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Patent No. 4,571,075
Patent No. 5,563,737
Patent No. 5,009,113
Patent No. 5,617,201
Patent No. 5,309,288
Patent No. 6,067,151

INSTRUCTION MANUAL
FOR INLINE REFRACTOMETER
PR-23(-...-AX/FM/CS/IA/IF)

WARNING

The process medium may be hot or otherwise hazardous.

Precautions when removing the sensor from the process line:
Make positively sure that the process line is not under pressure. Open a vent valve to the atmosphere.
For a prism wash system, close a hand valve for the wash medium and disable the wash valve.
Loosen the clamp cautiously, be prepared to tighten again.
Be out of the way of any possible splash and ensure the possibility of escape.
Use shields and protective clothing adequate for the process medium.
Do not rely on avoidance of contact with the process medium.
After removal of the sensor, it may be necessary to mount a blind cover for security reasons.

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1 Introduction

The K-Patents inline refractometer is an instrument for measuring liquid concentration in the process line. The measurement is based on the refraction of light in the process medium, an accurate and safe way of measuring liquid concentration.

The inline refractometer sensor (A in Figure 1.1) measures the refractive index n_D and the temperature of the process medium. This information is sent via the interconnecting cable (B) to the Indicating transmitter (C). The Indicating transmitter DTR calculates the concentration of the process liquid based on the refractive index and temperature, taking pre-defined process conditions into account. The output of the DTR is a 4 to 20 mA DC output signal proportional to process solution concentration. Process data can also be downloaded to a computer via an Ethernet cable.

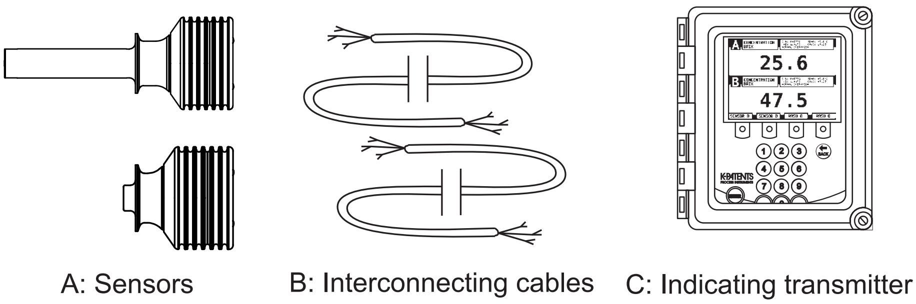


Figure 1.1 Refractometer equipment

1.1 PR-23 refractometer models

The basic system of one or two sensors connected to an Indicating transmitter (DTR) is the same for all PR-23 inline refractometer models. However, there are different sensor models, each model is adapted for different process requirements.

The models PR-23-AC and PR-23-AP meet the 3-A Sanitary Standard requirements. With an ATEX approved PR-23-...-AX sensor or a FM approved PR-23-...-FM sensor or a CSA approved PR-23-...-CS sensor a PR-23 process refractometer system can also be used in potentially explosive atmosphere. The ATEX approved Intrinsically safe refractometer PR-23-...-IA can even be used in explosive atmosphere. The Safe-Drive™ system with a PR-23-SD sensor enables safe sensor insertion and removal also when process line is in full operation.

1.2 Principle of measurement

The K-Patents inline refractometer sensor determines the refractive index n_D of the process solution. It measures the critical angle of refraction using a yellow LED light source with the same wavelength (580 nm) as the sodium D line (hence n_D). Light from the light source (L) in Figure 1.2 is directed to the interface between the prism (P) and the process medium (S). Two of the prism surfaces (M) act as mirrors bending the light rays so that they meet the interface at different angles.

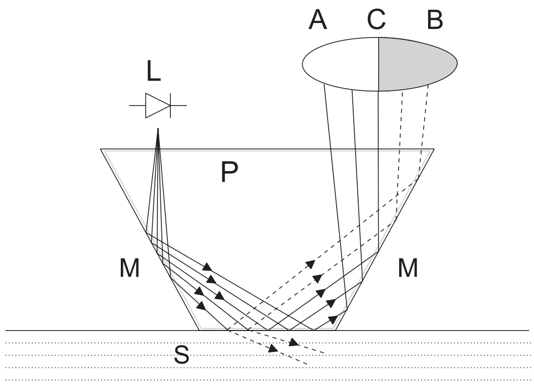


Figure 1.2 Refractometer principle

The reflected rays of light form an image (ACB), where (C) is the position of the critical angle ray. The rays at (A) are totally internally reflected at the process interface, the rays at (B) are partially reflected and partially refracted into the process solution. In this way the optical image is divided into a light area (A) and a dark area (B). The position of the shadow edge (C) indicates the value of the critical angle. The refractive index n_D can then be determined from this position.

The refractive index n_D changes with the process solution concentration and temperature. When the concentration changes, the refractive index normally increases when the concentration increases. At higher temperatures the refractive index is smaller than at lower temperatures. From this follows that the optical image changes with the process solution concentration as shown in Figure 1.3. The color of the solution, gas bubbles or undissolved particles do not affect the position of the shadow edge (C).

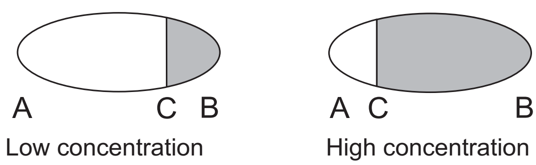


Figure 1.3 Optical images

The position of the shadow edge is measured digitally using a CCD element (Figure 1.4) and is converted to a refractive index value n_D by a processor inside the sensor. This value is then transmitted together with the process temperature via an interconnecting cable to the Indicating transmitter for further processing, display and transmission.

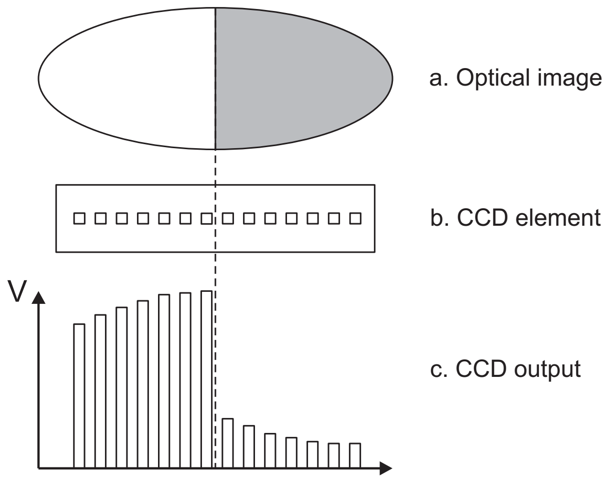


Figure 1.4 Optical image detection

1.3 General safety considerations

The process medium may be hot or otherwise hazardous. Use **shields and protective clothing** adequate for the process medium - do not rely on avoiding contact with the process medium.

Precautions when removing a standard sensor from the process line :

- Make positively sure that the process line is not under pressure. Open a vent valve to the atmosphere.
- For a prism wash system, close a hand valve for the wash medium and disable the wash valve.
- Loosen the flange or the clamp cautiously, be prepared to tighten again.
- Be out of the way of any possible splash and ensure the possibility of escape.
- After removal of the sensor, it may be necessary to mount a blind cover for security reasons.

Note: For the Safe-Drive™ system safety rules, see Section 11.5 and for additional precautions required by explosive atmosphere, see Section 9.8.2.

1.4 Warranty

K-Patents warrants that all products made by K-Patents shall be free of defects in material and workmanship. K-Patents agrees to either replace or repair free of charge any such product or part thereof which shall be returned to the nearest authorized K-Patents repair facility within two (2) years from the date of delivery.

Before returning a defective product for service or replacement, please contact K-Patents or your nearest K-Patents representative (see *http://www.kpatents.com/* for contact information). For the health and safety of personnel handling your return, clean the instrument, especially the parts that have been in contact with the process liquid, before packing it. Ship the cleaned instrument to the address given to you.

1.5 Disposal

When disposing of an obsolete instrument or any parts of an instrument, please observe the local and national requirements for the disposal of electrical and electronic equipment. An aluminium or stainless steel sensor housing can be recycled with other metallic waste of the same type.

2 Inline refractometer sensor

2.1 Sensor description

Figure 2.1 below shows a cutaway picture of a PR-23 inline refractometer sensor. The measurement prism (A) is flush mounted to the surface of the probe tip. The prism (A) and all the other optical components are fixed to the solid core module (C), which is springloaded (D) against the prism gasket (B). The light source (L) is a yellow Light Emitting Diode (LED), and the receiver is a CCD element (E). The electronics is protected against process heat by a thermal isolator (K) and cooling fins (G). The sensor processor card (H) receives the raw data from the CCD element (E) and the Pt-1000 process temperature probe (F), then calculates the refractive index n_D and the process temperature T. This information is transmitted to the Indicating transmitter.

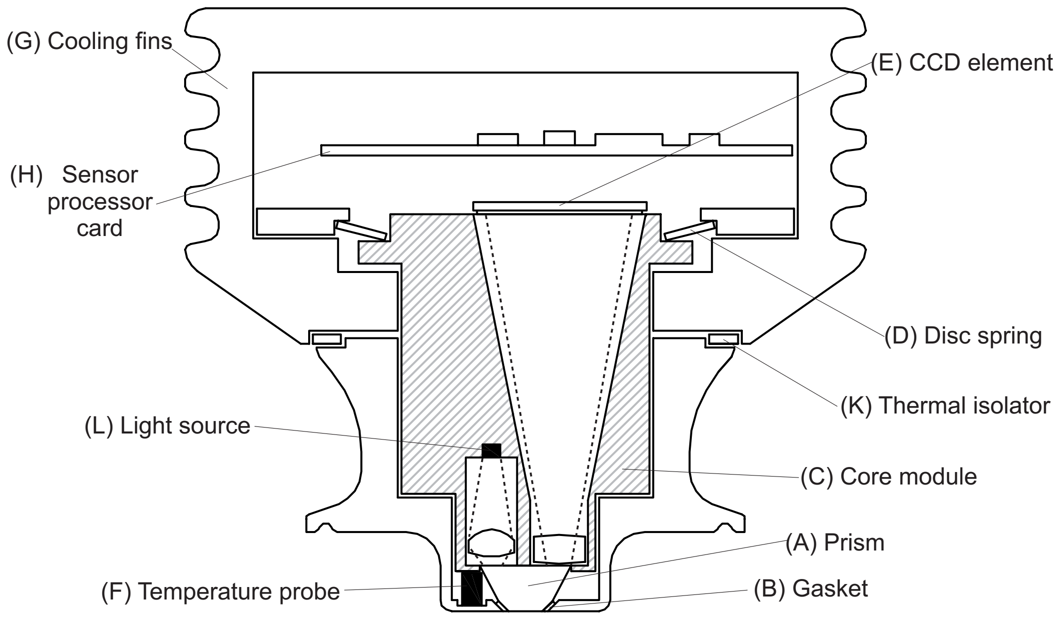


Figure 2.1 PR-23 sensor structure

2.2 Mounting the sensor

The sensor mounting location should be chosen with care to ensure reliable readings from the process. Some basic rules, described in this section, apply to all sensor models. The model specific instructions can be found in Chapter 9, “Sensor specifications”. For the Sanitary compact refractometer PR-23-AC see Section 9.3, for the Probe sanitary refractometer PR-23-AP see Section 9.4, for the Process probe refractometer PR-23-GP see Section 9.5, for the Teflon body refractometer PR-23-M and Teflon body semicono refractometer PR-23-MS see Section 9.6 and for the Saunders body refractometer PR-23-W see Section 9.7. For mounting an ATEX/FM/CSA approved sensor in explosive atmosphere, see Section 9.8.2. For mounting an intrinsically safe refractometer PR-23-...-IA, see Section 9.9. For mounting of the Safe-Drive™ system with the PR-23-SD sensor, see Section 11.4.

2.2.1 Choosing sensor mounting location

A K-Patents inline refractometer sensor can be located either indoors or outdoors in most climates. However, when a sensor is located outdoors, some basic protection against direct exposure to sunlight and rain should be provided. Special care should be taken if the pipe wall is translucent (e.g. of fiberglass), as light from outside reaching the prism through the pipe wall may disturb the measurement.

The mounting location needs to be such that sediments or gas bubbles cannot accumulate by the sensor. Good flow velocity is essential in keeping the prism clean.

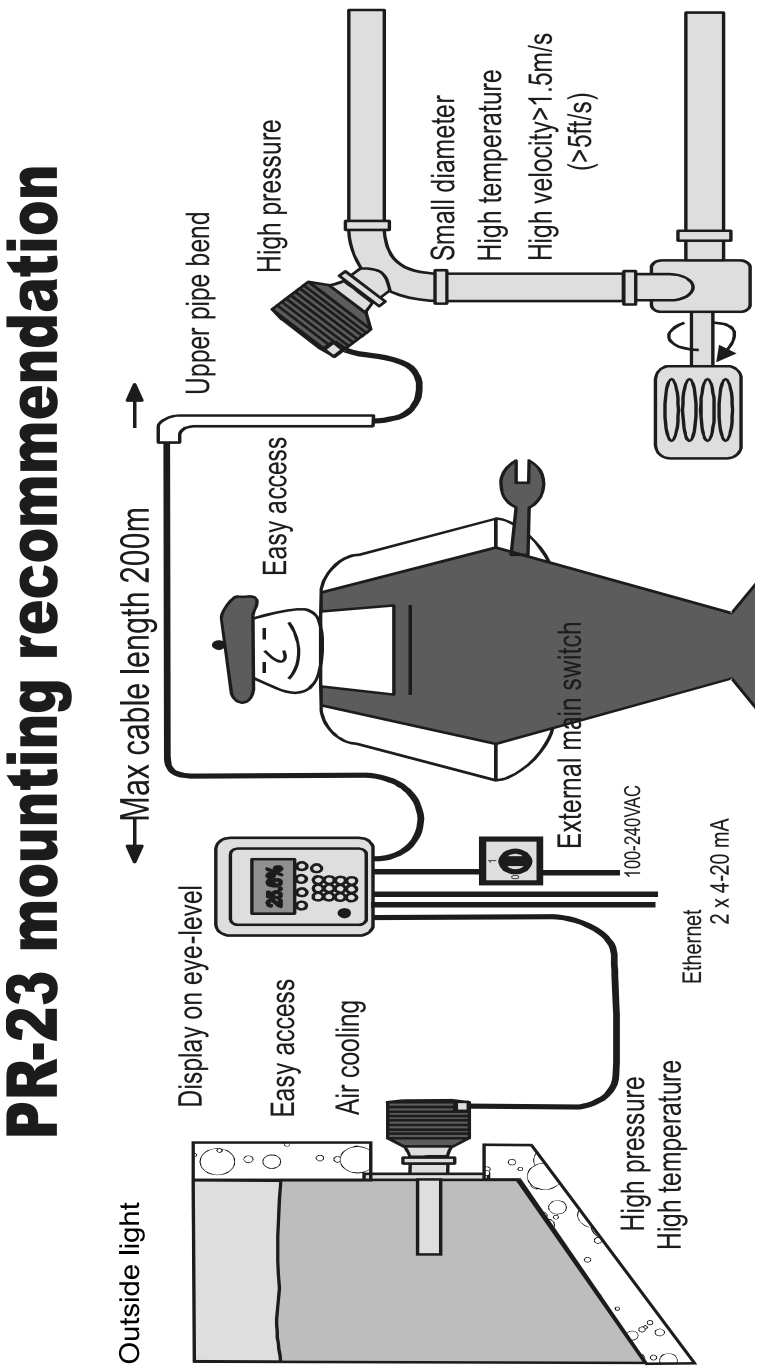
Important: If the process pipe vibrates, support the pipe. A vibrating pipe might damage the in-line sensor mounted on it.

Always check that the sensor head is kept cool enough; the sensor head should not be too hot to keep a hand on. The sensor cover should not be exposed to high temperature radiation. In most cases, draft and natural convection provide sufficient air cooling if the air gets to flow freely around the sensor head.

Additional cooling is necessary when the ambient temperature is higher than 45 °C (113 °F) or when the process temperature is above 110 °C (230 °F) and the ambient temperature is above 35 °C (95 °F). The air cooling is improved by blowing pressurized air against the sensor cover. The pressurized air can be supplied by the ventilation system. If no air is available it is also possible to wind a copper coil for cooling water around the sensor head cover (except for PR-23-SD where sensor head needs to be kept clear for insertion and retraction).

Important: Always mount the sensor so that the interconnecting cable points downwards from the sensor head.

2.2.2 PR-23 mounting guide



2.2.3 Check list for pipe mounting

Most K-Patents inline refractometer models are mounted in a pipe. K-Patents recommends a minimum flow velocity of 1.5 m/s (5 ft/s). The diameter and form of the pipe and the process temperature all affect the measurement and need to be taken into account.

1. If the process pipe diameter varies, select the *position with the smallest diameter* (and accordingly highest velocity). Then the prism keeps better clean.

2. If the refractometer is used in a feed-back control loop, *make the time lag short.* E.g. when a dilution valve is controlled, mount the refractometer close to the dilution point. However, make sure complete mixing has occurred at mounting location.

3. If the temperature varies along the process pipe, select the *position with the highest process temperature.* Then the risk of prism coating is minimized, because higher temperature means higher solubility and also lower viscosity.

4. Often the *position with the highest process pressure* (= after pump + before valve) has favorable flow conditions without sedimentation or air trapping risks.

5. The sensor should be conveniently accessible for service.

2.2.4 Check list for mounting in a tank, a vessel or a large pipe

A probe sensor PR-23-AP or PR-23-GP can be inserted with a flange or clamp into tanks and vessels which either don't have a scraper or where the mixer doesn't touch the vessel wall. A probe sensor can also be flush mounted in a cooker where the scraper touches the wall.

1. The inserted probe sensor is mounted close to a stirrer to ensure representative sample of the process liquid and to keep the prism clean.

2. The sensor should be conveniently accessible for service.

3 Indicating transmitter DTR

3.1 Indicating transmitter description

The Indicating transmitter DTR is a specialized computer designed to process data received from one or two sensors. The Indicating transmitter enclosure (Figure 3.1) contains a front panel with a backlit Liquid Crystal Display (LCD) and a keyboard. The front panel swings open to give access for connections and service. Knockout padlock provisions are included in the enclosure's both cover latches for locks to prevent unauthorized access.

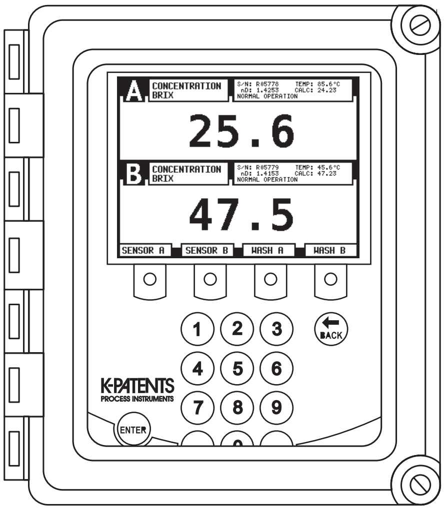


Figure 3.1 The Indicating transmitter enclosure

The sensors send the values of the refractive index n_D and the process temperature T to the DTR. The microprocessor system then linearizes the concentration reading (example in Figure 3.2), and performs an automatic temperature compensation.

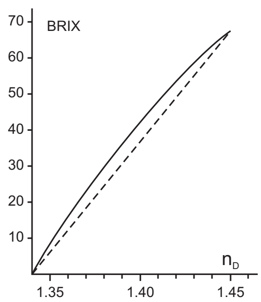


Figure 3.2 A linearized curve

3.2 Mounting Indicating transmitter

The Indicating transmitter should preferably be located in an easily accessible, well lit and dry area. The enclosure must not be exposed to rain or direct sunlight. Avoid vibration. Take interconnecting cable length into consideration when choosing the mounting location.

The enclosure is mounted vertically on an upright surface (wall) using four mounting feet, see Figure 3.3. The LCD is best viewed when approximately on the eye level of the user.

Important: Do not drill mounting holes in the enclosure as that will affect the protection class of the enclosure and damage the electronics.

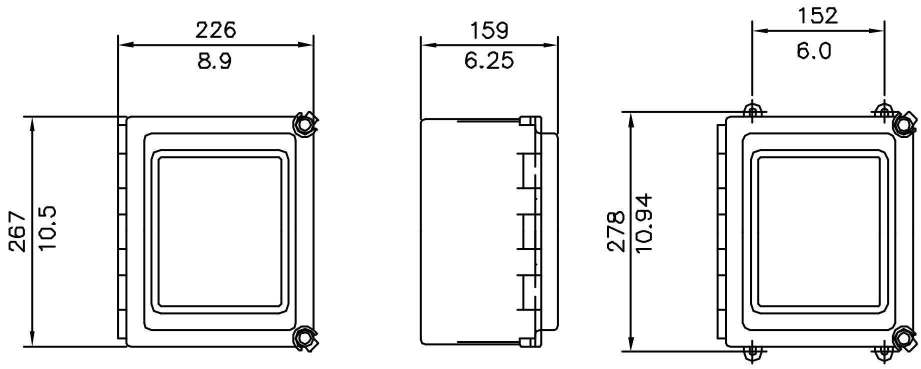


Figure 3.3 Indicating transmitter: dimensions (mm/in) and mounting feet measures

Note: The LCD display has an operating temperature range of 0–50 °C and a storage temperature range of -20–60 °C.

Important: The DTR does not have a built-in power switch. The system is always powered on when connected to a power source. K-Patents recommends mounting an external power switch to control the DTR's power supply, Figure 3.6.

3.3 Electrical connections

3.3.1 Interconnecting cable

The cable contains a pair of twisted signal wires (1, 2) and a cable shield (3) (see Section 3.3.2 and Figure 3.7). Standard delivery is 10 meters (33 feet) of cable. The maximum length of an interconnecting cable is 200 m (660 ft). The signal wires (1, 2) are interchangeable (non-polarized). The cable shield is connected to the protective earth at the Indicating transmitter.

The junction box enables the use of customer's own cable as long as it meets IEC 61158-2 type A standard requirements, see Section 10.3.2, "Interconnecting cable specifications".

3.3.2 Connecting sensor

1. Remove the four screws holding the Sensor nameplate (Figure 3.4). The terminal strip is under the nameplate.
2. Connect the signal wires to terminal (1) and (2), and the cable shield to terminal (3).
3. Tighten up cable gland. Screw nameplate back on.

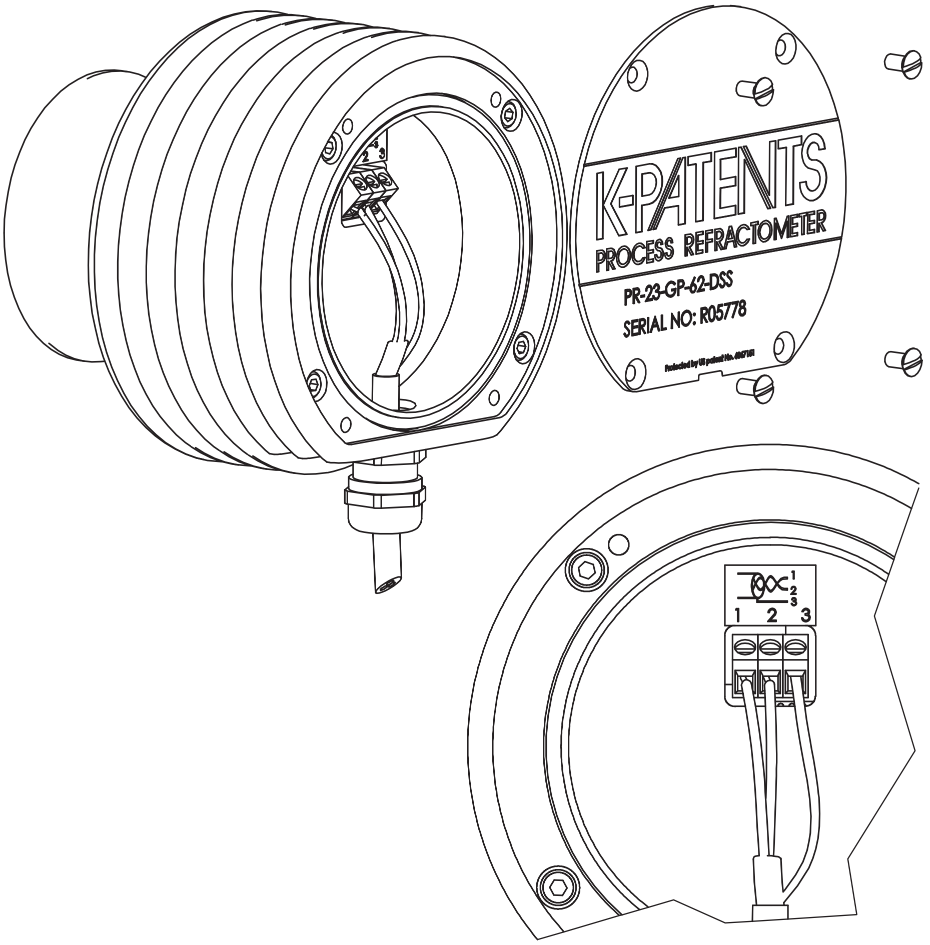


Figure 3.4 Sensor electrical connections

3.3.3 Connecting the Indicating transmitter

All the electrical terminals of the Indicating transmitter are behind the Front panel. To access them, first open the enclosure cover. Then loosen the front panel screw (Figure 3.5) and swing open the Front panel. All terminals are now accessible.

