, allowing 100% of the preadjusted flowrate (thumbwheel) to be as flowrate pressure.
When the sensor is touched by the LN2 level, OR by splashing on the sensor, and the sensor is below -181 C, the "flow allowed" is reduced by 3%, and every 1 seconds 3 % lower.
If the lowering on the sensor was caused by splashing, this will reduce the splashing so that the sensor will become some warmer again.
If the lowering on the sensor was caused by the real LN2 level reaching the sensor, the reducing of the flowrate will not cause the sensor to become some warmer, but the sensor will stay below -181 C.
When the sensor is below -181 C, also the count down for switching off starts.(visible in the monitor screen next to the sensor). When the sensor is xx seconds below -181 (while the flowrate then is reduced to 0%), the pump switches to STANDBY mode and will wait for the next action (depending on which working mode is chosen).
(the xx stands for 15 seconds as it is the default setting for the #900 pumps. If you have a very small application to fill, it is better to set this value to 80 seconds.)

If the sensor below -181 C was NOT caused by the LN2 level reaching the sensor, but was caused by splashing on the sensor, there will be a moment that the sensor will rise again above the -177 C.
This moment will be before the counting down to shut off is finished.
Then also the "flow allowed" will increase slowly again, while also the counting down for the shut off is resetted. This means that the flow will keep increasing until the "flow allowed" is 100% again and filling on 100% flowrate continues.

After this, there will be a moment that again the temperature on the sensor will come below -181 C. Again the "flow allowed" will reduce, and the countdown for shut off will start.
Notice that then the application will be fuller than the first time.
This mechanism will continue until the application is fully filled, and the temperature of the sensor is below -181 longer than xx seconds.

So, also when the flowrate is too high and the sensor is reacting too much on the filling, the application should be fully filled before the pump shuts off. But it would be better that the filling is so, that the sensor comes below -181 only when the real LN2 level reaches the sensor.

Trick in this is to make sure that the LN2 stream from the filling comes not directly on the sensor. Therefor the sensor should be mounted so, that the stream of LN2 is NOT reaching the sensor.
If the (yellow) phase separator can be mounted, this will help already a lot. The gas is spread out because of the phase separator, while the liquid will drip nicely to below.
The phase separator should always be placed above the highest possible LN2 level.
If the phase separator can not be mounted (because the application is too small), make sure that the liquid does not spray in the direction of the sensor, or place the sensor in a wider tube with some holes.
Also it is possible to use a fill hose which is closed at the bottom with a hole in the side. Then the gas flow will not spray directly into the LN2 level, making a more stable level.

**Note that it is important that you do not set the adjustment for the feeding height to a too higher value than it actual is. When the "flow allowed" parameter is on 0%, there should NOT come any LN2 from the pump.
If you set the feeding height to the height from the pump exhaust to your application top, or a little lower, it should work.

**Note that if you increase the filling flowrate, the filling can be faster, but that then the sensor may be splashed sooner, or that the cold gas flow cools down the sensor too much, so that the sensor reaches -181 before the application is fully filled. This will start the mechanism of regulation down the flowrate, and restarting count down for shut off.
So it can happen that a lower flowrate will fill your application sooner than a higher flowrate.

13 Appendix H: detailed working of mode 6 (and 8 and C)

For working mode 6, when the pump is switched to STANDBY, (by hand on the push button, or automatic by an external signal), the pump starts building pressure and will fill up the application until the sensor touches LN2.
While the sensor is cooled down, the built-in PID regulation will regulate the flowrate back when the sensor temperature comes closer to the "wanted temperature" of -192 C. This is visible in the right upper corner at the "flow allowed" bar. This is on 100% in the beginning, but will go lower when the "wanted temperature" is approached.

If the sensor temperature becomes lower than -192 C (sensor halfway in the LN2) the pumping will go slower, trying to keep the temperature of the sensor on -192.
If the temperature on the sensor drops too low, pumping will go lower, and if the temperature comes above the -192, pumping will increase. This will keep the level in the application always on about the same.
If the sensor stays too cold for more than the "shut off time" (20 minutes), pumping shuts off completely, but will be turned ON when the sensor is too warm again. In most applications this will never happen.

Important in this is to adjust the maximum flowrate (thumbwheel) not too high, so that the PID is capable of regulating back fast enough. The optimal adjustment would be, that in the "stable" situation (when the level is reached), the "flow allowed" bar is at 30 to 50%. Probably in the stable situation the flowrate needed to keep the level constant will be around 10 mBar only. So if the maximum flowrate would have been set on 200 mBar, the PID should regulate back to 5% which is a lot.
When 10 mBar is needed to keep the level steady, 30 mBar should be high enough as maximum flowrate setting (thumbwheel), and the PID can regulate back to 30%, which is a nice setting.

When the pump is switched to SLEEP (by hand on the push button, or automatic by a signal), the pump stops pumping and releases all pressure.

Note: For optimal regulation the highest point of the filling hose should be at the end, so that the filling hose will be completely filled with LN2, and a little more pressure "overflows" the filling hose. Do not have the hose in the middle somewhere higher than at the end. A horizontal fill line would be the best.

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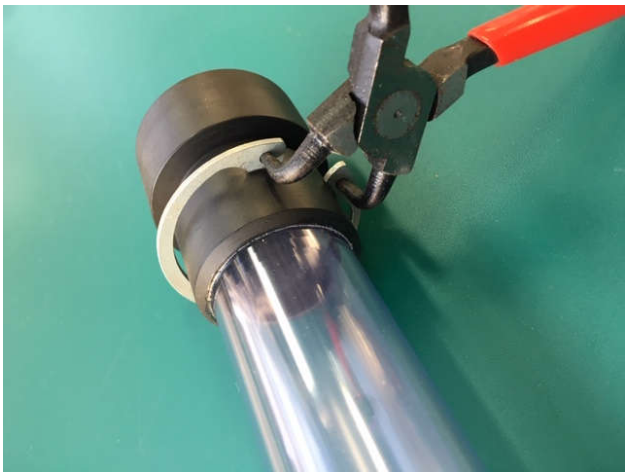
14 Appendix H: Demounting and mounting protection pipe

In some case you may want to remove and mount back the protection pipe, on suggestions from us.



It is for us 2 minutes work, if you have the right tool.
You need to have a special pliers as shown on the picture

The points should fit in the big ring.
With the pliers you can pinch the ring, so that it becomes smaller. When the ring is small enough, you can pull the protection pipe out of the fitting on the pump.

The trick in this is pinching and pulling in the same time.
Probably this is more convenient when done with two people.

When the pipe is out of the pumphead, slowly pull of the pipe from the tubes and heater.
Do not bend the pipes too much.

Then put the new pipe on.
!!!!! Note that the heater and risepipe should be as this picture

The bigger tube should be under the printed circuit board of the heater, so that the big tube is under, and the small plastic tube on the circuit board is above.
(it is possible to have the pipe above the circuit board, but then it will NOT fit in, and the heater spring can be damaged)

Try to slide the heater board and the bigger pipe inside the new protection pipe without force.
When it is in, slide the protection pipe all the way to the pumphead.
Push the protection pipe in the pumphead without force.
Turn around the protection pipe until it clicks deeper. (!!)
There is only one position in which the pipe goes in deep enough.
When it is in deep enough, you can see that the ring could be in, in this position.

Now pull back the pipe a little, so that you can insert the ring together with the pipe into the pumphead.
Use the pliers to make the ring small enough.
Then gently push the pipe in, while the ring goes in also.
Let the ring loose, so that it will click in place.