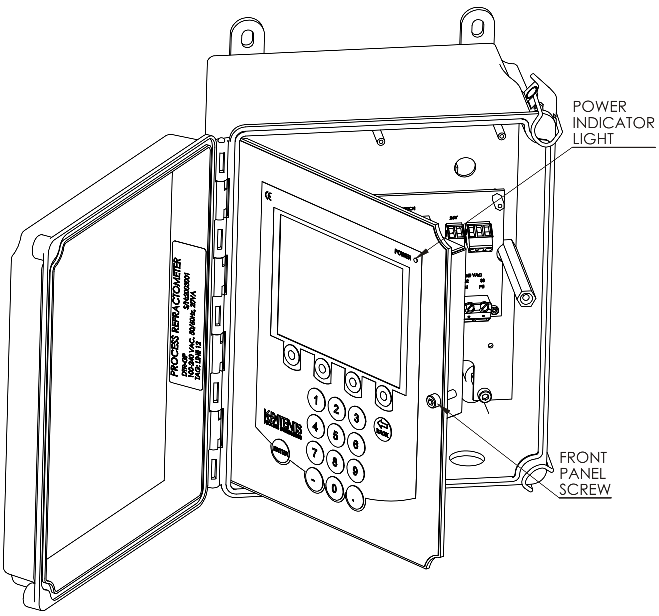


Figure 3.5 Opening the Front panel of the Indicating transmitter

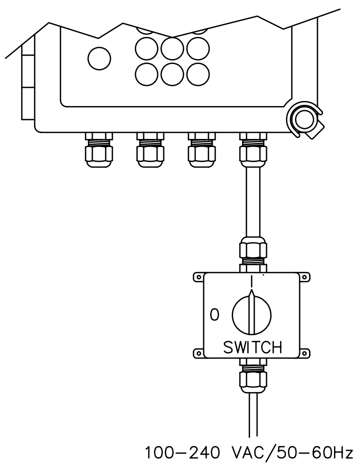


Figure 3.6 The recommended external power switch

Warning! Check that the power is off before opening the Front panel. If the *green power indicator light* (Figure 3.5) is on, there is still power in the system. To completely turn off the power, unplug the power supply cord or switch it off with an external power switch, if installed (see Figure 3.6).

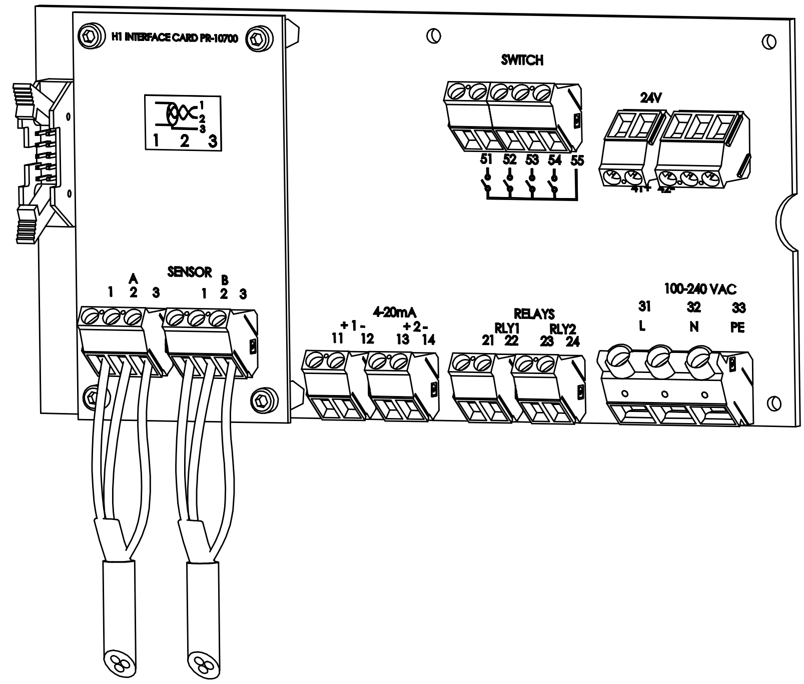


Figure 3.7 The Motherboard of the Indicating transmitter

Description of the terminals on the H1 interface card PR-10701 and on the Transmitter motherboard PR-10600 (Figure 3.7):

On H1	
A 1 2 3	Connection for Sensor A, signal wires (1, 2), cable shield (3).
B 1 2 3	Connection for Sensor B, signal wires (1, 2), cable shield (3).
On Motherboard	
11 12	4–20 mA output 1, positive (11), negative (12), max. load 1000 Ohm, galvanically isolated.
13 14	4–20 mA output 2, positive (13), negative (14), max. load 1000 Ohm, galvanically isolated.
21 22	Relay 1, one contact output, max. 250 V AC, max. 3 A.
23 24	Relay 2, one contact output, max. 250 V AC, max. 3 A.
31 32 33	Power, L (31), N (32), protective earth (33), 100-240 V AC, 50–60 Hz. An external power switch (Figure 3.6) is recommended.
41 42	24V terminal for DTR internal use only. **Note:** Connecting terminal to external 24V supply will void warranty. Connecting external devices to 24V terminal will void warranty.
51 52 53 54 55	Switch inputs: switch 1 (51), switch 2 (52), switch 3 (53), switch 4 (54) and common (55). A voltage of 3 V DC is provided over each switch. The switch terminals are galvanically isolated.

3.3.4 Power terminals

The primary AC power is connected to a separate terminal strip 31/32/33 marked `POWER` in the lower right-hand corner of the Motherboard (Figure 3.7). The three terminals are marked 31/L, 32/N and 33/PE (protective earth). The power terminal 33/PE is directly connected to the exposed metal parts of the Indicating transmitter DTR.

3.3.5 Reset button

It is possible to reset and restart both the Indicating transmitter DTR and the sensor(s) by pushing the reset button. The button is accessed through the cable hole in the front panel shield (see Figure 3.8 below). You need a thin stick or similar utensil, preferably of non-conducting material, to reach the reset button. After pressing the reset button, the display will black out for a few seconds. The instrument will be back to full operation within 30 seconds.

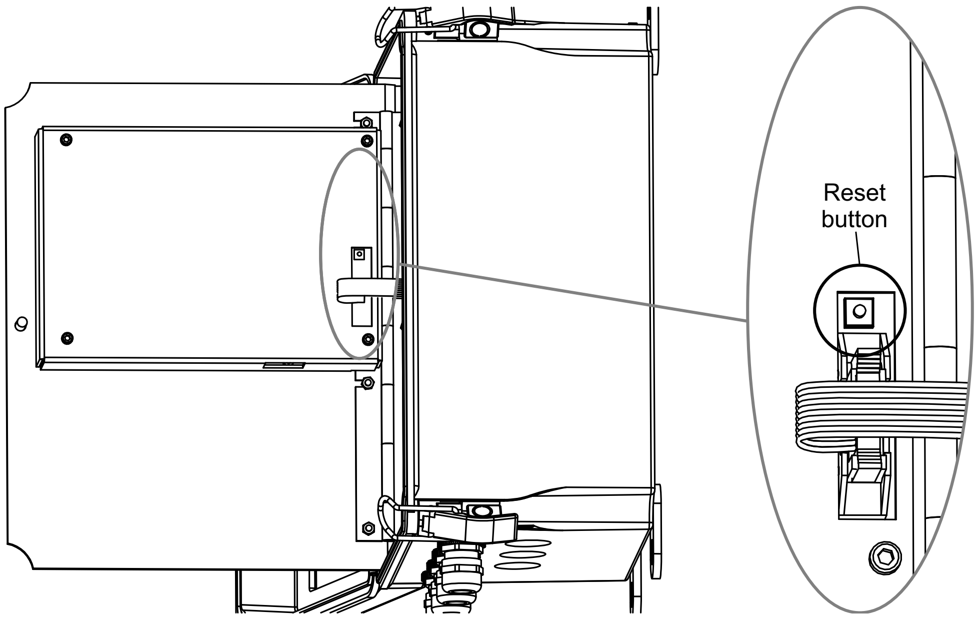


Figure 3.8 Location of the reset button

4 Prism wash systems

4.1 Prism coating

Deposit build-up on the prism surface disturbs the measurement. Look out for *an abnormally high concentration reading* or *an upward concentration (CONC) drift*.

In most applications the prism will keep clean due to the self-cleaning effect. If coating occurs, check the following:

- Sufficient flow velocity, see Section 2.2.3, "Check list for pipe mounting".
- A temperature difference between process fluid and sensor probe may cause coating. This may happen with small flows if the thermal insulation is inadequate. In some cases it helps to also insulate the clamp connector.

In case of a coating problem, the preferred solution is to try to increase the flow velocity, e.g. by installing a pipe portion with smaller diameter.

Installing a wash nozzle can be considered, if increasing the velocity or using a flow booster does not provide a solution (Section 4.2).

4.2 Prism wash

Three alternative media can be used for prism wash: *steam*, *water*, *high pressure water*. The built-in relays of the Indicating transmitter can be configured to control the prism wash cycle, see Section 6.1.3, "Configuring relays".

4.2.1 Recommended wash pressures and times

The recommended wash pressures and times are given in the tables below.

Wash medium parameters for integral wash nozzles in PR-23-AP/GP					
	Minimum *above process pressure*	**Maximum** *above process pressure*	**Wash time**	**Recovery**	**Interval**
Steam (SN)	2 bar (30 psi)	4 bar (60 psi)	3 s	20–30 s	20–30 min
Water (WN)	2 bar (30 psi)	4 bar (60 psi)	10 s	20–30 s	10–20 min
High pressure water (WP)	15 bar (220 psi)	40 bar (600 psi)	10 s	20–30 s	10–20 min

Wash medium parameters for flow cell wash nozzle AFC					
	Minimum *above process pressure*	**Maximum** *above process pressure*	**Wash time**	**Reco-very**	**Interval**
Steam (SN)	3 bar (45 psi)	6 bar (90 psi)	3–5 s	20–30 s	20–30 min
Water (WN)	3 bar (45 psi)	6 bar (90 psi)	10–15 s	20–30 s	10–20 min
High pressure water (WP)	30 bar (450 psi)	70 bar (1000 psi)	10–15 s	20–30 s	10–20 min

Wash medium parameters for Safe-Drive™ Isolation valve nozzle SDI					
	Minimum *above process pressure*	**Maximum** *above process pressure*	**Wash time**	**Reco-very**	**Interval**
Steam (SN)	5 bar (75 psi)	8 bar (115 psi)	3–5 s	20–30 s	20–30 min
High pressure water (WP)	30 bar (450 psi)	70 bar (1000 psi)	10–15 s	20–30 s	5–20 min

Important: In steam wash, do not exceed the recommended wash times, because some process media may burn to the prism surface if steamed for longer time. In case of coating, shorten the wash interval.
See also Section 6.3.2 for the Automatic wash cut parameter.

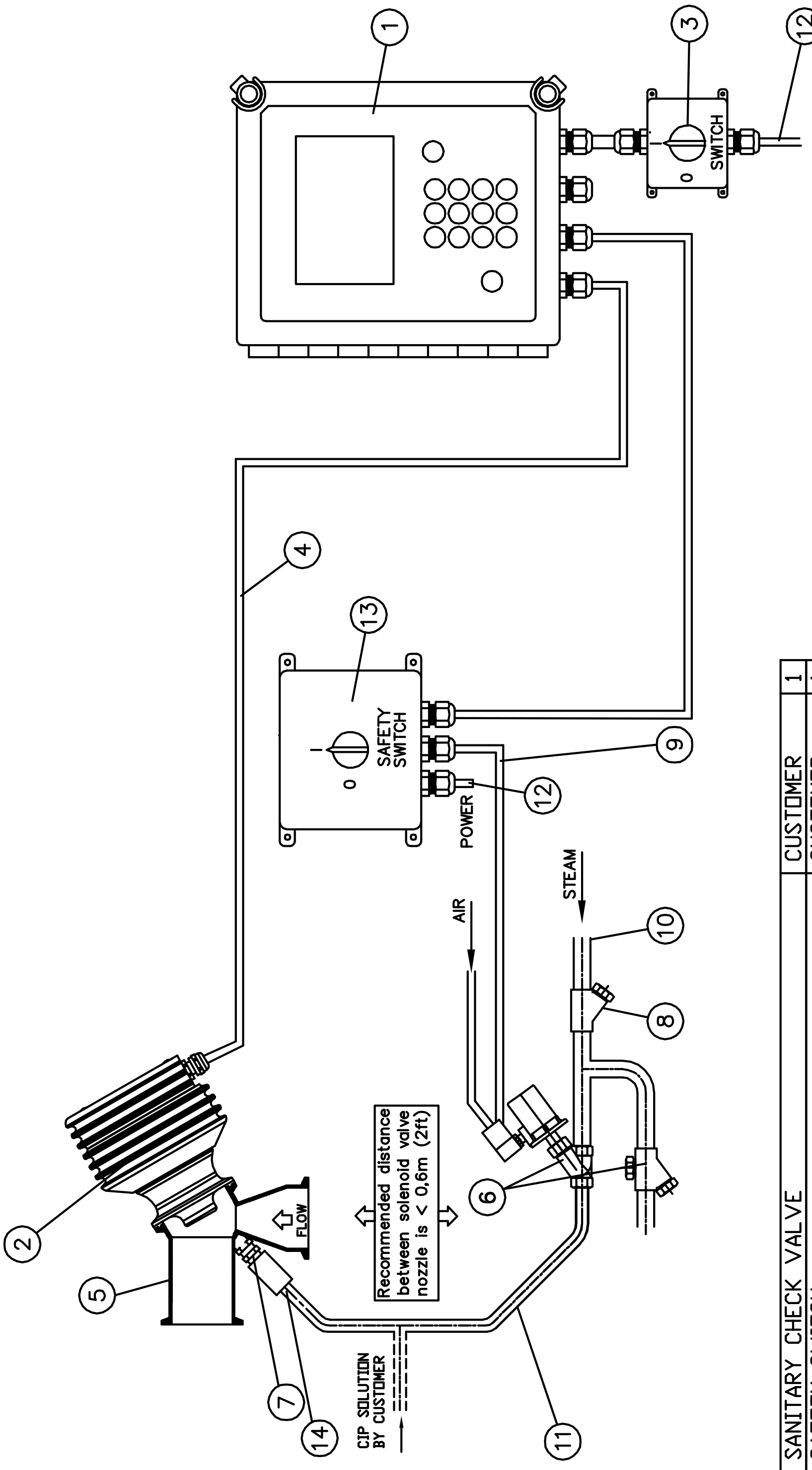
Note: In water wash, water temperature should be above the process temperature.

Note: The check valve pressure drop is 0.7 bar (10 psi).

4.2.2 Prism wash systems

The prism wash system for steam is described by Figure 4.1 and for high pressure water by Figure 4.3.

! **Warning!** In high pressure wash systems, pressure increase can occur in a closed pipe section when the high pressure pump is operated. K-Patents recommends to mount a pressure relief valve in the pipe section. Relief pressure should be according to pipe pressure rating.



PART	PART SPECIFICATIONS	SUPPLIED BY	
1	INDICATING TRANSMITTER DTR	K-PATENTS	1
2	SENSOR PR-23-AC/AP/GP	K-PATENTS	1
3	MAIN SWITCH	K-P/CUSTOMER	1
4	CABLE BETWEEN DT-R AND SENSOR PR-8230-...	K-P/CUSTOMER	1
5	FLOW CELL AFC-HSS-H10/15/20/25 -SI/RI-NC	K-PATENTS	1
6	SHUT-OFF VALVE&STEAM TRAP PR-3340-230/110	K-PATENTS	1
7	STEAM NOZZLE	K-PATENTS	1
8	STRAINER	K-PATENTS	1
9	SOLENOID CABLE, 3x1 (AWG 17)	CUSTOMER	1
10	STEAM PIPE 1/2"	CUSTOMER	1
11	STEAM PIPE 1/4"	CUSTOMER	1
12	POWER SUPPLY 100-240 VAC/50-60Hz	CUSTOMER	2
13	SAFETY SWITCH	CUSTOMER	1
14	SANITARY CHECK VALVE	CUSTOMER	1

Figure 4.1 A prism wash system for steam

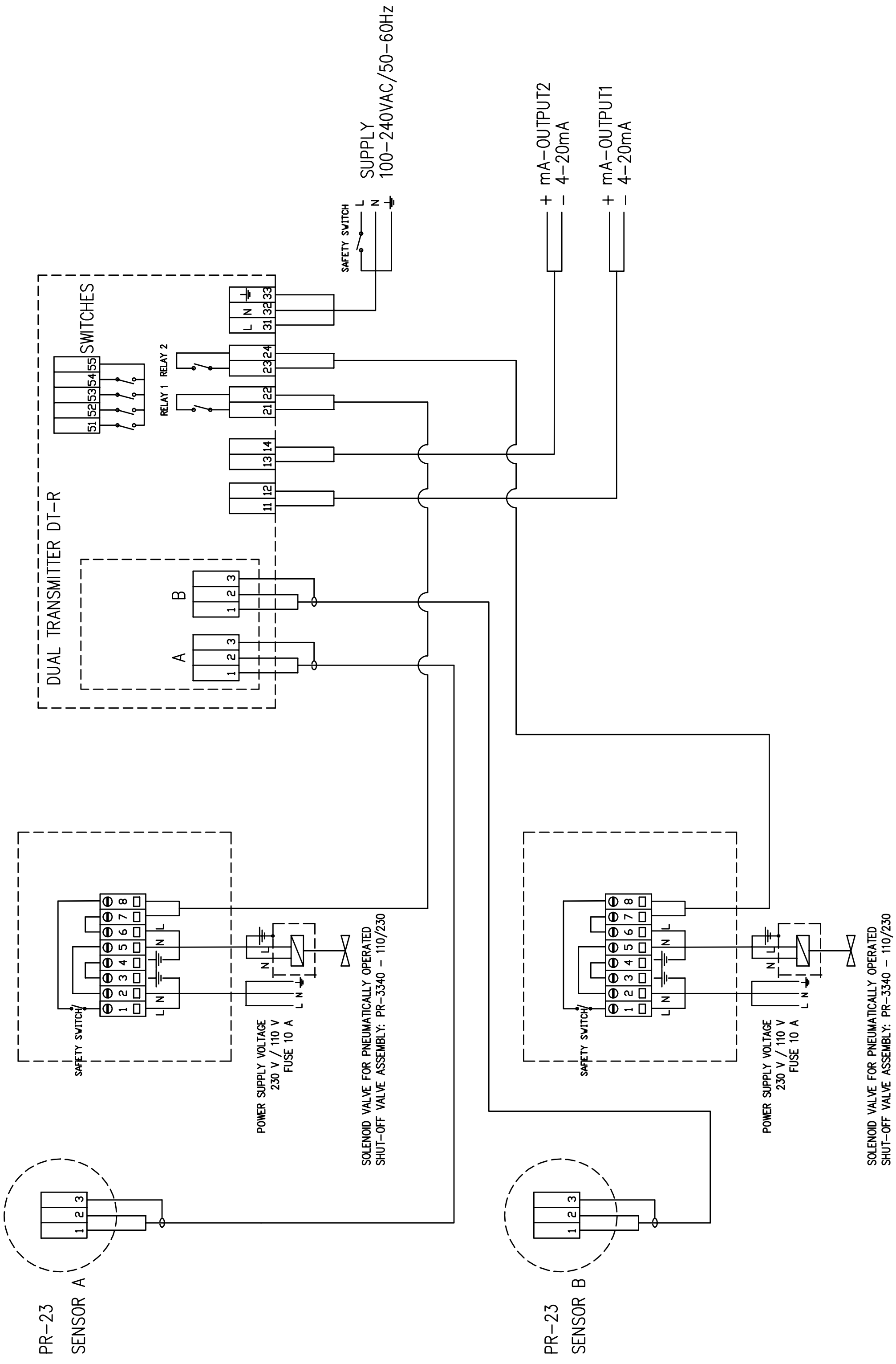
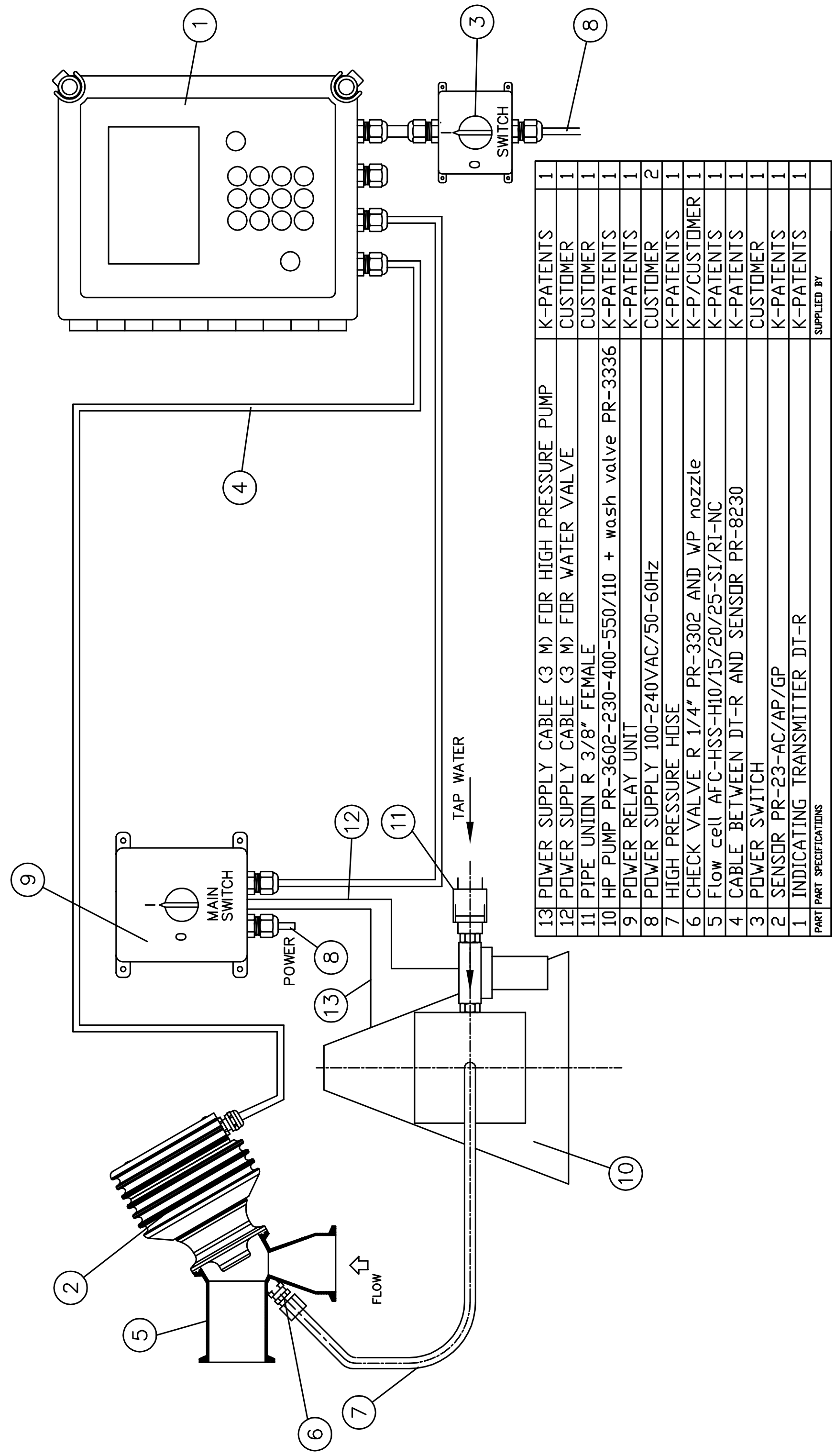


Figure 4.2 Wiring for a prism wash system for steam



PART	PART SPECIFICATIONS	SUPPLIED BY	
13	POWER SUPPLY CABLE (3 M) FOR HIGH PRESSURE PUMP	K-PATENTS	1
12	POWER SUPPLY CABLE (3 M) FOR WATER VALVE	CUSTOMER	1
11	PIPE UNION R 3/8" FEMALE	CUSTOMER	1
10	HP PUMP PR-3602-230-400-550/110 + wash valve PR-3336	K-PATENTS	1
9	POWER RELAY UNIT	K-PATENTS	1
8	POWER SUPPLY 100-240VAC/50-60Hz	CUSTOMER	2
7	HIGH PRESSURE HOSE	K-PATENTS	1
6	CHECK VALVE R 1/4" PR-3302 AND WP nozzle	K-P/CUSTOMER	1
5	Flow cell AFC-HSS-H10/15/20/25-SI/RI-NC	K-PATENTS	1
4	CABLE BETWEEN DT-R AND SENSOR PR-8230	K-PATENTS	1
3	POWER SWITCH	CUSTOMER	1
2	SENSOR PR-23-AC/AP/GP	K-PATENTS	1
1	INDICATING TRANSMITTER DT-R	K-PATENTS	1

Figure 4.3 A prism wash system for high pressure water

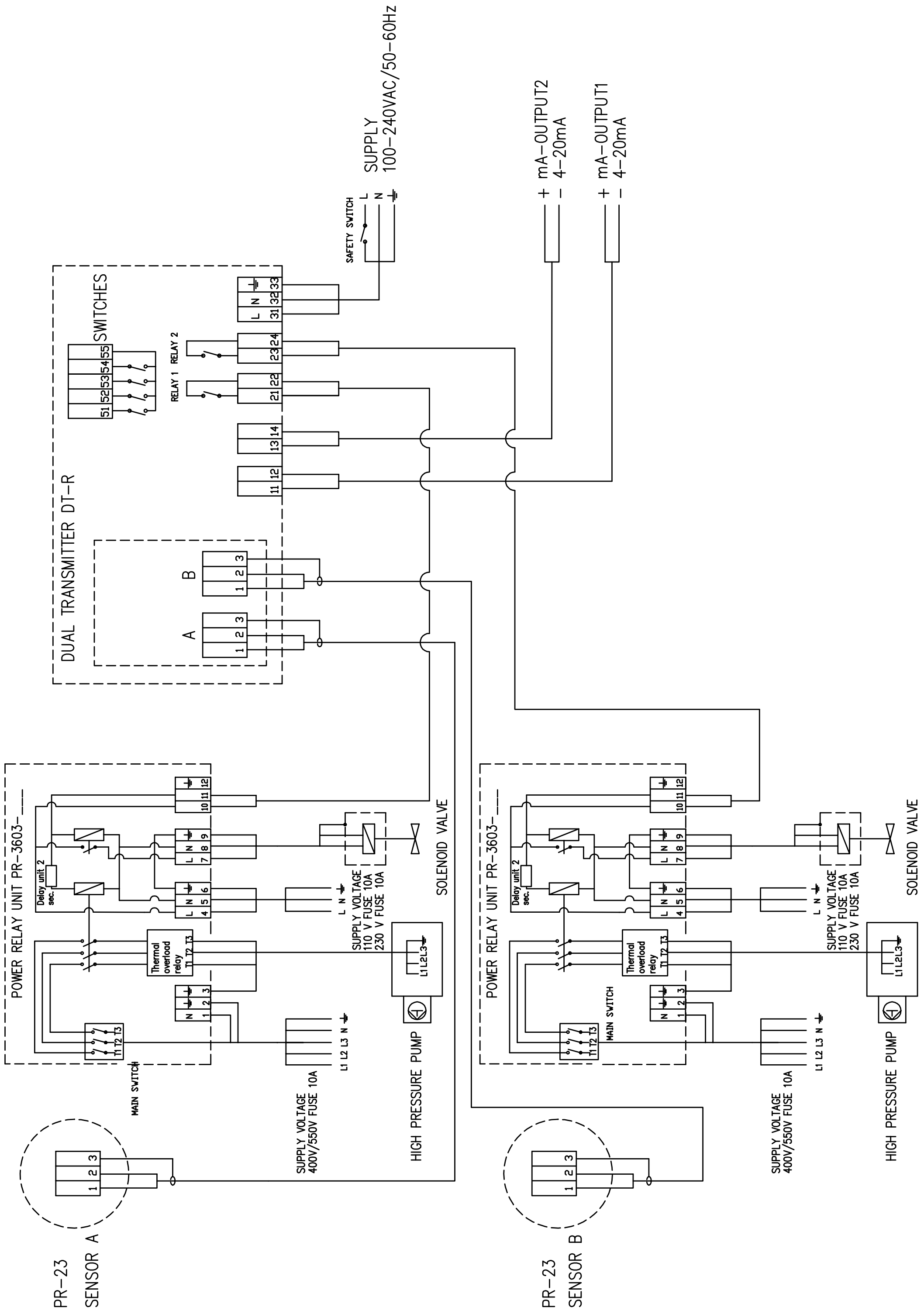
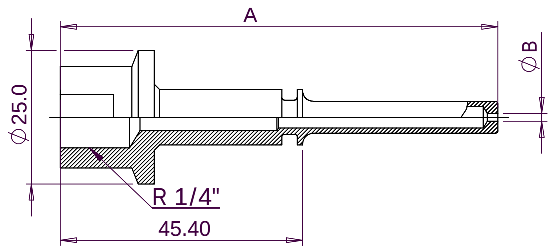


Figure 4.4 Wiring for a prism wash system for high pressure water

4.2.3 Prism wash nozzles

When selecting a wash nozzle for a **compact refractometer**, take into account both the wash medium and the flowcell model:flowcells with larger pipe diameters need longer wash nozzles. Figure 4.5 below shows a wash nozzle for a flowcell and gives the measurements and part numbers for each nozzle type.



Flowcell -H10 or -H15			
	A	B	part nr
steam	45.4	4.0	PR-3365
water	60	2.5	PR-3364
pressurized water	60	1.5	PR-3366
Flowcell -H20 or -H25			
	A	B	part nr
steam	67.4	4.0	PR-3375
water	82.0	2.5	PR-3374
pressurized water	82.0	1.5	PR-3376

Figure 4.5 Wash nozzles for flowcell AFC-HSS-XXX-XX-NC

Figure 4.6 shows how the nozzle is mounted in a flow cell (-NC with stud for a wash nozzle). **Note:** See Section 9.3.5 for more information on flowcells.

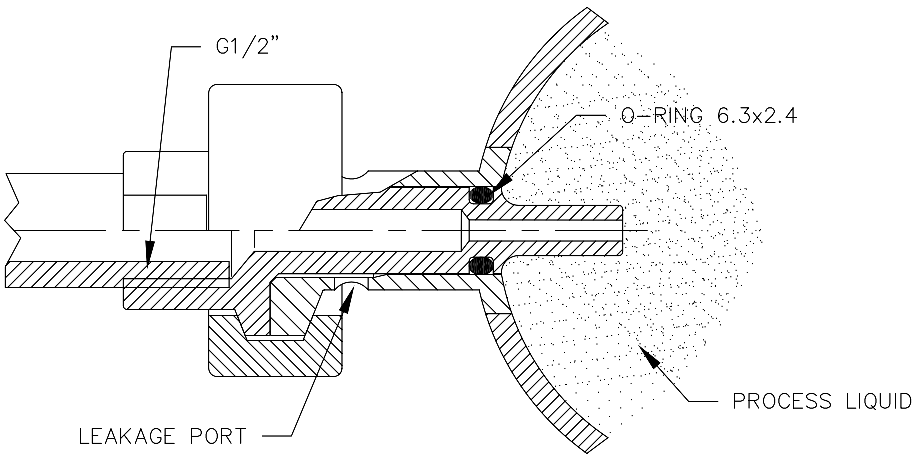


Figure 4.6 Process connection of a wash nozzle

For **probe refractometers**, select the wash nozzle according to wash medium and refractometer model, see Table 4.1 below.

	PR-23-AP	PR-23-GP
Steam nozzle	PR-9321	PR-9324
Water nozzle	PR-9320	PR-9323
Pressurized water nozzle	PR-9322	PR-9325

Table 4.1 Prism wash nozzle selection

Figure 4.7 shows the mounting of the wash nozzle for Sanitary probe refractometer PR-23-AP. Figure 4.8 shows the mounting of the wash nozzle for Process refractometer PR-23-GP.

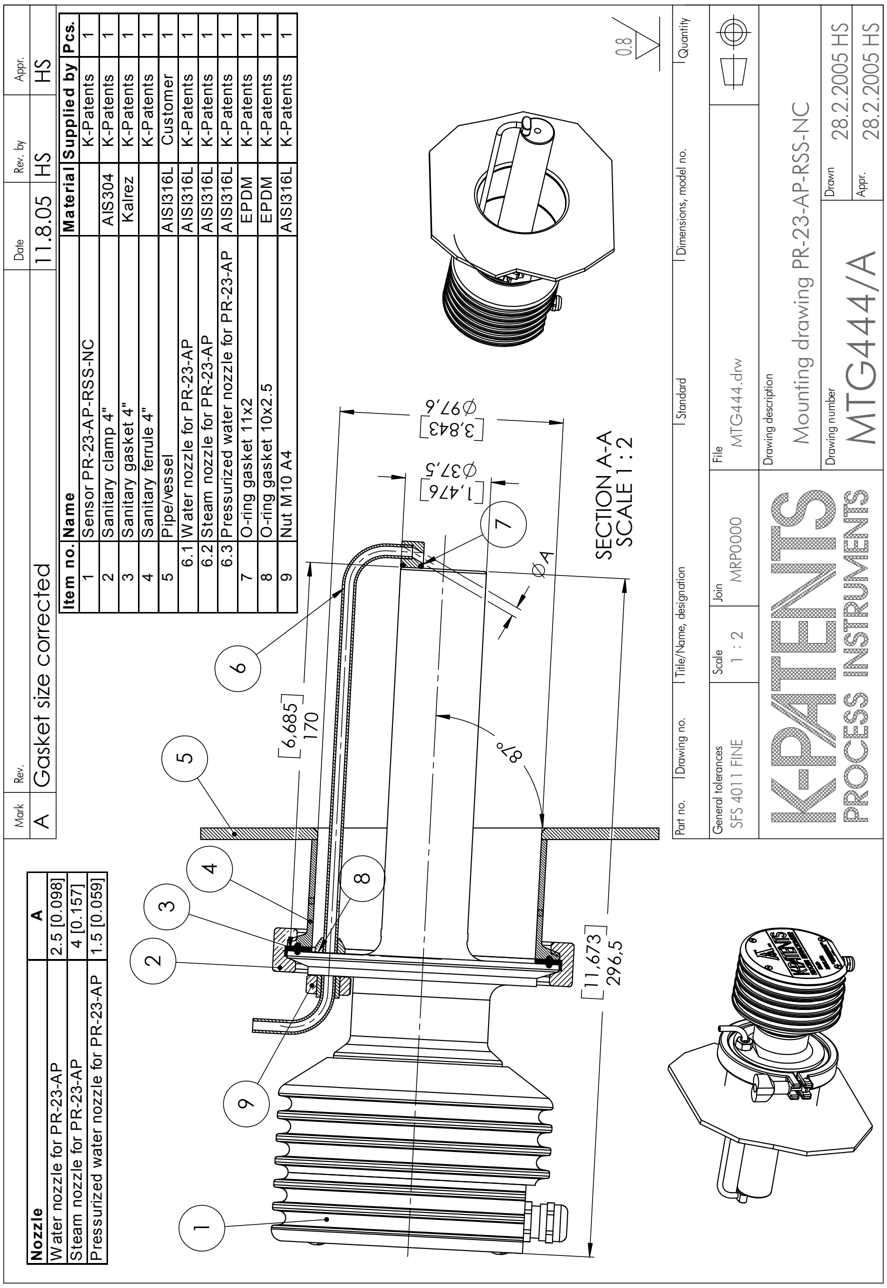


Figure 4.7 Mounting of the wash nozzle for Sanitary probe refractometer PR-23-AP

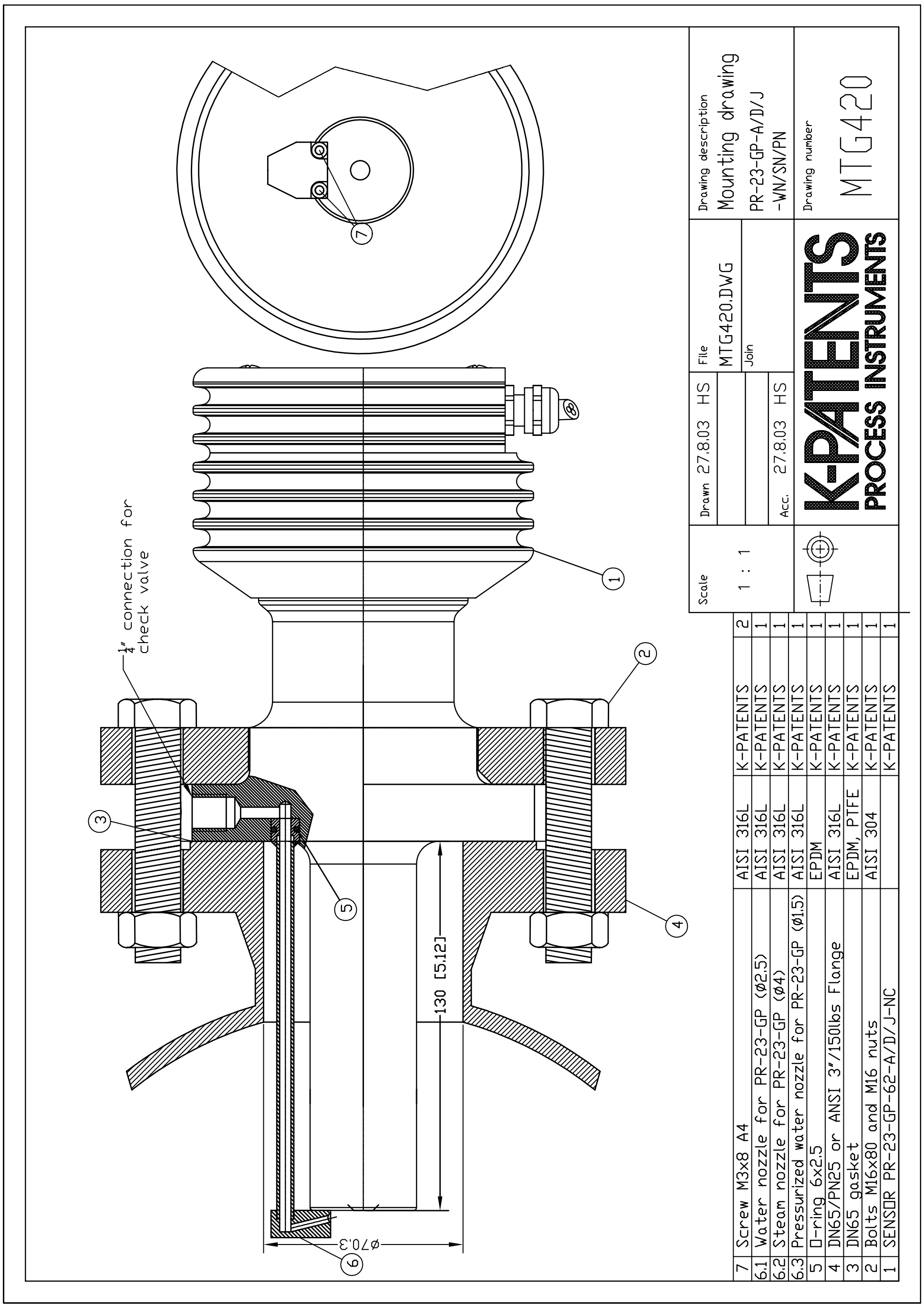


Figure 4.8 Mounting of the wash nozzle for Process refractometer PR-23-GP

5 Startup and use

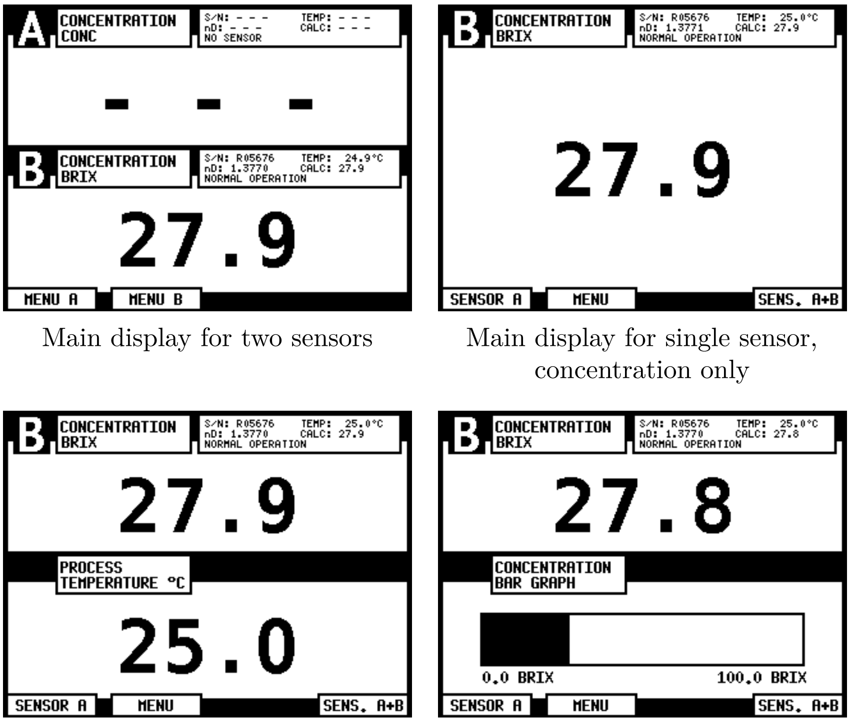
5.1 Startup

5.1.1 Initial check

1. Check the wiring, Section 3.3, “Electrical connections”.

2. Connect the power. The **Power indicator light** (Figure 3.5) and the screen should light up within a few seconds.

3. The Main display should come up on the display, Figure 5.1.



Main display for two sensors

Main display for single sensor, concentration only

Main display for single sensor, concentration and temperature

Main display for single sensor, concentration and bar graph

Figure 5.1 Main display alternatives

4. In case the display shows a row of dashes, there is no corresponding sensor (for example in Figure 5.1, upper left, there’s no sensor A, only sensor B is connected). The diagnostic message is for that sensorNO SENSOR.

5. Check the serial number of the sensor at the upper right corner in the display.

6. For a connected sensor, the diagnostic message at start-up should be NORMAL OPERATION or, if the process pipe is empty, NO SAMPLE. Otherwise, see Section 8.4, "Diagnostic messages table".
7. The TEMP value should show the current process temperature.
8. The value and the correct setup of the two mA output signals can be checked by selecting DESCRIPTION in the Main menu and then mA OUTPUTS in the Description menu (Section 5.3).
9. If internal relays or switch inputs are used, their settings can also be checked through the Description menu (Section 5.3).

5.1.2 Calibration check

Wait until normal process conditions occur. The concentration reading is pre-calibrated at delivery and a copy of the Sensor calibration certificate is inside the Indicating transmitter. If the diagnostic message is NORMAL OPERATION but the concentration reading does not agree with the laboratory results, then consult Section 6.2, "Calibrating the concentration measurement".

5.1.3 Testing prism wash

1. Check that the steam or water washing parts are connected (Section 4.2.2, "Prism wash systems").
2. In the Main display, press MENU. Then press 3 (to give the command SENSOR STATUS). In this Sensor status display by pressing the soft key WASH. If soft key WASH does not appear, no internal relay is configured for this purpose.
3. Check the n_D reading, for a successful wash it must drop below 1.34 during steam wash and drop to approximately 1.33 during water wash.

Important: Before testing prism wash, check that there is liquid in the pipe in front of the refractometer sensor.

5.2 Using the Indicating transmitter

The Indicating transmitter DTR receives the refractive index value n_D and the process temperature from the sensor(s). Starting from these values, it calculates the concentration of the process media for display and further transmission. The DTR can also be programmed to give alarm for high or low concentration. If the refractometer has a prism wash system, the DTR can control the wash with its built-in timer.

For information on how to use the Indicating transmitter DTR for configuration and calibration, see Chapter 6, "Configuration and calibration".

5.2.1 Keyboard functions

Number keys: The 10 number keys, minus sign, and decimal point are used to enter numerical parameters. They are also used for menu selections.

ENTER key: The ENTER key is used to implement the selected (highlighted) menu command or to accept an entered value.

BACK key: The commands are arranged into a decision tree, the BACK key is used to move one step backward to the preceding display. It is also used to erase or cancel a numerical input.

Soft keys: The meaning of the soft key is shown on the display immediately above the key. Figure 5.2 gives an example the soft key functions, from left to right:

1. SENSOR A: Switch to corresponding menu for Sensor A.
2. Arrow down: Move one step down in the menu.
3. Arrow up: Move one step up in the menu
4. SELECT: Select the highlighted command (equivalent to pressing ENTER).

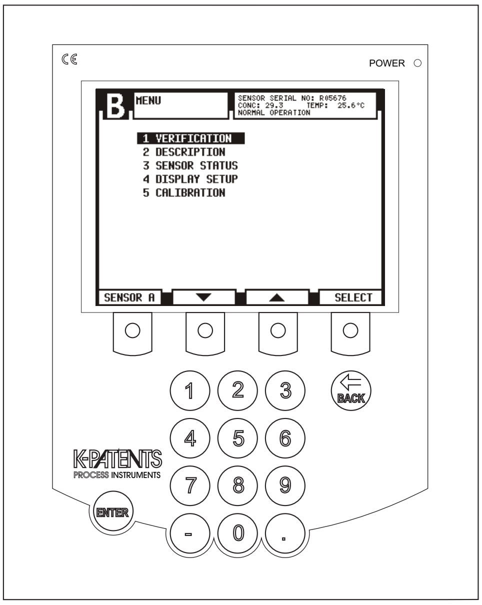


Figure 5.2 The DTR keyboard and the Main menu for sensor B

Note: Press the key *under the display*. The display is *not* touch sensitive.

5.2.2 Display setup

Selecting MENU/MENU A/MENU B or SENSOR A or SENSOR B (depending on your Main display format) in the Main display gives the Menu display. Choose 4 DISPLAY SETUP to change the Main display format and bar graph settings, to adjust backlight or contrast and to invert the display. In DTR program version 2.0 or newer you can also switch between the existing display languages.

Figure 5.3 Display setup menu

Main display format: As you can see in Figure 5.1, there are four different Main display formats: the dual sensor format shows information on both sensors while the three different single sensor formats show selected information on one sensor at a time. Choose 1 MAIN DISPLAY FORMAT in the Display setup menu to change the Main display. The current format is shown on the display format selection display, see Figure 5.4 below.

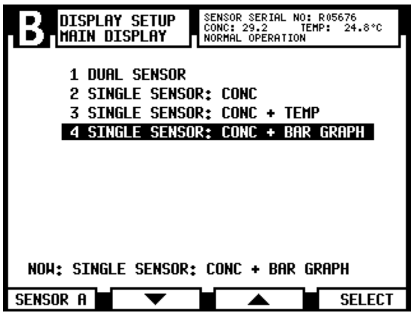


Figure 5.4 Main display format selection.

Note: An automatic 60 s (in verification 5 min) timeout will make backsteps from any display until the Main display is reached.

Display appearance: The 2 DISPLAY BACKLIGHT & CONTRAST can be selected from the Display setup menu (Figure 5.3). The values can be changed by using the arrow soft keys or alternatively a one digit input, for example 8 designates 80 % when adjusting contrast.

The 3 DISPLAY INVERSION contains two choices. The default setting of the display is 1 POSITIVE DISPLAY, i.e. yellow background and black text. However, in some environments the display may be clearer if 2 NEGATIVE DISPLAY, i.e. black background and yellow text, is chosen.

Bar graph settings: The command 4 BAR GRAPH allows you to set the bar graph span and zero separately for sensors A and B.
Note: Bar graph is only visible when Main display is in the bar graph format, see above.

Display language: The command 5 DISPLAY LANGUAGE lets you choose the DTR display language from the existing display languages, i.e. the languages that are loaded into the DTR. The default language is English and it is always available. The order and number of the languages in the language menu varies depending on what languages are loaded into the DTR. Language change through this menu is immediate.

5.3 Viewing system information

The DESCRIPTION selection from the Main menu (Figure 5.2) opens a path to complete information about the system and calibration. This path is risk-free in the sense that no values can be changed through this menu. To be able to make changes, CALIBRATION must be selected from the main menu.

The Description menu (Figure 5.5) leads to the following information:

1. SYSTEM: See Figure 5.5, right side.
2. mA OUTPUTS: See Section 6.1.1, "Configuring mA outputs"
3. RELAYS: See Section 6.1.3, "Configuring relays".
4. SWITCHES: See Section 6.1.4, "Configuring input switches".
5. PRISM WASH: See Sections 6.1.3 and 6.3, "Configuring prism wash".
6. PARAMETERS: See Section 6.2, "Calibrating the concentration measurement".
7. NETWORK: The Ethernet address and card ID of the DTR. See Section 12, "Ethernet connection specification".

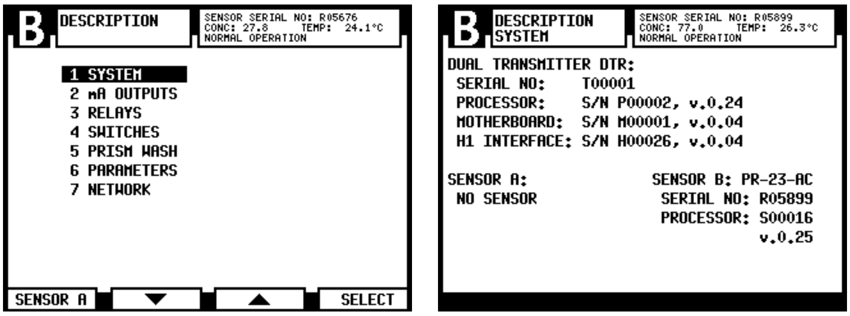


Figure 5.5 System description

5.4 Viewing sensor status

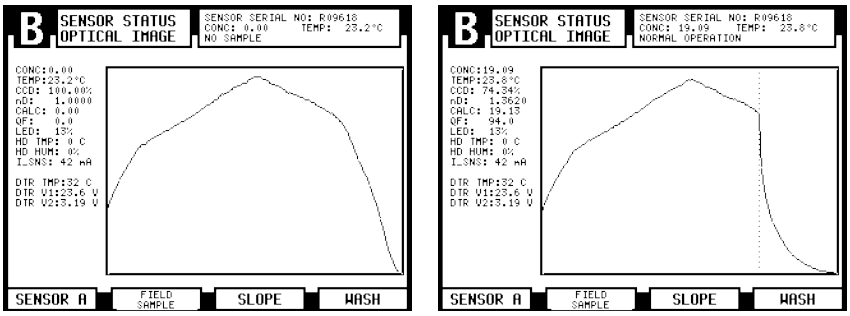
Select SENSOR STATUS at the Main menu.

5.4.1 Optical image

There are two different image detecion algorithms in the PR-23. The original image detection algorithm has been complemented with an advanced IDS (Image Detection Stabilization) algorithm which compensates for some unwanted noise in the image. These algorithms differ somewhat in how the image looks like, but the meaning of different diagnostic values is the same.

With the original image detection algorigm the Optical image graph (See Figure 1.4 for explanation) should look like Figure 5.6, right side. The vertical dotted line indicates the position of the shadow edge. For empty pipe, the optical image looks like Figure 5.6, left side. The soft key SLOPE leads to a graph (Figure 5.7) showing the slope (or first differential) of the optical image graph in Figure 5.6.

Note: In case there is no signal from the sensor, the image field is crossed over.



Empty pipe Normal conditions

Figure 5.6 Typical optical images without IDS

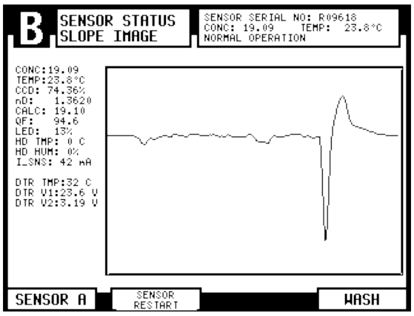
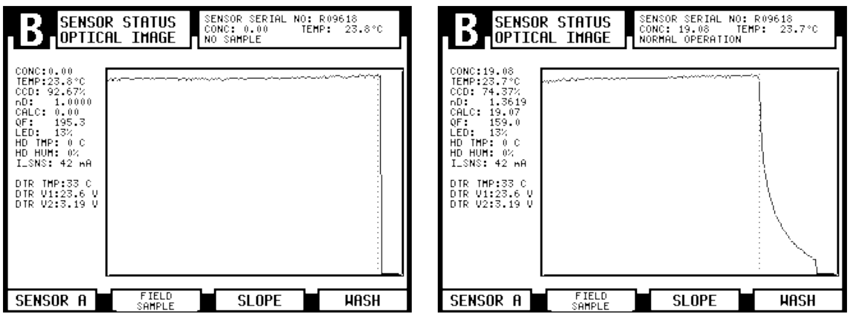


Figure 5.7 A slope graph without IDS

5.4.2 Optical image with IDS

For the IDS enabled image detection algorithm the images look like figure 5.8 and the slope like figure 5.9.



Empty pipe Normal conditions

Figure 5.8 Typical optical images with IDS

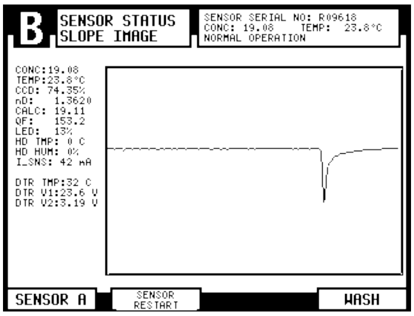


Figure 5.9 A slope graph with IDS

It should be noted that the "empty" optical image may have vertical left and/or right edge close to the edge of the image. In the example, only the right edge is visible.

5.4.3 Diagnostic values

The values at the left of the graph are used for diagnostic purposes:

- CONC is the final concentration value including Field calibration adjustment, see
  Figure 6.7.
- TEMP, see Section 5.4.4.
- CCD gives the position of the shadow edge on CCD in %.
- nD is the refractive index value n_D from the sensor.
- CALC is the calculated concentration value without Field calibration adjustment,
  Section 6.2.3
- QF or Quality Factor is a value in the range 0–200. It measures the image sharpness, a typical good value is 100. A QF value below 40 usually indicates prism coating.
- LED is a measure of the amount of light from the light source in %. Should be below 100 %.
- HD TMP = sensor head temperature, see Section 5.4.4.
- HD HUM = sensor head humidity, see Section 5.4.5.
- I_SNS value shows the current to sensor, the nominal value is 40 mA.
- DTR TMP = Indicating transmitter temperature, see Section 5.4.4.
- DTR V1 gives the voltage from the power module, the nominal value is 24V.
- DTR V2 gives the DC supply voltage, the nominal value is 3.3 V.

Note: The Slope display also has a soft key SENSOR RESTART which can be used to restart the current sensor (see upper left corner of the display for sensor letter) after a sensor software update.

5.4.4 Temperature measurement

The system contains three different temperature measurements displayed to the left of the graphs in Figure ??:

TEMP is the process temperature used for automatic temperature compensation in the Indicating transmitter (Section 6.2, “Calibrating the concentration measurement”).

HD TMP measures the temperature on the Sensor processor card PR-10100 (Figure 2.1).

DTR TMP measures the temperature on the Motherboard of the Indicating transmitter (Figure 3.7, “The Motherboard of the Indicating transmitter”).

Both sensor head temperature and DTR temperature are monitored by the built-in diagnostics program, see Sections 8.1.8, “Message HIGH SENSOR TEMP”, and 8.1.9, “Message HIGH TRANSMITTER TEMP”.

5.4.5 Sensor head humidity

The Sensor processor card contains also a humidity sensor. The value HD HUM is the relative humidity inside the Sensor. It is monitored by the diagnostics program, see Section 8.1.7, “Message HIGH SENSOR HUMIDITY”.

5.5 Sensor verification

A company maintaining quality system according to ISO 9000 quality standards must have defined procedures for controlling and calibrating its measuring equipment. Such procedures are needed to demonstrate the conformance of the final product to specified requirements. For the recommended verification procedure, please see Chapter 13.

6 Configuration and calibration

All changes of configuration and calibration are made through the Calibration menu selected from the Main menu by 5 CALIBRATION.

Password: It may be necessary to enter a password before proceeding to the Calibration menu. The password is printed on the title page of this manual. The password function is activated and deactivated via the 6 PASSWORD command in the Calibration menu.
By default the password is activated.

6.1 Configuring refractometer system

The Indicating transmitter has **two** built-in **4–20 mA outputs** (mA OUTPUT 1, mA OUTPUT 2), **two relay contact outputs** (RELAY 1, RELAY 2), and **four switch inputs** (SWITCH 1,
SWITCH 2, SWITCH 3, SWITCH 4). Each of these resources can be freely assigned to either sensor A or sensor B.

6.1.1 Configuring mA outputs

For the electrical properties of the two output signals, see Section 3.3.3, "Connecting the Indicating transmitter".

- First select 5 CALIBRATION in the Main menu and enter password if necessary. Then select 2 OUTPUTS in the Calibration menu. In the Outputs menu, select 5 mA OUTPUTS.
- Select the mA output, 1 or 2, to get to the Output menu (Figure 6.1 below) where the output can be configured.
  Note: The line at the bottom of the Output menu display indicates the current configuration of the selected mA output, e.g. in Figure 6.1 mA Output 1 has been configured to send the concentration reading of Sensor B.

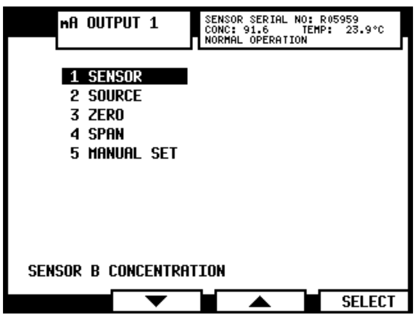


Figure 6.1 The Output menu for mA Output 1

- To change the sensor the selected output is assigned to, select 1 SENSOR in the Output menu.

- To change output source for the selected output, select 2 SOURCE.
  Note: Selecting 1 NOT DEFINED 'turns off' the selected output.
- The 3 ZERO value sets the value when the signal is 4 mA. The default zero value is 0.00, the unit depends on the source and display unit set for the sensor in question (and can thus be for example 0 BRIX or 0 °F).
- The 4 SPAN sets the range, i.e. the value given when the signal is 20 mA.

Example: If your measurement unit is CONC% and you want to measure the range 15–25 CONC%, first choose concentration as mA output source. Then set the zero value at 15 and span at 10. This means that the output signal is 4 mA at 15 CONC% and 20 mA at 15+10=25 CONC%. To change this output to range 10–30 CONC%, change zero to 10 and span to 20 (10+20=30).

- 5 MANUAL SET allows you to set different output values to check the output signal. Press the BACK key to return normal output function.

Note: If you want to 'turn off' the mA output, select NOT DEFINED in the Source menu.

6.1.2 Signal damping

The Outputs display also provides the possibility to enter signal damping to diminish the influence of process noise. The damping is applied to the CONC value (and thus the output signal) of the current sensor (see upper edge of the display to check which sensor is currently chosen and switch in the Outputs display if necessary).

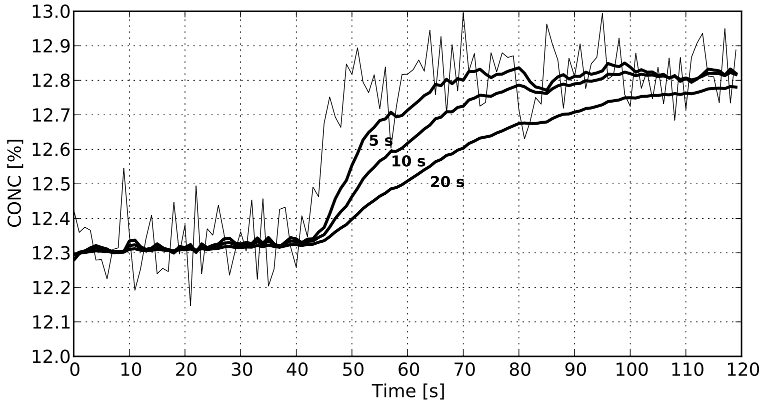
The PR-23 offers two types of signal damping. **Exponential (standard) damping** works for most processes and is the standard choice for slow and continuous processes. However, if the process has fast step changes, **linear (fast) damping** gives shorter settling time. The factory setting is always exponential damping, access the 4 DAMPING TYPE command to switch to linear damping or back to exponential damping.

The damping time is set separately through the Outputs menu. What the damping time means in practice, depends on the damping type:

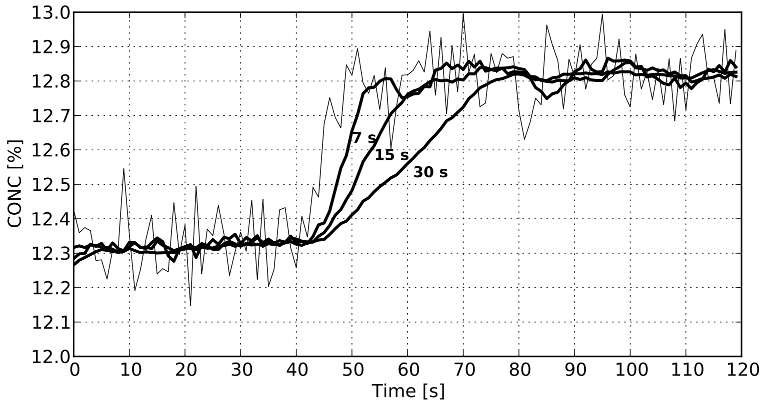
In the exponential damping (standard damping), the damping time is the time it takes for the concentration measurement to reach half of its final value at a step change. For example, if the concentration changes from 50 % to 60 % and damping time is 10 s, it takes 10 seconds for the DTR to display concentration 55 %. A damping time of 5–15 seconds seems to work best in most cases, the factory setting is 5 sec.

In the linear damping (fast damping), the output is the average of the signal during damping time. After a step change the signal rises linearly and reaches the final value after the damping time. Figure 6.2 shows how the damping time affects the measurement.

Note: Avoid overdamping, the signal should not be made insensitive.



Exponential damping



Linear damping

Figure 6.2 Effect of damping time on measurement

6.1.3 Configuring relays

For the electrical properties of the built-in relays, see Section 3.3.3. Each of the two relays can be configured individually to either Sensor A or Sensor B, i.e. 0–2 relays can be assigned to a sensor. Relays can also be opened and closed manually, mainly to test them.

To configure the relays, follow the instructions below:

1. Select 5 CALIBRATION from the Main menu.
2. Select 3 RELAYS from the Calibration menu.
3. Select the relay, either 1 RELAY 1 or 2 RELAY 2, to be configured.
4. In the Relay menu (see Figure 6.3) select 1 SENSOR to assign the current relay to either Sensor A or Sensor B.
   Note: The current assignment of the relay is shown at the bottom of the Relay menu display, e.g. Figure 6.3 Relay 1 is assigned to Sensor A with function Low limit.

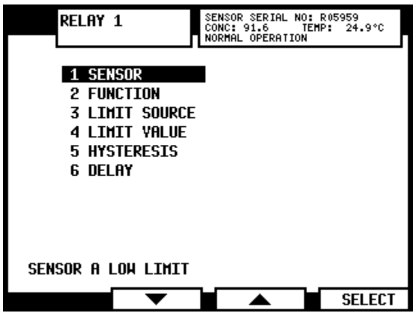


Figure 6.3 Relay menu for Relay 1

5. In the relay menu, select 2 FUNCTION to set the relay function:

0	FUNCTION NOT DEFINED	Factory setting.
1	FUNCTION NORMAL OPERATION	Closed contact if diagnostic message is NORMAL OPERATION during HOLD (see Section 6.1.4). The contact is also closed when message is NO SAMPLE.
2	FUNCTION INSTRUMENT OK	Closed contact if there is no equipment malfunction.
3	FUNCTION LOW LIMIT	Used as alarm relay, closing contact if source value is below set limit. (See below for limit source selection.)
4	FUNCTION HIGH LIMIT	Used as alarm relay, closing contact if source value is above set limit. (See below limit source selection.)
5	FUNCTION PRECONDITION	See Figure 6.9.
6	FUNCTION WASH	See Section 6.3.

6. If you choose either low limit or high limit as relay function, you'll have define a limit source. For this, select 3 LIMIT SOURCE in the Relay menu (Figure 6.3).
   Limit source selection:

1	SOURCE NOT DEFINED	Factory setting.
2	SOURCE CONCENTRATION	Measured concentration CONC
3	SOURCE PROCESS TEMPERATURE	Process temperature

7. The **Limit value** is set separately by choosing 4 LIMIT VALUE in the Relay menu (Figure 6.3) and entering a numeral limit value.
8. The **Hysteresis** value is set by choosing 5 HYSTERESIS in the Relay menu (Figure 6.3). The value indicates how soon the relay opens after the process has temporarily gone over the high limit or under the low limit. For example if the high limit is 50 and the hysteresis is 2, the relay will not reopen until the process drops below 48.
9. To change the **relay delay time**, choose 6 DELAY in the Relay menu (Figure 6.3). The delay is given in seconds, factory setting is 10 s.

For **manual set**, go (back) to the Select relay menu and choose 3 MANUAL SET. In the manual set display you can open and close the any relay by pressing the appropriate soft key. The current status of the relay (open or closed) is displayed next to the relay name, see Figure 6.4 below:

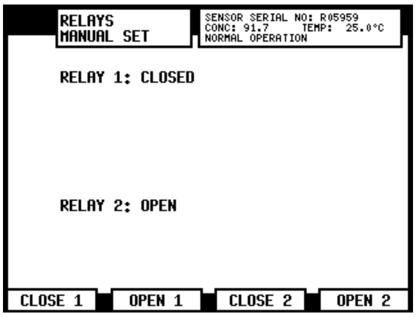


Figure 6.4 The manual set display for relays

6.1.4 Configuring input switches

For the electrical properties of the four input switches, see Section 3.3. To see which switches are closed, check the Description menu, see Section 5.3. To configure the switches, follow the instructions below:

1. Select Menu to get to the Main menu.
2. Select 5 CALIBRATION from the Main menu.
3. Select 5 SWITCHES from the Calibration menu.
4. Select the switch, 1, 2, 3 or 4, to be configured. You now get the Switch menu, see Figure 6.5 below.

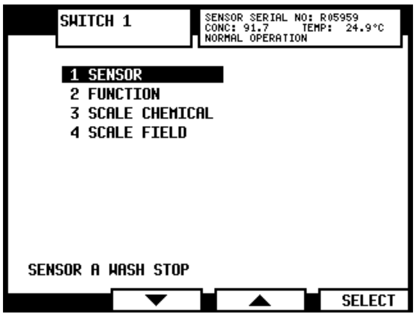


Figure 6.5 Switch menu

5. First select 1 SENSOR to assign the chosen switch to a given sensor.
   Note: The selection line will automatically go to the currently valid setting, i.e. in Figure 6.6 next page Switch 1 has been assigned to Sensor A.
6. In the Switch menu, select 2 FUNCTION to set switch function.

1 NOT DEFINED	Factory setting
2 HOLD	When used with a built-in wash relay, this function is useful for an intermittent process: the prism is

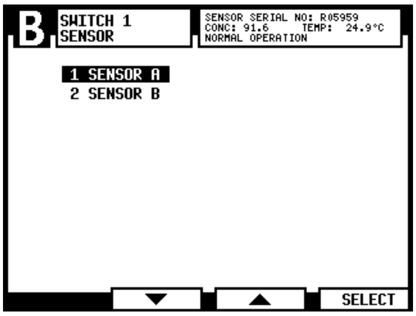


Figure 6.6 Arrival to Switch 1's sensor selection menu, sensor A selected

	washed when the process stops (as indicated by contact closure).The wash is repeated when the process restarts (if the stop lasts over 60 seconds). The signal is on hold between washes.When used with an external independent timer, contact closure holds the output signal.
3 WASH STOP	Switch closure prevents wash cycle. It can be used to prevent wash action when the process pipe is empty. The message WASH STOP will appear when a wash cycle is initiated.
4 REMOTE WASH	At switch closure the system waits for an external wash command before initiating wash.
5 SCALE SELECT	Any chemical curve and associated field calibration scale can be selected by switch closure. The scales assigned to each switch independently.
6 CALIBRATION SEAL	Contact closure prevents access to calibration and configuration ("external password"). Can be used to seal the calibration.

7. If you chose Scale select as switch function, return to the Switch menu (if not returned automatically) and choose 3 SCALE CHEMICAL to enter the parameters for the chemical curve assigned to the switch. See Section 6.2.1 for more information on chemical curves and chemical curve parameters.
8. If necessary, the chemical curve assigned to a switch can be adjusted by field calibration parameters. Select 4 SCALE FIELD in the Switch menu to enter the parameters.See Section 6.2.3 for more information on field calibration and field calibration parameters.

6.2 Calibrating the concentration measurement

The concentration calibration of the K-Patents inline refractometer PR-23 is organized in six layers.

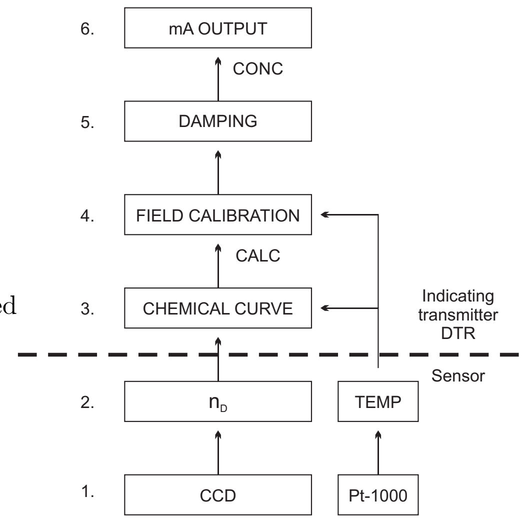


Figure 6.7 The six layers of concentration calibration

1. *The information from the CCD element and the Pt-1000 temperature element.* The position of the shadow edge (Figure 1.4, “Optical image detection”) is described by a number called CCD and scaled from 0–100 %.

2. *The sensor calibration*: The actual refractive index n_D is calculated from the CCD value. The process temperature is calculated from the Pt-1000 resistance. The sensor output is n_D and temperature TEMP in Centigrade. Hence, the calibrations of all PR-23 sensors are identical, which makes sensors interchangeable. Furthermore, the calibration of each sensor can be verified using standard refractive index liquids, see Section ??.

3. *The chemical curve*: The Indicating transmitter DTR receives n_D and TEMP and calculates the concentration value according to chemical curves derived from available chemical literature and K-Patents expertise. The result is a temperature compensated calculated concentration value CALC.

4. *Field calibration*: Adjustment of the calculated concentration value CALC may be required to compensate for some process conditions or to fit the measurement to the laboratory results. The Field calibration procedure, Section 6.2.3, determines the appropriate adjustment to CALC. The adjusted concentration is called CONC. If there is no adjustment, CALC and CONC are equal. Thus the chemical curve is kept intact as a firm base for the calculation, the adjustment is merely additional terms.

5. *Damping*: See Section 6.1.2.

6. *Output signal*: The range of the 4 to 20 mA signal is defined by its two endpoints on the CONC scale, see Section 6.1.1.

6.2.1 The chemical curve

The chemical curve is the theoretical concentration curve based on n_D and TEMP. It is defined by a set of 16 parameters (Table 6.1, one set for each sensor).

C_{00}	C_{01}	C_{02}	C_{03}
C_{10}	C_{11}	C_{12}	C_{13}
C_{20}	C_{21}	C_{22}	C_{23}
C_{30}	C_{31}	C_{32}	C_{33}

Table 6.1 The chemical curve parameters

A chemical curve is specific to the given process medium, e.g. sucrose or sodium hydroxide. The set of parameters is given by K-Patents and should not be altered, except in case of changing to another process medium. The parameters can be changed by selecting first 5 CALIBRATION from the Main menu, then, in the Calibration menu, 1 CHEMICAL & FIELD PARAMETERS, and finally 1 CHEMICAL CURVE PARAMETERS.

6.2.2 Selecting display units and display decimals

The display units and display decimals are set separately for each sensor, so first go to the Calibration menu of the correct sensor. Then select 2 OUTPUTS in the Calibration menu and in the Outputs menu choose either 1 DISPLAY UNITS or 2 DISPLAY DECIMALS.
For the display units, select either 1 CONCENTRATION or 2 TEMPERATURE and then the unit. For display decimals, enter the number of decimals you want to see on display by entering a number in the range 0–5 (0 meaning no decimals are shown).
Note: Change of concentration unit will not change the numerical value of the concentration. Change of temperature unit will recalculate the numerical temperature value according to selected scale (°C or °F).

6.2.3 Field calibration

K-Patents provides a *field calibration service* that adapts the calibration to the factory laboratory determinations based on the data supplied. The field calibration procedure should be made under normal process conditions using standard laboratory determinations of sample concentration.

Record the calibrating data on the PR-23 field calibration form (found in the end of this manual), also available at *<http://www.kpatents.com/>* and by emailing a request to *<info@kpatents.com>*. Fax the completed Field calibration form to either K-Patents headquarters or your local K-Patents representative. A computer analysis of the data will be made at K-Patents and optimal calibration parameters will be sent to be entered in the Indicating transmitter DTR.

For a complete report, 10–15 valid data points (see below) are needed. A data point is of use for calibration only when the diagnostic message is NORMAL

OPERATION. If prism wash is employed, do not take samples during the wash. Each data point consists of:

LAB%	Sample concentration determined by the user
From DTR display:	(see Figure 6.8)
CALC	Calculated concentration value
T	Process temperature measurement in Centigrade
nD	Actual refractive index n_D
CONC	Measurement in concentration units, the large size number

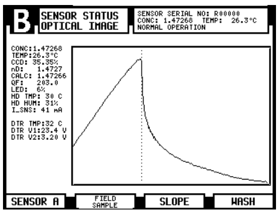
In addition to the calibration data, write down the Indicating transmitter serial number, the sensor serial number and the sensor position, i.e. whether it is installed as Sensor A or as Sensor B.

Accurate calibration is only achieved if the sample is taken correctly. Pay special attention to following details:

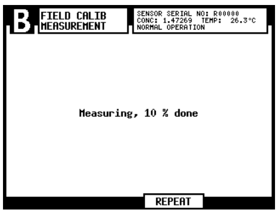
– The sampling valve and the refractometer should be installed close to each other in the process.

! **Warning!** Wear protective clothing appropriate to your process when operating the sampling valve and handling the sample.

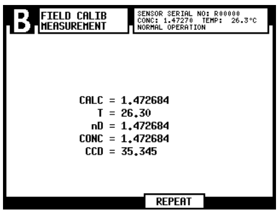
– Run the sample before starting to collect data points to avoid sampling old process liquid that has remained in the sampling valve.
– Read the values CALC, T(emp), nD and CONC in the DTR's display at exactly the same time with sampling.
The easiest way of doing this is to use the FIELD SAMPLE soft key available through the Sensor status display (DTR program version 2.0 or newer). The value of each sample is the average of 10 consequent measurements to increase accuracy and reduce possible process noise.



Press the FIELD SAMPLE soft key...



...wait while DTR measures... (take sample for lab)



...and press REPEAT for next data point or BACK to get to the Sensor status display.

Figure 6.8 Using FIELD SAMPLE soft key

– Use a tight container for the sample to avoid evaporation.

Important: Offline calibration using process liquid very seldom gives reliable results, as problems are caused by

– low flow which makes sample to form an unrepresentative film on the prism
– sample evaporation at high temperature or undissolved solids at low temperature giving deviations from laboratory determinations

– an ageing sample which is not representative
– outside light reaching the prism

Thus *calibration using the process liquid should always be made inline.*

6.2.4 Entering field calibration parameters

The field calibration parameters supplied by K-Patents are entered by selecting 5 CALIBRATION from the Main menu, followed by first 1 CHEMICAL & FIELD PARAMETERS and then by 2 FIELD CALIBRATION PARAMETERS.
Important: If there is already a previous field calibration, it should be cleared (by setting all values to 0) before entering a new field calibration.

6.2.5 Direct BIAS adjustment

The concentration measurement value can also be directly adjusted by changing the field adjustment parameter f00.

The value of the bias parameter f00 will be added to the concentration value: NEW CONC = OLD CONC + f00.

6.3 Configuring prism wash

In some applications the process flow does not keep the prism clean because of sticky process medium or low flow velocity. In these applications the prism can be automatically cleaned by installing a wash system (see Chapter 4).

The prism wash settings for sensors A and B are independent of each other. The wash system is active if a relay has been configured to be a wash relay (see Section 6.1.3) and the wash time is not zero. An automatic wash function can be configured so that both sensors have different parameters.

6.3.1 Wash cycle

The wash logic is shown in Figure 6.10 as a flow diagram. The automatic prism wash cycle (Figure 6.9) consists of three phases: *precondition*, *wash* and *recovery*. The optional preconditioning function is used to e.g. blow out the condensate before washing. After the preconditioning there is a one-second pause to avoid having both precondition and wash relays active at the same time.

The wash cycle is initiated when the wash interval has elapsed. The wash can also be started by closing an external switch (Remote wash, see Section 6.1.4) or manually from the user interface at the Sensor status display (see Section 5.1.3). The order of priority for these wash triggers is:

1. manual wash
2. remote wash request
3. wash interval timer

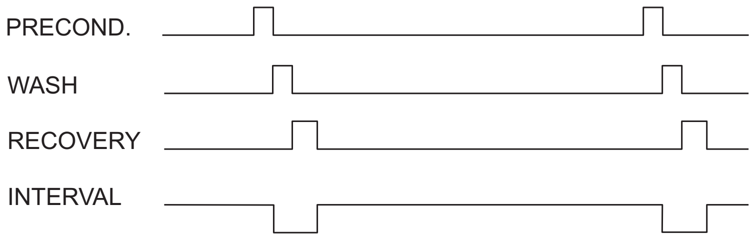


Figure 6.9 The automatic prism wash cycle

Note: For safety reasons two sensors never wash simultaneously. If the manual wash button for sensor A is pressed while sensor B is washing, the wash cycle for sensor A is started after B has finished. Similarly, if the interval time for sensor B elapses when A is washing, the wash for sensor B is delayed until A has finished.

In case of remote wash request the request is discarded if it arrives when the other sensor is washing. The request is honored only if the contacts are held closed until the other sensor has finished.

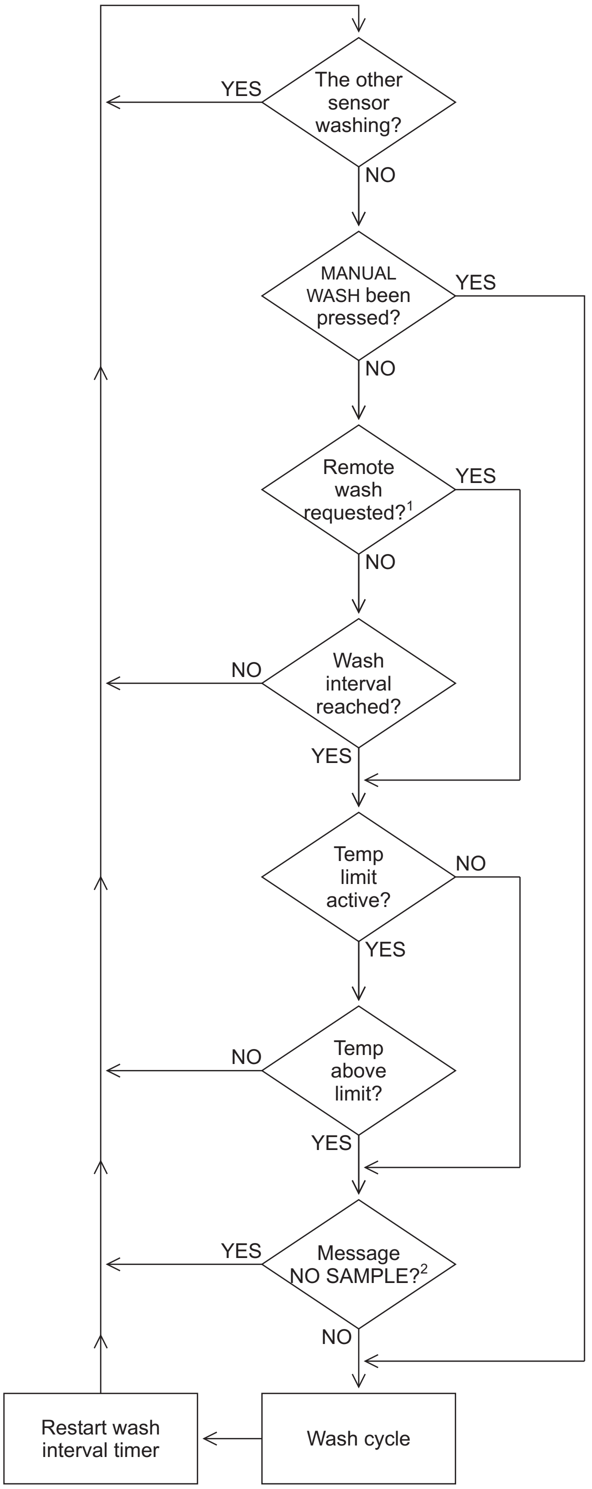
The wash relay is closed for the wash time specified in the wash settings. If the wash auto-cut functionality is active, the wash may be ended earlier (see Figure 6.11). The specified wash time is never exceeded.

After the wash phase is completed, a recovery time is spent. During the wash cycle (precondition, wash, recovery) the measurement result is in hold unless otherwise specified.

Preventing automatic wash:

The preconditioning and wash relays are never activated by the automatic wash control:

- Under the diagnostic message NO SAMPLE (see Section 8.2.6) as this indicates a clean prism in an empty process line. The diagnostic message is WASH STOP/NO SAMPLE.
- If a wash stop input switch is closed (see Section 6.1.4), indicating e.g. that there is no process flow. The diagnostic message is EXTERNAL WASH STOP.
- If the process temperature limit is activated and the temperature falls below the limit, indicating that the process is not running. The diagnostic message is LOW TEMP WASH STOP



NOTES

1. Remote wash is triggered at the closing of the switch. If the switch is held closed, only one wash cycle is carried out.
2. The wash is inhibited if there is no sample, no sensor or the sensor cannot measure correctly.

Figure 6.10 Wash logic

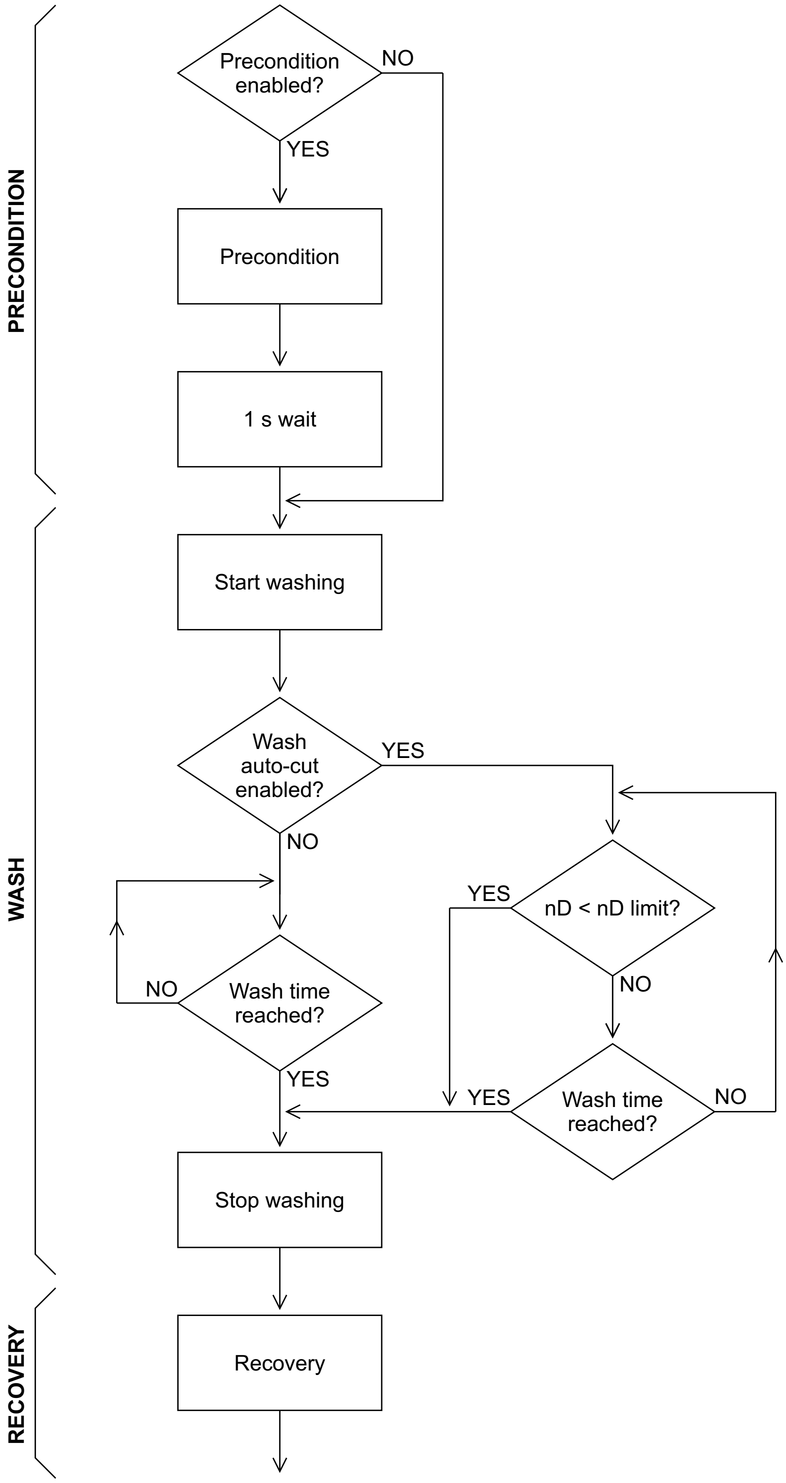


Figure 6.11 Wash cycle

6.3.2 Setting prism wash parameters

To set the prism wash parameters for a given sensor, first select the sensor, then select 5 CALIBRATION from the Main menu, and then 4 PRISM WASH. This menu contains the alternatives (factory settings are given in parentheses):

1	PRECONDITION TIME	0–30 s (0 s) 1 WASH nD LIMIT (on next 'page')
2	WASH TIME	0–30 s (3 s)
3	RECOVERY TIME	0–120 s (20 s)
4	WASH INTERVAL	0–1440 min (20 min)
5	WASH CHECK MODE	(Disabled)
6	HOLD DURING WASH	(Active)
7	TEMP LIMIT ACTIVATION	
8	TEMP LIMIT VALUE °C	
9	EMPTY PIPE CHECK	(Active)

The prism wash cycle: See Figure 6.11 and Section 6.3.1. The timing of the wash cycle is controlled by the WASH INTERVAL, PRECONDITION TIME, WASH TIME and RECOVERY TIME settings. If the WASH INTERVAL is set to zero, the wash can be initiated only by using the manual wash or remote wash request.

If the PRECONDITION TIME is zero (or there is no relay configured for preconditioning), the preconditioning phase is skipped. If the WASH TIME is zero (or there is no relay for wash), the wash functionality is completely disabled.

The recommended wash times and wash medium pressures are given in Section 4.2.1, "Recommended wash pressures and times".

Wash check: The prism wash check monitors automatically that the wash really has an effect on the prism. In the WASH CHECK STANDARD mode, prism wash is accepted if the refractive index n_D either falls below wash nD limit (default 1.34) at NORMAL OPERATION or NO SAMPLE occurs. This is the indication of a successful wash with water or steam.
If the wash is not accepted, the diagnostic message PRISM WASH FAILURE (see Section 8.4) will appear. This message is reset by a successful wash.
The WASH CHECK AUTOMATIC WASH CUT mode differs from the standard mode by stopping the wash 2 seconds after the n_D falls below the limit.

To stop the measurement for the duration of the prism wash, choose 6 HOLD DURING WASH and in that menu activate the hold function. The CONC reading and mA output are held in the value they had immediately before starting the wash cycle.

To activate (or deactivate) a temperature limit, choose 7 TEMP LIMIT ACTIVATION and then the appropriate command in the menu.

To set a low temperature limit, choose 8 TEMP LIMIT VALUE °C and enter the temperature (in °C!) where the limit should be.

The empty pipe check prevents washing if message is NO SAMPLE, i.e. there's no process liquid in the pipe. To deactivate (or active) the empty pipe check, choose 9 EMPTY PIPE CHECK and then the appropriate menu command.

To change the wash nD limit, select first 0 MORE ... and then 1 WASH nD LIMIT to set the n_D value to be used with the wash check functionality.

7 Regular maintenance

The need for regular maintenance is minimal, due to the construction with no moving parts, no mechanical adjustements, no trimpots and with a solid-state light source. The following rules apply:

- Keep the sensor head and the Indicating transmitter clean and dry.
- Check that the ambient temperature is not above +45 °C (113 °F). The sensor head should not be too hot to keep a hand on.
- If your refractometer has prism wash, check that it works, see Section 5.1.3.

7.1 Checking the sensor humidity level

The PR-23 sensor head has an internal humidity detector. The humidity reading can be checked on the Indicating transmitter display, select 3 SENSOR STATUS from the Main menu. **Check the humidity reading once in every three months.**

Increasing humidity level indicates either condensate forming in the sensor head (if the process temperature is below ambient) or prism leakage. If the humidity reading exceeds 30 %, replace the dryer. If the reading exceeds 50 %, check the prism seals. Relative humidity exceeding 60 % will produce a diagnostic message HIGH SENSOR HUMIDITY (see Section 8.1.7).

The dryer (desiccant) is a transparent plastic package inside the sensor head cover, see Figure 7.1 (G). When the dryer is **yellow**, it **is effective**. When it turns **green**, it **needs to be replaced**. The dryer cannot be reactivated by any means, it *must* be replaced. You can order new dryer packages (drying agents/desiccants), spare part number **PR-9108**, from either K-Patents or a K-Patents representative.

For instructions on how to open the sensor head to replace the dryer, see Section 7.3.2.

7.2 Checking the prism and prism gaskets

Once a year check that the prism surface is smooth and clean. If the prism is scratched or the gaskets seem to leak, follow the procedure described in Figure 7.3.3 to replace them.

7.3 Disassembling and assembling the sensor

! **Warning!** Wear appropriate **protective clothing** and be careful when removing the sensor! Always check that the pipeline is empty before removing a sensor from the process line. **Never remove the sensor if there is process liquid in the pipe** (except when using the Safe-Drive™ system designed for safe sensor removal during process).

7.3.1 Disassembling the sensor

The letters in the text refer to Figure 7.1. The instructions are valid for all PR-23 models.

1. Remove the sensor from the process line and rinse it well.
2. Open the four sensor label M4 screws and remove Sensor nameplate (A), see Figure 3.4, "Sensor electrical connections".
3. Disconnect wires from terminal strip (B) and remove cable from cable gland (C).
4. Fix the sensor so that the sensor head is in a vertical position, as shown in Figure 7.1.
5. **Warning!** There can be overpressure inside the sensor, carefully follow the instructions below:
   Open two of the four hexagon socket screws that were hidden by the nameplate. Then loosen the other two screws by 4mm (1/8") and pull the sensor cover (D) until possible pressure inside has been relieved. If the cover is stuck, use the two unscrewed hexagon screws as pullers by screwing them into the two holes between the screws.
6. Lift off the sensor cover (D) and disconnect the cable from the Terminator card (F).

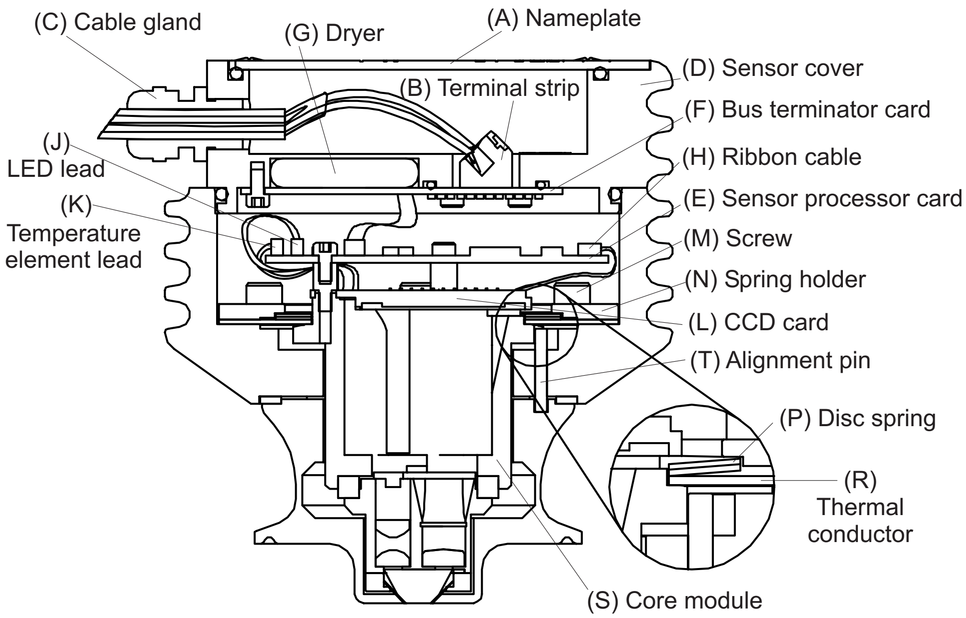


Figure 7.1 Sensor in disassembly position

7.3.2 Replacing the dryer

1. Follow the instructions in Section 7.3.1.
2. Place the sensor cover (D) with the bus terminator card (F) upwards.
3. Open five hexagon socket screws holding the bus terminator card (F) and remove the card.
4. Inspect the dryer (G) according to Section 7.1.
5. Replace the dryer package (G) with a fresh package.
6. Close the sensor cover (D) as soon as possible.

7.3.3 Replacing the prism and prism gaskets

1. Follow the instructions in Section 7.3.1.
2. Disconnect the ribbon cable (H) from the sensor processor card (E) according to Figure 7.2. Disconnect the LED lead connector (J) and the temperature element lead (K) screw terminals.

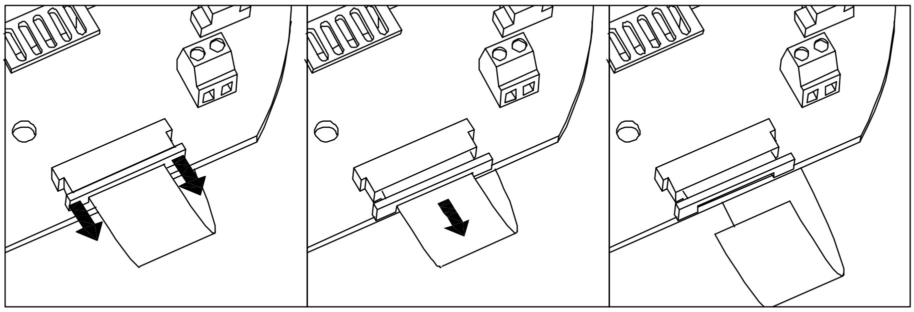


Figure 7.2 Ribbon cable connector

3. Remove the sensor processor card (E) held by three hexagon socket screws.
4. Remove the CCD card (L) kept by three spacer screws. **Note:** Removing the screws may introduce a slight calibration change.
5. Loosen carefully the six hexagon socket screws (M) of the disc spring holder (N). Turn in small steps, alternating between the screws.
   ! **Warning!** Never touch the screws (M) when the instrument is in the process line.
6. Remove the disc spring holder (N), the two disc springs (P), and the thermal conductor (R).
7. Lift out the core module (S). The module does not turn due to the alignment pin (T).
8. Pull out the temperature element (a) about one inch away from the Core module, Figure 7.3.

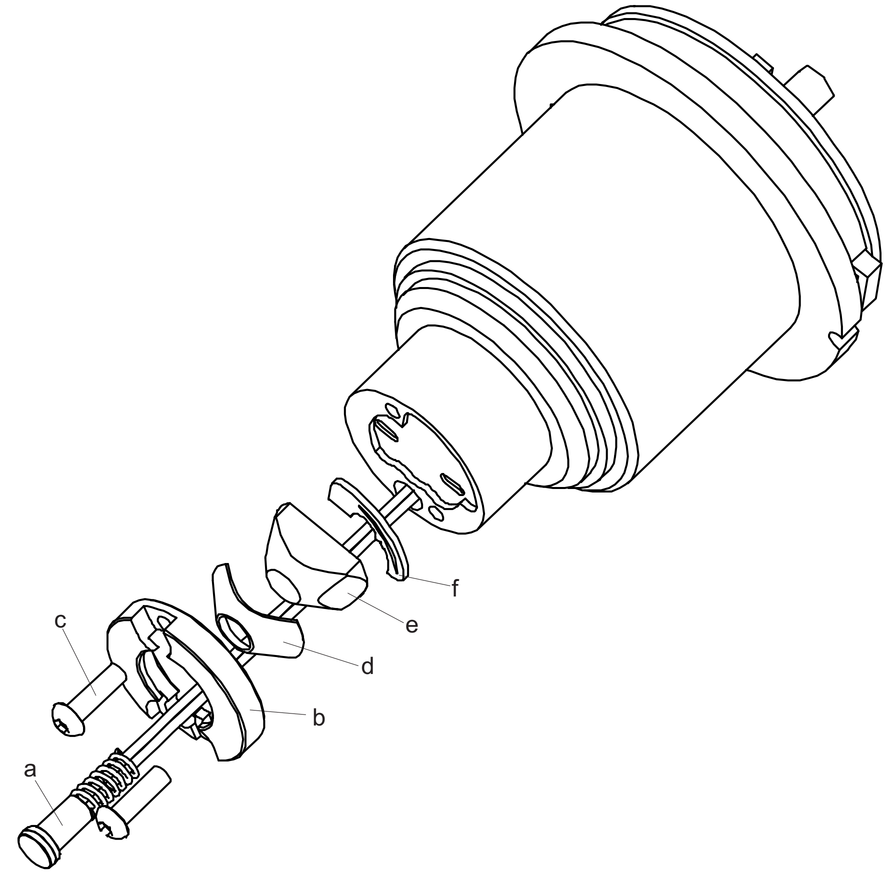


Figure 7.3 Removal of prism

9. Remove prism support (b) kept by two rounded hexagon socket screws (c).

10. Remove old prism gasket (d).

11. To remove the prism (e), push it gently against the springs machined into the prism plate (f), as indicated by an arrow in Figure 7.4.

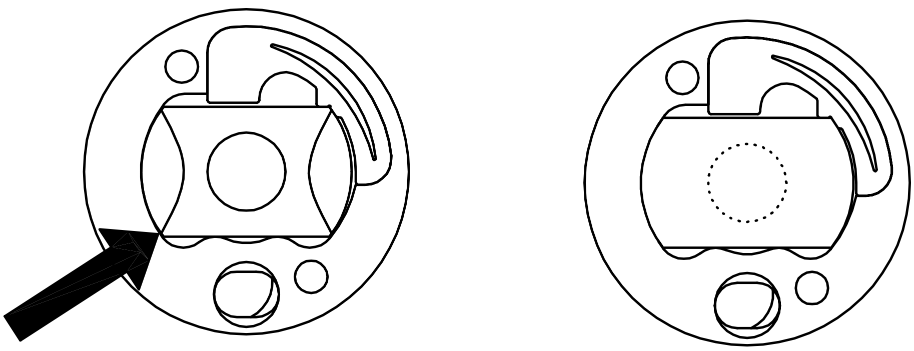


Figure 7.4 The prism and prism plate

12. Clean the prism. **Important:** Do not leave any fingerprints on any of the four smooth optical surfaces!

13. Put the prism (e) in place, pushing gently against the springs of the prism plate (f). The direction of the force is indicated in Figure 7.4, left. To make sure the prism is in correct position, press the prism in the opposite direction of the arrow.

14. Cover the prism by a new prism gasket (d) (with the center hole uncut), Figure 7.4, right.

15. Put the prism support (b) upon the gasket. Keep the gasket in place by keeping a finger in the middle. Check that the gasket is symmetrical around the middle of the prism surface.

16. Tighten the screws (c) to the bottom. **Important:** Make sure you are using the original round-headed screws.

17. Check that the temperature element (a) is properly spring-loaded. In outer position, the sensor tip should be level with the prism sensor, Figure 7.5. It should flex inwards 2–3 mm as indicated by the arrow in Figure 7.5, but return to the outer position.

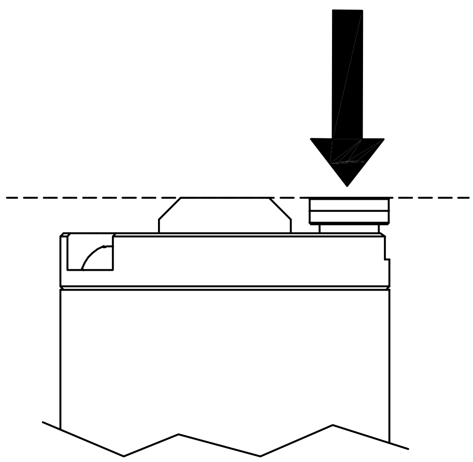


Figure 7.5 Temperature element position

18. Mount the core module (S), Figure 7.1. Note the alignment pin (T).

19. Mount the thermal conductor (R) with the holes aligned to the screw holes. Mount the disc springs (P). Figure 7.1 shows which side of the springs should be up.

20. Mount the disk spring holder (N). Fasten the six screws (M) in small steps, following the pattern of numbers in Figure 7.6. Tighten to 5 Nm torque.

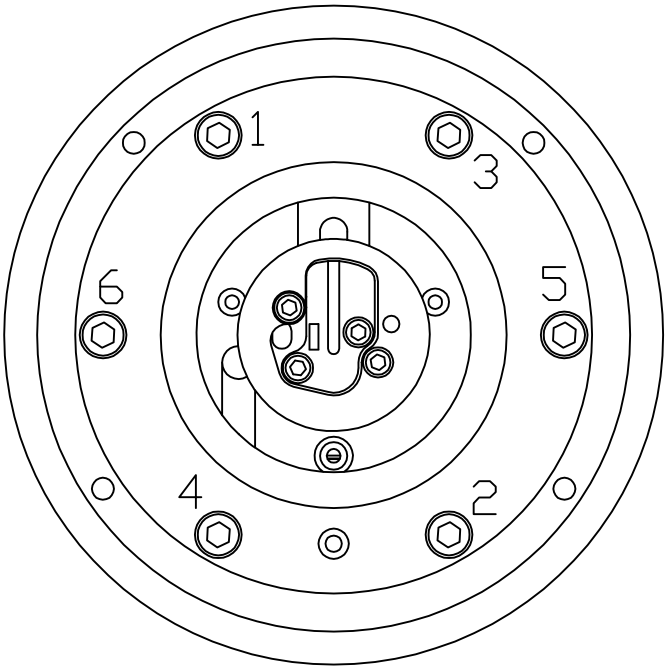


Figure 7.6 Tightening the spring holders

21. Clean the window of the CCD element. Attach the CCD card (L) to the core module (S) by the three spacer screws.

22. Attach the sensor processor card (E) with the three hexagon socket screws. Connect the ribbon cable (H), the LED connector, and the temperature element screw terminal.

23. Check the dryer color, Section 7.3.2 and replace dryer as necessary, see Section 7.1 and Section 7.3.2.

24. Connect the cable from the Sensor processor card (E) to the the Bus terminator card (F).

25. Close the sensor cover (D).

26. Place the sensor on a table with the prism upwards. Use a sharp knife to cut away the circular piece of the gasket (d) covering the prism surface, see Figure 7.4. Support the knife on the prism surface only, as the knife may scratch the steel.

27. Perform a sensor verification, Section 5.5.
Note: If the sensor processor card (E) was replaced, the sensor calibration parameters are lost. The recalibration is made using the same procedure as for sensor verification, Section 5.5.

28. Now the sensor is ready for process installation.

8 Troubleshooting

8.1 Hardware

To troubleshoot refractometer hardware problems, it is often important to localize the different cards inside the DTR. The Diagnostic LEDs on the cards help solve the problems and give an indication on whether a connection is good.

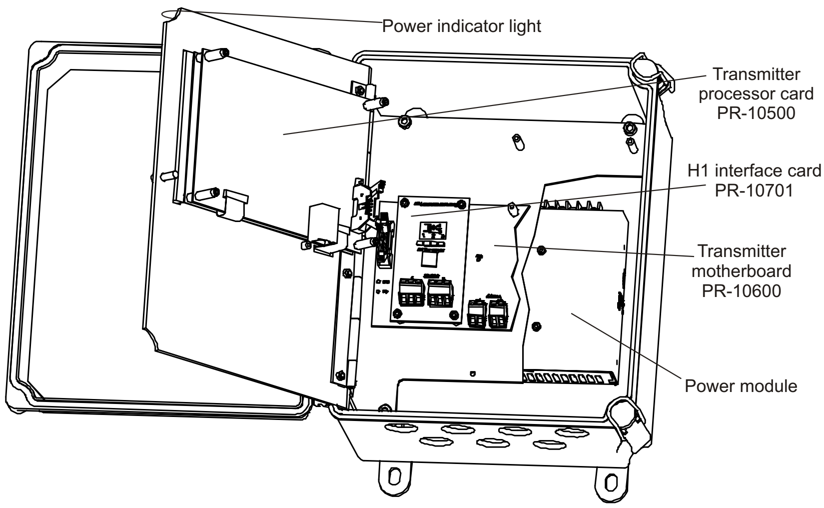


Figure 8.1 Positions of the transmitter cards

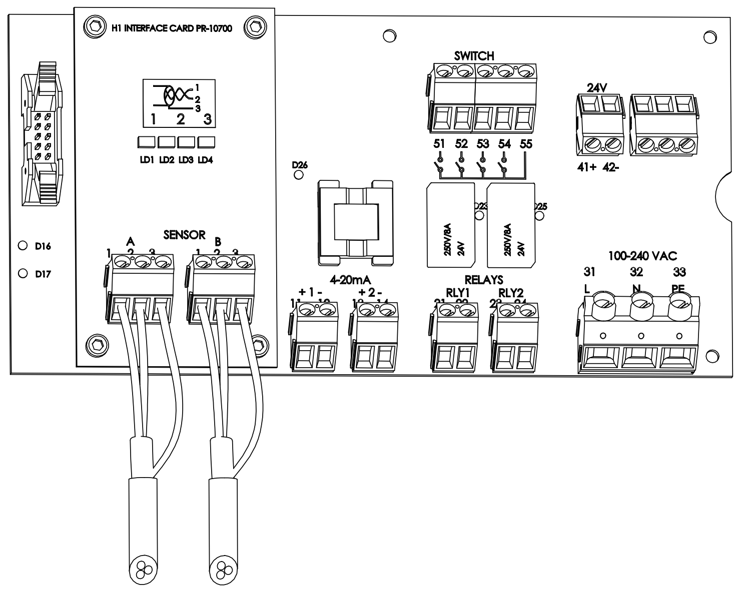


Figure 8.2 Motherboard PR-10600 and H1 interface card PR-10701 in detail.

8.1.1 Blank display

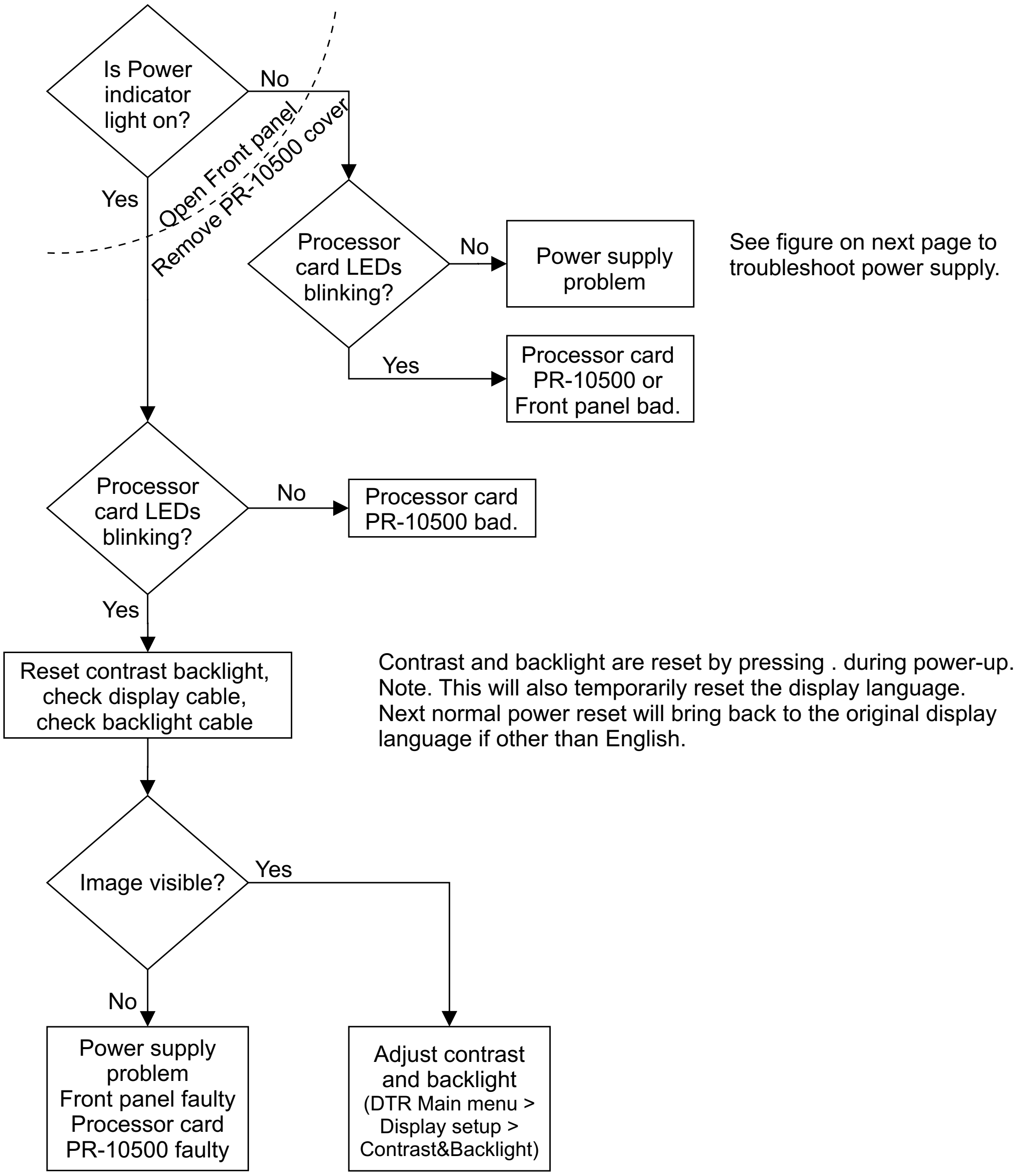


Figure 8.3 Troubleshooting a blank display.

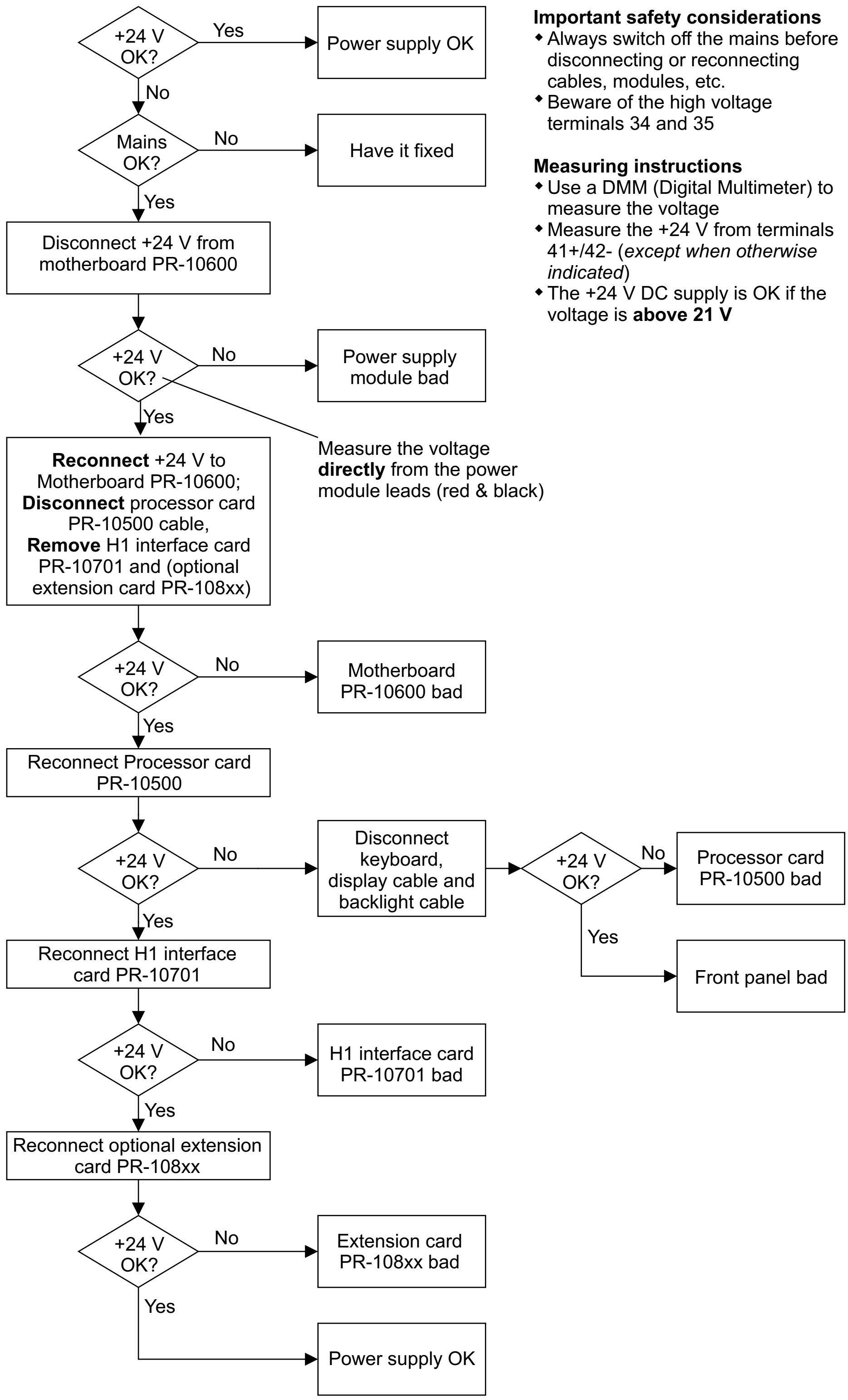


Figure 8.4 Checking the power supply.

8.1.2 Diagnostic LEDs

Figure 8.1 and Figure 8.2 assist to localize the diagnostic LEDs.

LED	**Status**	**Indication**	**See**
Front panel			
green LED	lit	DTR power is on; Processor card PR-10500 is active.	8.1.1
Transmitter processor card PR-10500			
2 yellow LEDs	blinking	Processor card ok.	
Transmitter motherboard PR-10600			
yellow LED (D17)	blinking	Motherboard processor working.	
green LED (D16)	lit	Processor card converts 24V/3V.	
green LED (D26)	lit	Isolating DC/DC conversion ok.	
2 green LEDs (D23, D25)	lit	Corresponding relay (RLY1/RLY2) has power.	
H1 interface card PR-10701			
green LED (LD1)	lit	Sensor A current correct, 20–60 mA.	
green LED (LD1)	blinking	Sensor A is being reset.	
red LED (LD2)	blinking	Sensor A current is too high and the card is trying to reconnect with correct current.	8.1.6
red LED (LD2)	lit	Sensor A current is too high and power supply to Sensor A has been switched off.	8.1.6
green LED (LD3)	lit	Sensor B current is correct, 20–60 mA	
green LED (LD3)	blinking	Sensor B is being reset.	
red LED (LD4)	blinking	Sensor B current is too high and the card is trying to reconnect with correct current.	8.1.6
red LED (LD4)	lit	Sensor B current is too high and power supply to Sensor B has been switched off.	8.1.6

Table 8.1 Diagnostic LEDs

Important: A lit red LED on PR-10701 always indicates a problem. Red LEDs are always turned off in normal operation, whether any sensors are connected or not.

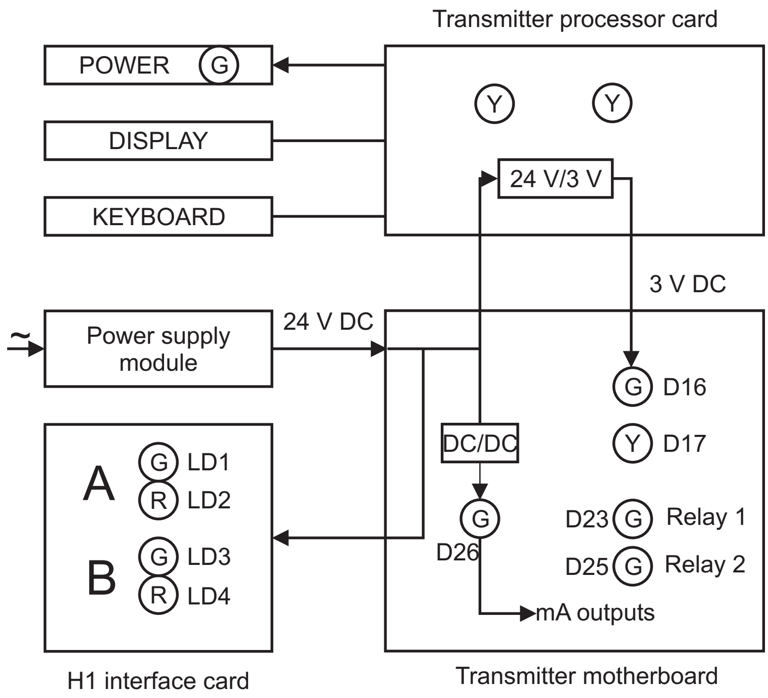


Figure 8.5 Diagnostic LED functions

8.1.3 Display unreadable

If the display is unreadable because of extreme display backlight and contrast settings or wrong display language, you can perform a **display reset**. A display reset will temporarily restore the display backlight and contrast to their factory settings and will return the display language to English.

For the display reset, you will need to access the DTR keyboard directly. Then do the following:

1. Switch off the DTR power.
2. Press (hold) down the dot (period/comma) key on the keyboard.
3. Switch on the DTR power.
4. Hold down the dot key until the DTR has started completely and you see the main display.

Note: The reset on the display language is temporary and the language will return to original next time the DTR is powered off, except if the language is permantently changed through the display settings menu.

8.1.4 Message NO SENSOR

Cause: The current in the cable to this sensor is below 20 mA. Normally this means that there's no sensor connected to the cable or that there's no cable to the DTR. If this message comes up while a sensor properly is connected, the most likely cause of this message is a fault in the sensor. It is also possible that the cable is totally dead for example if it is accidentally cut through.
See also Diagnostic LED LD1/LD3, Section 8.1.2 "Diagnostic LEDs". The concentration display will be a dashed line.

8.1.5 Message NO SIGNAL

Besides the message, the concentration display will be a dashed line although a sensor is connected.

Cause: The current in the cable to this sensor is in the correct range 20–60 mA, but no data is coming in from the sensor. This indicates that the Sensor processor card (Figure 7.1) is faulty.
See also Diagnostic LED LD1/LD3, Section 8.1.2 "Diagnostic LEDs".

Action: Replace the Sensor processor card. To replace, follow instructions in Section 7.3.1. Observe the note at the end of Section 7.3.3, "Replacing the prism and prism gaskets".

8.1.6 Message SHORT-CIRCUIT

The current in the cable to the sensor A/B exceeds 60 mA. First, the DTR attempts for a short time to reconnect with the sensor in question. If the short-circuit persists, the sensor in question is switched off completely to protect the Motherboard from overheating.

See also Diagnostic LED LD2/LD4, Section 8.1.2, "Diagnostic LEDs".

Note: If two sensors are connected to the DTR, a short-circuit in one of the cables may disturb the measurement of both sensors as DTR attempts to re-connect. The measurement of the non-affected sensor returns to normal as soon as the short-circuited sensor is switched off.

If the DTR detects a short-circuit that persists, the affected sensor is switched off to prevent further damage. The message SHORT-CIRCUIT will stay on the screen until the DTR is powered off and on.
See also Diagnostic LED LD2/LD4, Section 8.1.2, "Diagnostic LEDs".

Cause and action: The most likely cause of these messages is a problem in the cable connecting the sensor in question to the DTR. Check that the cable is undamaged and replace it if necessary, then turn the DTR off and back on.

8.1.7 Message HIGH SENSOR HUMIDITY

Tells that humidity measured at the Sensor processor card exceeds 60 % relative humidity. The reason may be moisture leaking in through prism seal or the cover being open. If the sensor cover has been off for a long time, see Section 7.3.2 “Replacing the dryer”. Also, check and, if necessary, replace prism seal, Section 7.3.3 “Replacing the prism and prism gaskets”.

8.1.8 Message HIGH SENSOR TEMP

The temperature on the Sensor processor card exceeds 65 °C (150 °F). To read this temperature, select 3 SENSOR STATUS from the Main menu. For action, see Section 2.2.1, “Choosing sensor mounting location”.

8.1.9 Message HIGH TRANSMITTER TEMP

The temperature of the Motherboard of the Indicating transmitter exceeds 60 °C (140 °F). To read this temperature, select 3 SENSOR STATUS from the Main menu and check DTR TMP. If the warning persists, the transmitter should be moved to a cooler place (for example out of sun).

8.1.10 Message LOW TRANSMITTER VOLT

The internal DC voltages of the transmitter are below specifications. Check the power supply input voltage. If the supply voltage is within specifications, replace power supply module, Figure 8.1.

8.1.11 Relays and switches not working

Check configuration, Section 5.3, “Viewing system information”, and for possible correction Section 6.1.4, “Configuring input switches”, Section 6.1.3 “Configuring relays”, and Section 6.3 “Configuring prism wash”.

Relay status is indicated by LEDs D23, D25 on the Motherboard, see Section 8.1.2 “Diagnostic LEDs”. For switches, check also LED D26 on the Motherboard indicating that the 3 V DC supply is correct, see Section 8.1.2 “Diagnostic LEDs”.

The wash function can be tested according to Section 5.1.3 “Testing prism wash”.

8.1.12 Output signal error during NORMAL OPERATION

If there is no output signal, check wiring (Section 3.3, “Electrical connections”) and the Diagnostic LED D26 (Section 8.1.2, “Diagnostic LEDs”).

If the mA signal does not correspond to the concentration display, check output signal configuration, Section 5.3, “Viewing system information”, and for possible correction Section 6.1.1, “Configuring mA outputs”. A low mA signal can also be caused by high resistance in the external current loop, see Section 3.3, “Electrical connections”.

A noisy signal can be damped, Section 6.1.2, “Signal damping”.

8.2 Measurement

8.2.1 Message OUTSIDE LIGHT ERROR

Cause: The measurement is not possible because too much outside light reaches the camera.

Action: Identify the light source (for example sun shining into an open tank or a translucent pipe) and block the light from getting to the prism at the sensor tip.

8.2.2 Message NO OPTICAL IMAGE

The optical image can be seen from selecting 3 SENSOR STATUS at the Main menu, Section 5.4.1. There are several possible causes:

1. The prism is heavily coated, Section 4.1. Perform prism wash if available, Section 5.1.3 "Testing prism wash". Remove sensor from line and clean prism manually.
2. There is moisture condensation in the sensor head, see Section 8.1.7.
3. The sensor head temperature is too high, see Section 8.1.8.
4. The light source is faulty. When the sensor is removed from the process, the yellow flashing light can be seen through the prism. **Note:** The light is only visible at an oblique angle. Also check the LED value in the Sensor status display (select 3 Sensor status in the Main menu); if the value is clearly below 100, LED fault is not likely.
5. There are negative spikes in the optical image. The probable cause is dust or fingerprints on the CCD window.
6. The CCD card in the sensor is faulty. See Section 7.3, "Disassembling and assembling the sensor".

8.2.3 Message PRISM COATED

Cause: The optical surface of the prism is coated by the process medium or impurities in the process medium.

Action: Perform prism wash if available, Section 5.1.3 "Testing prism wash". Remove sensor from line and clean prism manually.

If the problem is recurrent, consider improving the flow conditions (see Section 2.2, "Mounting the sensor") or, if prism wash is available, adjust the wash parameters, see Section 6.3, "Configuring prism wash".

8.2.4 Message OUTSIDE LIGHT TO PRISM

Cause: Some light from the outside reaches the sensor and may disturb the measurement.

Action: Identify the light source (for example sun shining into an open tank or a translucent pipe) and block the light from getting to the prism at the sensor tip.

8.2.5 Message LOW IMAGE QUALITY

Cause: The most likely cause for this message is scaling on the prism. There still is a optical image available, but the measurement quality may not be optimal.

Action: Clean the prism, see Section 8.2.3 above.

8.2.6 Message NO SAMPLE

The operation of the equipment is OK but there is no process liquid on the prism. The optical image looks like Figure ??, left.

8.2.7 Message TEMP MEASUREMENT FAULT

Indicates faulty temperature element. Disconnect the temperature sensor leads from the screw terminals at the processor card, Section 7.3.1, "Disassembling the sensor". The resistance value of the Pt-1000 element should be close to 1000 Ω. To change the temperature element, see Section 7.3.3 "Replacing the prism and prism gaskets".
Note: The prism gasket must be replaced, too.

Note: A difference to some other process temperature measurement is not a fault. PR-23 measures the true temperature of the prism surface.

8.2.8 Concentration drift during NORMAL OPERATION

For drift upward, suspect prism coating, Section 4.1, "Prism coating". Otherwise check calibration (Section 6.2, "Calibrating the concentration measurement") and sensor verification (Section 5.5, "Sensor verification").

8.3 Wash

8.3.1 Message EXTERNAL HOLD

The concentration measurement is on HOLD due to an external switch closure. For explanation, see Section 6.1.4, “Configuring input switches”.

8.3.2 Messages PRECONDITIONING, WASH, RECOVERING

- PRECONDITIONING: An optional preconditioning relay is closed, see Section 6.3 “Configuring prism wash”.
- WASH: The internal wash relay is closed, see Section 6.3 “Configuring prism wash”.
- RECOVERING: The concentration measurement is on HOLD during a preset time.

8.3.3 Message PRISM WASH FAILURE

No dip of n_D value during prism wash. The accepted size of the dip is set as the WASH CHECK function, Section 6.3, “Configuring prism wash”. See also Section 5.1.3 “Testing prism wash”.

8.3.4 Message EXTERNAL WASH STOP

Tells that wash action is prevented because an EXTERNAL WASH STOP switch is closed, see Section 6.1.4 “Configuring input switches”.

- NO SAMPLE (Section 8.2.6) indicates empty pipe

8.3.5 Message LOW TEMP WASH STOP

Tells that wash action is prevented because of LOW TEMP: low process temperature indicates empty pipe. To set the limit, see Section 6.3 “Configuring prism wash”.

8.3.6 Message NO SAMPLE/WASH STOP

Tells that wash action is prevented because of NO SAMPLE: the process pipe is empty and the prism is clean.

8.4 Diagnostic messages table

Important: The messages are listed in descending order of priority. *Example:* If both NO OPTICAL IMAGE and TEMP MEASUREMENT FAULT are activated, only NO OPTICAL IMAGE will be shown. The wash related messages have priority only during the wash cycle (preconditioning–wash–recovery).

Message	Section
SHORT-CIRCUIT	8.1.6
NO SIGNAL	8.1.5
OUTSIDE LIGHT ERROR	8.2.1
NO OPTICAL IMAGE	8.2.2
TEMP MEASUREMENT FAULT	8.2.7
PRECONDITIONING	8.3
WASH	8.3
RECOVERING	8.3
HIGH SENSOR HUMIDITY	8.1.7
HIGH SENSOR TEMP	8.1.8
HIGH TRANSMITTER TEMP	8.1.9
LOW TRANSMITTER VOLT	8.1.10
EXTERNAL WASH STOP	8.3.4
LOW TEMP WASH STOP	8.3.5
NO SAMPLE/WASH STOP	8.3.6
EXTERNAL HOLD	8.3.1
NO SAMPLE	8.2.6
PRISM COATED	8.2.3
OUTSIDE LIGHT TO PRISM	8.2.4
LOW IMAGE QUALITY	8.2.5
PRISM WASH FAILURE	8.3.3
NO SENSOR	8.1.4
NORMAL OPERATION	

9 Sensor specifications

Note: For the specifications of the PR-23-SD sensor for K-Patents Safe-Drive™ system, see Sections 11.2 and 11.3.

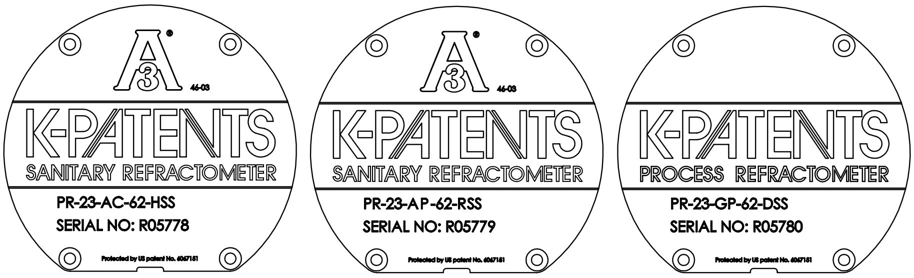


Figure 9.1 Sensor nameplates

9.1 Sensor compatibility

Electrically: All the K-Patents PR-23 refractometer sensors are interchangeable. The PR-23 sensors are **not** interchangeable with the PR-01 and PR-03 range sensors. Furthermore, the PR-23 sensors are **not** compatible with the K-Patents PR-01 / PR-03 indicating transmitter IT-R.

Mechanically: The sanitary process refractometer PR-23-AC-62-HSS fits the same 2 1/2" sanitary process connection as the sanitary refractometer PR-03-A62-HSS.

9.2 Sensor rangeability

The refractive index standard range of a PR-23 refractometer sensor is 1.320–1.530 (corresponds to 0–100 Brix), Figure 9.2.

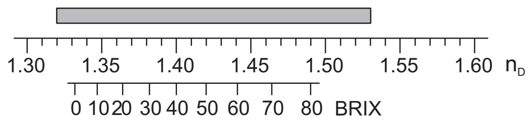


Figure 9.2 PR-23 rangeability

The refractometer models PR-23-M/MS and PR-23-W for aggressive solutions and ultra-pure fine chemicals can be equipped with a sapphire prism with a refractive index range 1.2600–1.4600, Figure 9.3.

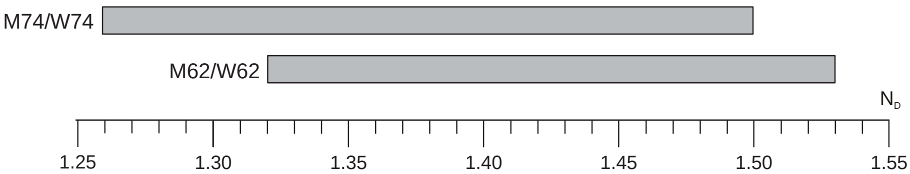


Figure 9.3 PR-23-M/MS/W rangeability with a sapphire prism (74) and with a standard prism (62)

9.3 Sanitary process refractometer PR-23-AC

The refractometer PR-23-AC is a 3A Sanitary process refractometer for measuring concentrations *in a pipe line*. Easy to install in any pipe size directly or using a flow cell. The Sanitary process refractometer is suitable for all food and beverage processing applications where on-line monitoring and control can help to improve product quality and reduce costs.

9.3.1 PR-23-AC sensor model code

MODEL AND DESCRIPTION	MODEL
PR-23 = Sensor	PR-23
Sensor model -A = 3A approved	-A
Sensor type C = Compact type for pipe line installation	C
Refractive Index range limits -62 = n_D 1.320–1.530 (0–100 Brix)	-62
Process connection -H = Sanitary 3A clamp, 2 1/2 inch -E = Varivent® in-line access unit clamp DN65	-H -E
Sensor wetted parts material SS = AISI 316 L	SS
Sensor housing -AA = Anodized aluminium -EC = Industrial epoxy coated aluminium -SC = Stainless steel	-AA -EC -SC

Example: Sensor: PR-23-AC-62-HSS-AA

9.3.2 PR-23-AC mounting hardware model code

Mounting hardware (without wash nozzles)

MODEL AND DESCRIPTION	MODEL
AFC = Elbow flow cell	AFC
Sensor connection -H = Sanitary 3A clamp, 2 1/2 inch	-H
Construction material SS = AISI 316	SS
Process connection -H = Sanitary 3A clamp	-H
Pipe section diameter 10 = 25 mm (1 inch) (A) 15 = 40 mm (1 1/2 inch) 20 = 50 mm (2 inch) 25 = 65 mm (2 1/2 inch) (A)	10 15 20 25
Flow cell inlet type -SI = Straight pipe -RI = Reduced pipe (cone)	-SI -RI

(A) with -SI option only

Mounting hardware with wash nozzles

MODEL AND DESCRIPTION	MODEL
AFC = Elbow flow cell	AFC
Sensor connection -H = Sanitary 3A clamp, 2 1/2 inch	-H
Construction material SS = AISI 316	SS
Process connection -H = Sanitary 3A clamp	-H
Pipe section diameter 10 = 25 mm (1 inch) (A) 15 = 40 mm (1 1/2 inch) (B) 20 = 50 mm (2 inch) (B) 25 = 65 mm (2 1/2 inch) (B)	10 15 20 25
Flow cell inlet type -SI = Straight pipe -RI = Reduced pipe (cone)	-SI -RI
Wash nozzle connection -NC = Nozzle connection	-NC
Wash nozzles for 10/15 flow cells -SN = Steam nozzle, PR-3365 (C) -WN = Water nozzle, PR-3364 (C) -WP = Pressurized water nozzle, PR-3366 (C) -PG = Plug for nozzle connection, PR-3367 **Wash nozzles for 20/25 flow cells** -SN = Steam nozzle, PR-3375 (C) -WN = Water nozzle, PR-3374 (C) -WP = Pressurized water nozzle, PR-3376 (C) -PG = Plug for nozzle connection, PR-3367	-SN -WN -WP -PG -SN -WN -WP -PG

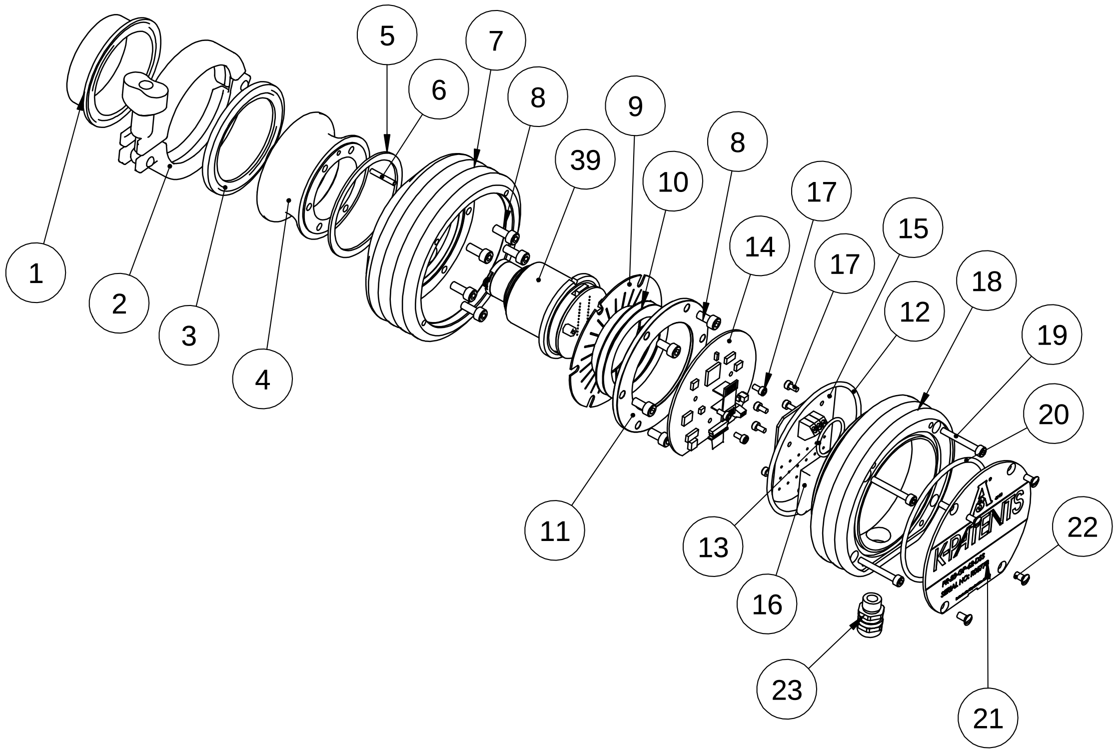
(A) with -SI option only
(B) with -RI option only
(C) nozzle inlet R 1/4 inch female

Example:	Sensor:	PR-23-AC-62-HSS-AA
	Flow cell:	AFC-HSS-H20-SI

9.3.3 PR-23-AC specifications

General specifications	
Refractive Index range:	Full range n_D 1.3200–1.5300 (corresponds to hot water – 100 Brix)
Accuracy:	Refractive index n_D ± 0.0002 (corresponds typically to ± 0.1 % by weight) Repeatability and stability correspond to accuracy
Speed of response:	1 s undamped, damping time selectable up to 5 min
Calibration:	With Cargille certified refractive index liquids over full range of n_D 1.3200–1.5300
CORE-Optics:	No mechanical adjustments (US Patent No. US6067151)
Digital measurement:	3648 pixel CCD element
Light source:	Light emitting diode (LED) 589 nm wavelength, sodium light
Temperature sensor:	Built-in Pt-1000
Temperature compensation:	Automatic, digital compensation
Instrument verification:	With certified refractive index liquids and K-Patents documented procedure
Ambient temperature:	Sensor: max. 45 °C (113 °F), min. -20 °C (-4 °F) Indicating transmitter: max. 50 °C (122 °F), min. 0 °C (32 °F)
SENSOR PR-23-AC:	Compact sensor model for small pipe lines
Process connection:	Sanitary 3A-clamp 2.5"; Varivent® in-line access unit clamp DN65 or via elbow flowcell (for line sizes of 2.5" and smaller)
Sanitary design:	3-A Sanitary Standard 46-03 approved and EHEDG (European Hygienic Equipment Design Group) tested
Process pressure:	Sanitary clamp max. 15 bar (200 psi) at 20 °C (70 °F)/9 bar (125 psi) at 120 °C (250 °F)
Process temperature:	-20 °C–+130 °C (-4 °F–+266 °F)
Process wetted parts, standard:	AISI 316L stainless steel, prism spinel, prism gaskets MTF (Modified Teflon)
Sensor protection class:	IP67, Nema 4X
Sensor weight:	2.0 kg (4.4 lbs)

9.3.4 PR-23-AC parts lists



Item	Pcs.	Part No.	Description
1	1	PR-9205	2.5" Sanitary ferrule
2	1	PR-9201	2.5" Sanitary clamp
3	1	PR-9202	2.5" Sanitary gasket EPDM
3	1	PR-9203	2.5" Sanitary gasket NBR
3	1	PR-9204	2.5" Sanitary gasket PTFE (Teflon®)
4	1	PR-10001	PR-23 H head (3A sanitary clamp connection)
4	1	PR-10021	PR-23 E head (Varivent® connection)
5	1		Thermal insulator PTFE (Teflon®)
6	1		Alignment pin
7	1	PR-10005	PR-23 base
8	6		Screw M5x10 DIN 912 A2
9	1	PR-9011	Thermal conductor
*	1	PR-9010	Disc spring set
10	2		Disc spring
11	1		Disc spring holder
12	1		O-ring seal 89.5 x 3
13	1		O-ring seal 24 x 2
14	1	PR-10100	Sensor processor card
15	1	PR-10300	Bus terminator card
16	1	PR-9108	Dryer for PR-23
17	8		Screw M3x6 DIN 912 A2

Item	Pcs.	Part No.	Description
18	1	PR-10000	PR-23 cover
19	4		Screw M4x30 DIN 912 A4
20	1	PR-10002	O-ring seal 83x3
21	1		PR-23-A nameplate
22	4		Screw M4x8 DIN 964 A4
23	1		Cable gland M16x1.5
39	1	PR-10012	PR-23 compact sensor CORE module

9.3.5 PR-23-AC mounting specifics

K-Patents sanitary process refractometer PR-23-AC is connected to the process by a 2 1/2" 3A sanitary clamp. The recommended mounting is *in a pipe bend, with a vertical flow upwards before the sensor, and a horizontal pipe after.* By this mounting is obtained

1. Self-cleaning of prism due to the flow directed against its surface.
2. Efficient drainage when the pipe is emptied.

For *pipe diameters of 3" or above*, a ferrule is welded directly to the pipe wall, Figure 9.4 (a ferrule, length 21.5 mm, is delivered with standard sensor delivery from K-Patents).

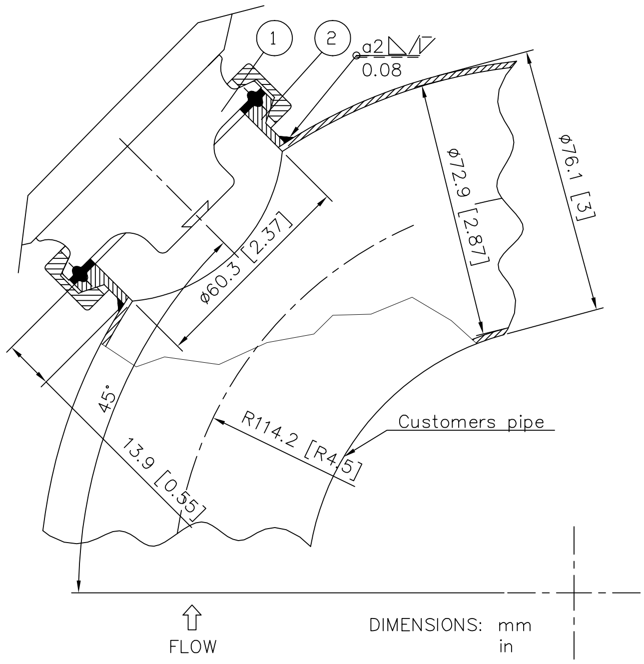
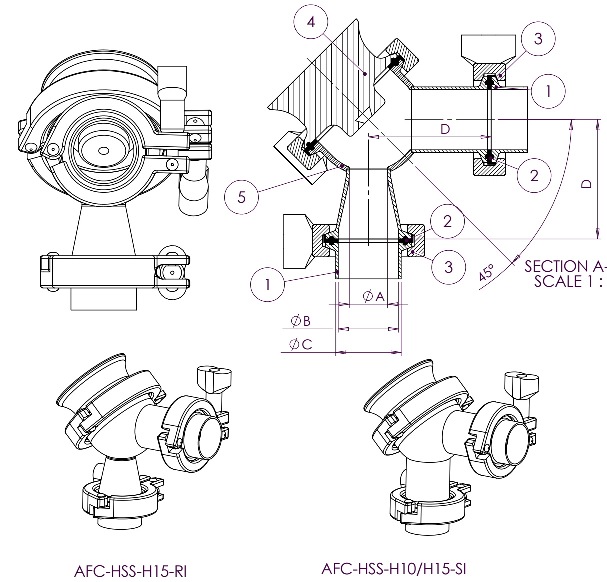


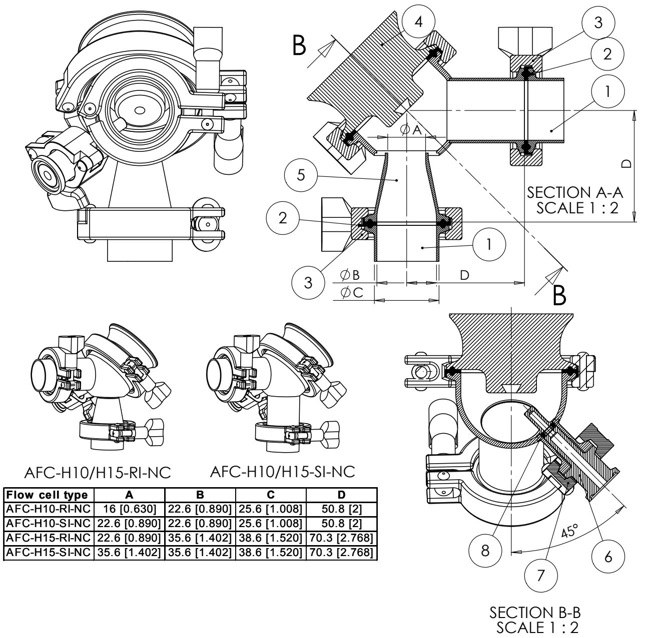
Figure 9.4 Mounting with sanitary ferrule
Pipe diameter 3" (80 mm) or more

For smaller pipe diameters, flow cells are available from K-Patents, Figures 9.5, 9.6, 9.7 and 9.8, see also the tables in Section 9.3.2. The flow cells are exchangeable with standard 90° bend pieces.



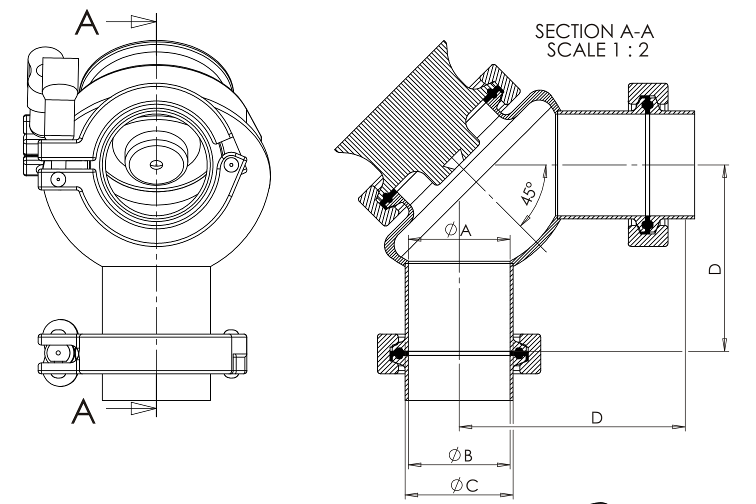
Flow cell type	A	B	C	D
AFC-H10-SI	22.6 [0.890]	22.6 [0.890]	25.6 [1.008]	50.8 [2]
AFC-H15-RI	22.6 [0.890]	35.6 [1.402]	38.6 [1.520]	70.3 [2.768]
AFC-H15-SI	35.6 [1.402]	35.6 [1.402]	38.6 [1.520]	70.3 [2.768]

Figure 9.5 Flow cell AFC-HSS-
H10 for pipe diameter 1" (25 mm) and
H15 for pipe diameter 1 1/2" (40 mm)



Flow cell type	A	B	C	D
AFC-H10-RI-NC	16 [0.630]	22.6 [0.890]	25.6 [1.008]	50.8 [2]
AFC-H10-SI-NC	22.6 [0.890]	22.6 [0.890]	25.6 [1.008]	50.8 [2]
AFC-H15-RI-NC	22.6 [0.890]	35.6 [1.402]	38.6 [1.520]	70.3 [2.768]
AFC-H15-SI-NC	35.6 [1.402]	35.6 [1.402]	38.6 [1.520]	70.3 [2.768]

Figure 9.6 Flow cell AFC-HSS- with wash nozzle connection (-NC)
H10 for pipe diameter 1" (25 mm) and
H15 for pipe diameter 1 1/2" (40 mm)



Flow cell type	A	B	C	D
AFC-HSS-H20-SI	48.6	48.6	51.6	89.0
AFC-HSS-H20-RI	35.6	48.6	51.6	89.0
AFC-HSS-H25-SI	60.3	60.3	64.1	108.0

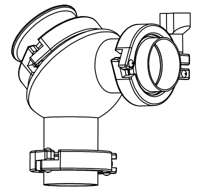
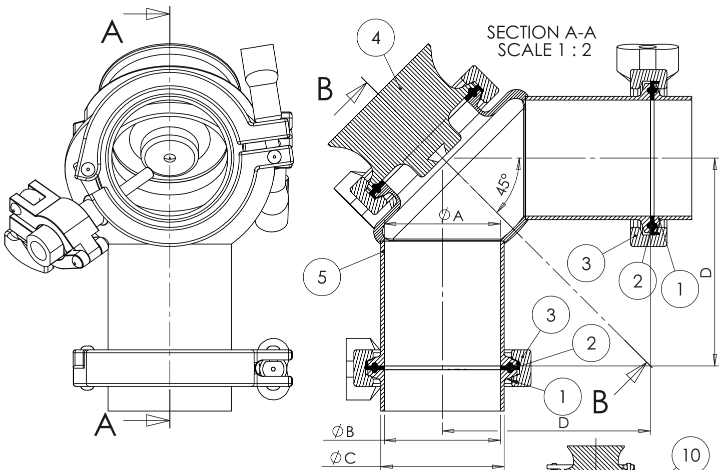


Figure 9.7 Flow cell AFC-HSS-
H20 for pipe diameter 2" (50 mm) and
H25 for pipe diameter 2 1/2" (65 mm)



Flow cell type	A	B	C	D
AFC-HSS-H20-SI-NC	48.6	48.6	51.6	89.0
AFC-HSS-H20-RI-NC	35.6	48.6	51.6	89.0
AFC-HSS-H25-SI-NC	60.3	60.3	64.1	108.0

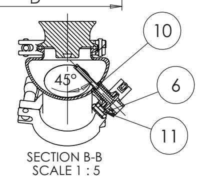


Figure 9.8 Flow cell AFC-HSS- with wash nozzle connection (-NC)
H20 for pipe diameter 2" (50 mm) and
H25 for pipe diameter 2 1/2" (65 mm)

9.4 Sanitary probe refractometer PR-23-AP

The K-Patents Sanitary probe refractometer PR-23-AP provides an accurate on-line BRIX measurement in cookers and tanks.

9.4.1 PR-23-AP model code

MODEL AND DESCRIPTION	MODEL
PR-23 = Sensor	PR-23
Sensor model -A = 3A approved	-A
Sensor type P = Probe type for tanks and large pipes	P
Refractive Index range limits -62 = n_D 1.320–1.530 (0–100 Brix)	-62
Process connection -T = Sanitary 3A clamp, 2 1/2 inch, insertion length 139.5 mm -R = Sanitary 3A clamp, 4 inch, insertion length 139.5 mm -P = MT4 DN 25/1T APV Tank bottom flange, flush mounted	-T -R -P
Sensor wetted parts material SS = AISI 316 L	SS
Sensor housing -AA = Anodized aluminium -EC = Industrial epoxy coated aluminium -SC = Stainless steel	-AA -EC -SC

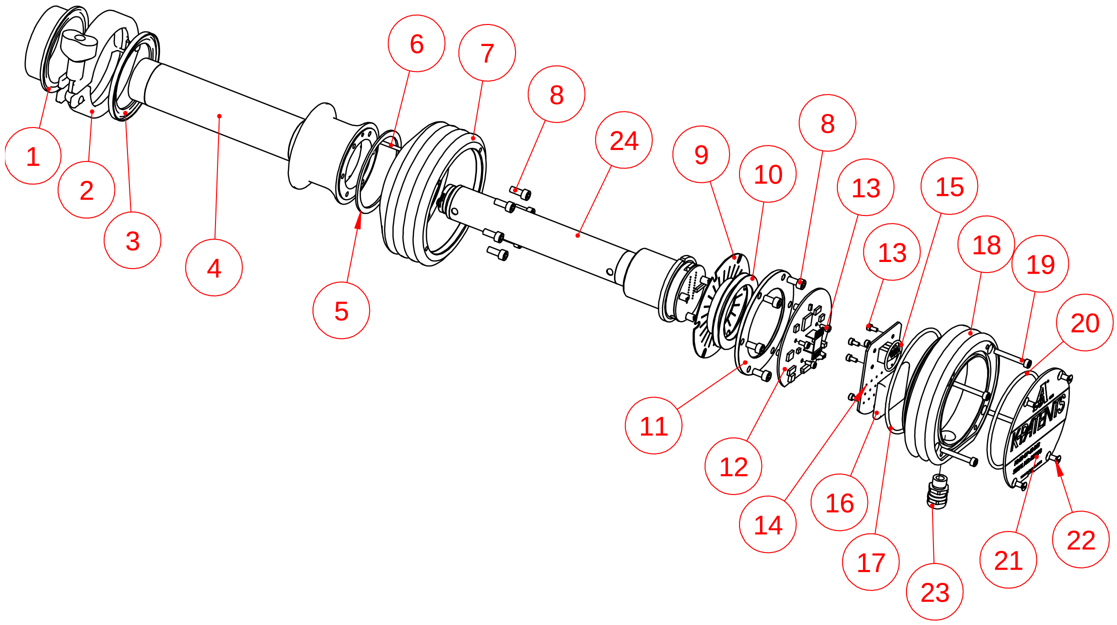
9.4.2 PR-23-AP mounting hardware model code

MODEL AND DESCRIPTION	MODEL
VFMA-23-PSS = MT4 DN25/1T APV tank bottom flange for PR-23-P62-PSS	VFMA-23-PSS

9.4.3 PR-23-AP specifications

General specifications	
Refractive Index range:	Full range n_D 1.3200–1.5300 (corresponds to hot water – 100 Brix)
Accuracy:	Refractive index $n_D \pm 0.0002$ (corresponds typically to $\pm$ 0.1 % by weight) Repeatability and stability correspond to accuracy
Speed of response:	1 s undamped, damping time selectable up to 5 min
Calibration:	With Cargille certified refractive index liquids over full range of n_D 1.3200–1.5300
CORE-Optics:	No mechanical adjustments (US Patent No. US6067151)
Digital measurement:	3648 pixel CCD element
Light source:	Light emitting diode (LED) 589 nm wavelength, sodium light
Temperature sensor:	Built-in Pt-1000
Temperature compensation:	Automatic, digital compensation
Instrument verification:	With certified refractive index liquids and K-Patents documented procedure
Ambient temperature:	Sensor: max. 45 °C (113 °F), min. -20 °C (-4 °F) Indicating transmitter: max. 50 °C (122 °F), min. 0 °C (32 °F)
SENSOR PR-23-AP:	Probe sensor model for large pipe lines and vessels
Process connection:	Sanitary 3A-clamp 2.5"; Sanitary 3A-clamp 4" or MT4 DN 25/1T APV Tank bottom flange
Sanitary design:	3-A Sanitary Standard 46-03 approved
Process pressure:	Sanitary clamp max. 15 bar (200 psi) at 20 °C (70 °F)/9 bar (125 psi) at 120 °C (250 °F)
Process temperature:	-20 °C–+150 °C (-4 °F–+302 °F)
Process wetted parts, standard:	AISI 316L stainless steel, prism spinel, prism gaskets MTF (Modified Teflon)
Sensor protection class:	IP67, Nema 4X
Sensor weight:	3.0 kg (6.6 lbs)

9.4.4 PR-23-AP parts lists



Item	Pcs.	Part No.	Description
1	1	PR-9205	2.5" sanitary ferrule
1	1	VFMA-23-PSS	MT4 DN25/1T APV tank bottom flange
1	1	PR-4275	4" sanitary ferrule
2	1	PR-9201	2.5" sanitary clamp
2	1	PR-9270	4" sanitary clamp
3	1	PR-9202	2.5" sanitary gasket EPDM
3	1	PR-9203	2.5" sanitary gasket NBR
3	1	PR-9204	2.5" sanitary gasket Teflon
3	1	PR-9243	MT4 DN25/1T APV gasket EPDM
3	1	PR-9272	4" 3A sanitary gasket EPDM
3	1	PR-9273	4" 3A sanitary gasket NBR
3	1	PR-9274	4" 3A sanitary gasket Teflon
4	1	PR-10008	PR-23-P-TSS head
4	1	PR-10006	PR-23-P-PSS head
4	1	PR-10007	PR-23-P-RSS head
5	1		Thermal insulator Teflon®
6	1		Alignment pin
7	1	PR-10005	PR-23 base
8	6		Screw M5x10 DIN 912 A2
9	1	PR-9011	Thermal conductor

Item	Pcs.	Part No.	Description
*	1	PR-9010	Disc spring set
10	2		Disc spring
11	1		Disc spring holder
12	1	PR-10100	Sensor processor card
13	8		Screw M3x6 DIN 912 A2
14	1	PR-10300	Bus terminator card
15	1		O-ring seal 24x2
16	1	PR-9108	Dryer package
17	1		O-ring seal 89.5x3
18	1	PR-10000	PR-23 cover
19	1		Screw M4x30 DIN 912 A4
20	1	PR-10002	O-ring seal 83x3
21	1		PR-23-A nameplate
22	4		Screw M4x8 DIN 964 A4
23	1		Cable gland M16x1.5
24	1	PR-10022	PR-23-P core

9.4.5 PR-23-AP mounting specifics

The Probe refractometer PR-23-AP is primarily designed for mounting in a tank wall. To ensure that the measurement is representative and that the prism stays clean, the probe should be installed close to a stirrer.

K-Patents probe refractometer, types PR-23-AP-T is connected to the process by a 2 1/2" 3A sanitary clamp, Figure 9.9. PR-23-AP-R is connected by 4" sanitary clamp.

Note: For higher process (or ambient) temperatures, use instead a flush mounted sensor, where the electronics in the sensor head are farther away from the process heat, Figure 9.10.

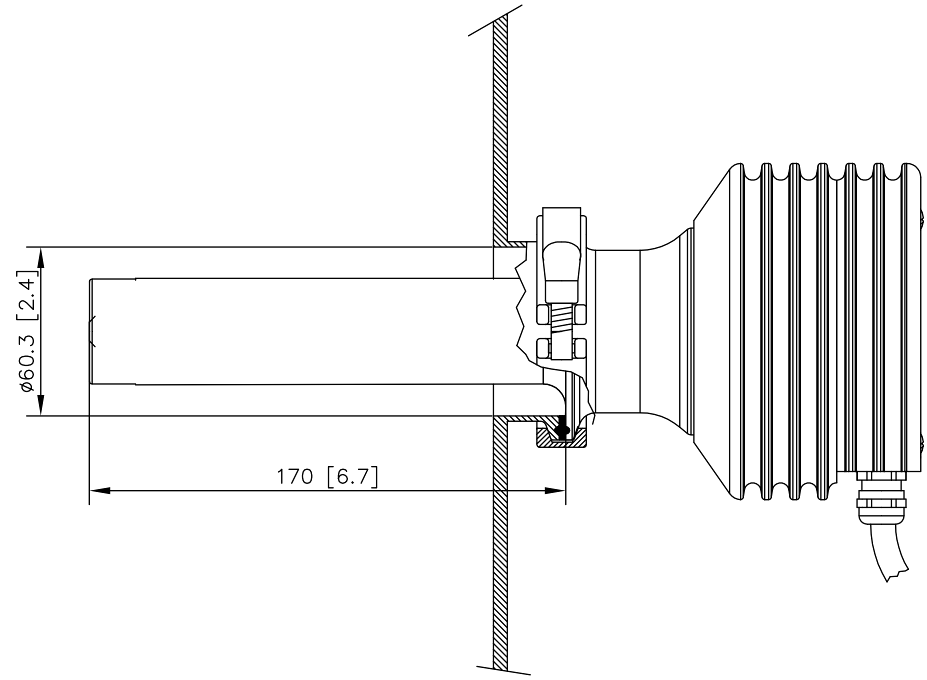


Figure 9.9 Insertion of Probe refractometer PR-23-AP62-TSS

The refractometer type PR-23-AP62-PSS is flush mounted, using a sanitary APV tank bottom flange, Figure 9.10. The sensor can be flush mounted in the side wall, which allows the use of a scraper. It is also easily installed through a steam jacket.

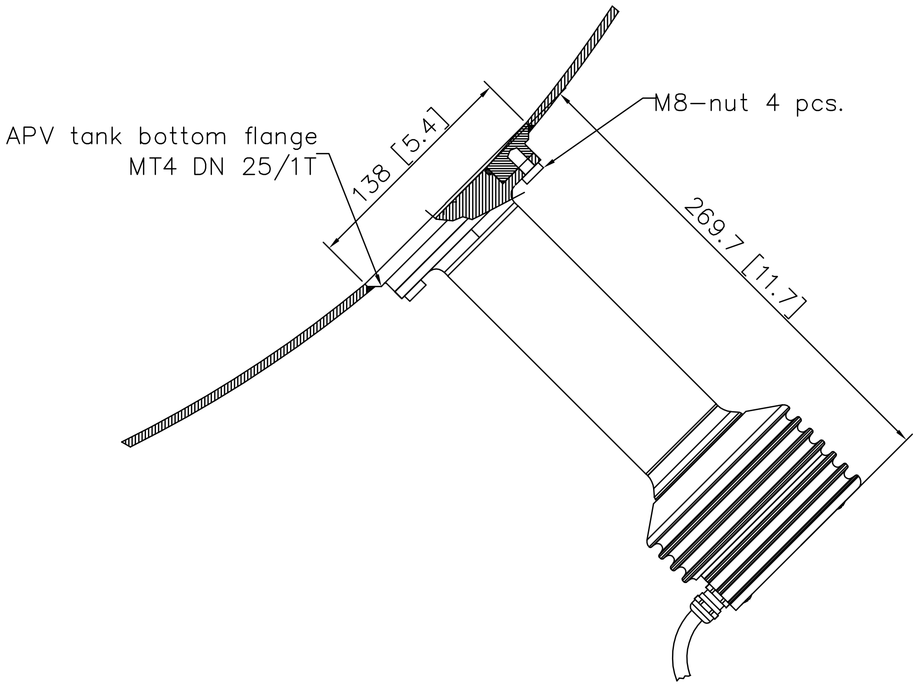


Figure 9.10 Flush mounting Probe refractometer PR-23-AP62-PSS

9.5 Probe process refractometer PR-23-GP

The K-Patents Probe process refractometer PR-23-GP is a general industry model for measuring liquid concentrations in various in-line applications, like chemicals, fibers, plastics, salts and sodium components. It is typically installed in large pipes and vessels.

9.5.1 PR-23-GP sensor model code

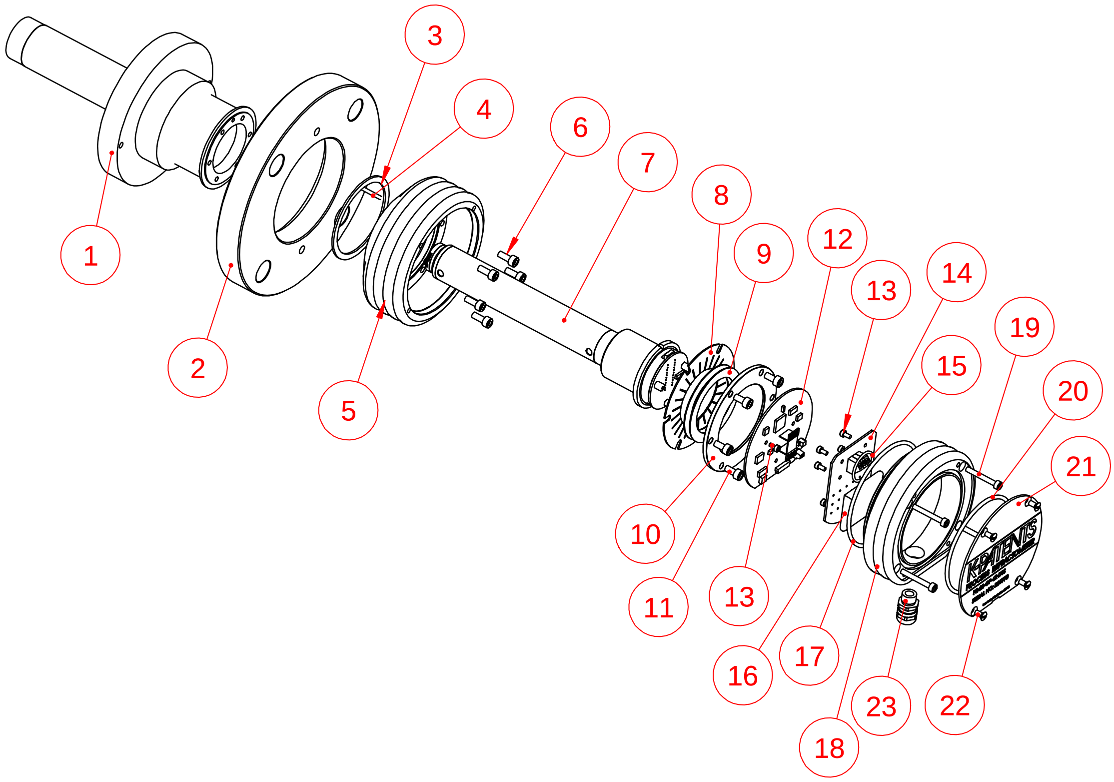
MODEL AND DESCRIPTION	MODEL
PR-23 = Sensor	PR-23
Sensor model -G = General	-G
Sensor type P = Probe type for tanks and large pipes	P
Refractive Index range limits -62 = n_D 1.320–1.530 (0–100 Brix)	-62
Process connection -A = ANSI-flange 150 lbs, 3 inch, insertion length 130 mm -D = DIN-flange 2656, PN25 DN80, insertion length 130 mm -J = JIS-flange 10k 80A, insertion length 130 mm -L = Sandvik L clamp, 88 mm, insertion length 130 mm	-A -D -J -L
Sensor wetted parts material SS = AISI 316 L	SS
Electrical classification -GP = General purpose	-GP
Sensor housing -AA = Anodized aluminium -EC = Industrial epoxy coated aluminium -SC = Stainless steel	-AA -EC -SC
Prism wash -SN = Integral steam nozzle -WN = Integral water nozzle -WP = Integral pressurized water nozzle -NC = Integral nozzle connection -YC = without nozzle connection	-SN -WN -WP -NC -YC

Example: Sensor: PR-23-GP-62-LSS-GP-AA-YC

9.5.2 PR-23-GP specifications

General specifications	
Refractive Index range:	Full range n_D 1.3200–1.5300 (corresponds to hot water – 100 Brix)
Accuracy:	Refractive index n_D ± 0.0002 (corresponds typically to ± 0.1 % by weight) Repeatability and stability correspond to accuracy
Speed of response:	1 s undamped, damping time selectable up to 5 min
Calibration:	With Cargille certified refractive index liquids over full range of n_D 1.3200–1.5300
CORE-Optics:	No mechanical adjustments (US Patent No. US6067151)
Digital measurement:	3648 pixel CCD element
Light source:	Light emitting diode (LED) 589 nm wavelength, sodium light
Temperature sensor:	Built-in Pt-1000
Temperature compensation:	Automatic, digital compensation
Instrument verification:	With certified refractive index liquids and K-Patents documented procedure
Ambient temperature:	Sensor: max. 45 °C (113 °F), min. -20 °C (-4 °F) Indicating transmitter: max. 50 °C (122 °F), min. 0 °C (32 °F)
SENSOR PR-23-GP:	Probe sensor for large pipe line and vessel installation
Process connection:	Flanges: ANSI 3” 150 lbs or DIN 80 P25 or JIS 80 A 10k; or Sandvik L clamp 88 mm
Process pressure:	Flange connections up to 25 bar (350 psi)
Process temperature:	-20 °C–+150 °C (-4 °F–+302 °F)
Process wetted parts, standard:	AISI 316L stainless steel, prism spinel, prism gaskets MTF (Modified Teflon)
Sensor protection class:	IP67, Nema 4X
Sensor weight:	Aluminium sensor with clamp/flange 4.0–9.0 kg (8.8–19.8 lbs), stainless steel sensor with clamp/flange 5.9–10.9 kg (13.0–24.0 lbs)

9.5.3 PR-23-GP parts lists



Item	Pcs.	Part No.	Description
1	1	PR-10009	PR-23-GP-L head
1	1	PR-10010	PR-23-GP-D head
2	1		ANSI 3" 150 lbs flange
2	1		DIN 80 PN 25 flange
2	1		JIS 80A 10k flange
3	1		Thermal insulator Teflon®
4	1		Alignment pin
5	1	PR-10005	PR-23 base
6	6		Screw M5x10 DIN 912 A2
7	1	PR-10022	PR-23-P core
8	1	PR-9011	Thermal conductor
*	1	PR-9010	Disc spring set
9	2		Disc spring
10	1		Disc spring holder
11	6		Screw M5x10 DIN 912 A2

Item	Pcs.	Part No.	Description
12	1	PR-10101	Sensor processor card
13	8		Screw M3x5 DIN 7380 A4
14	1	PR-10300	Bus terminator card
15	1		O-ring seal 24x2
16	1	PR-9108	Dryer for PR-23
17	1		O-ring seal 89.5x3
18	1	PR-10000	PR-23 cover
19	4		Screw M4x30 DIN 912 A4
20	1	PR-10002	O-ring seal 83x3
21	1		PR-23-G nameplate
22	4		Screw M4x8 DIN 964 A4
23	1		Cable gland M16x1.5

9.5.4 PR-23-GP mounting specifics

Model	
PFC-23-GP-ASS-Y-NC	190.5 [7.5]
PFC-23-GP-DSS-Y-NC	200 [7.874]
PFC-23-GP-JSS-Y-NC	185 [7.283]

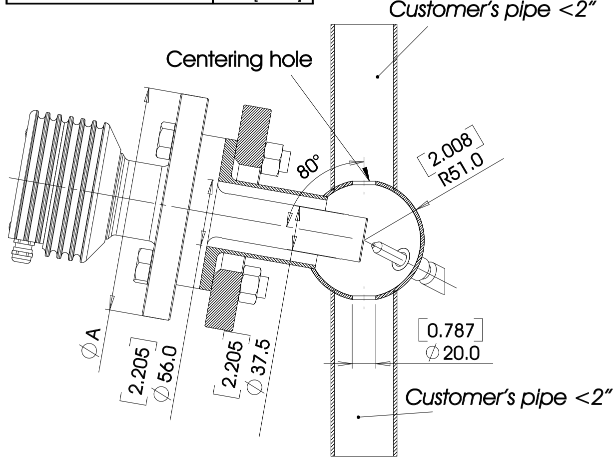
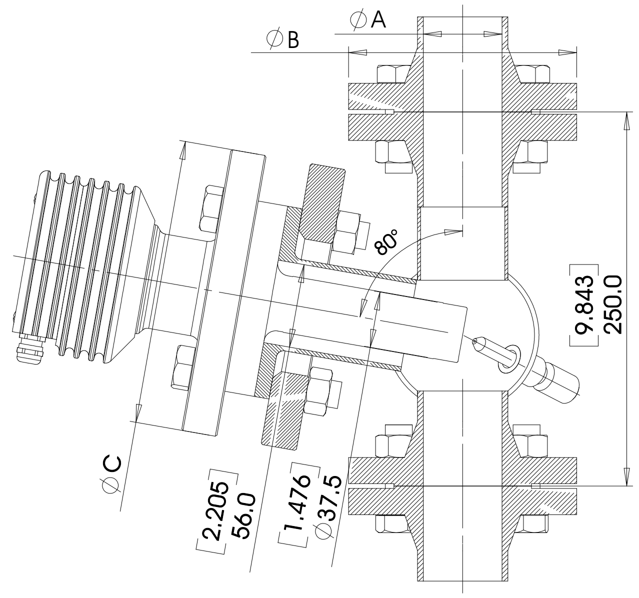


Figure 9.11 PR-23-GP-A/D/JSS Y flowcell



Model	A	B	C
PFC-23-GP-ASS-A10-NC	26.7 [1.051]	108 [4.252]	190.5 [7.5]
PFC-23-GP-ASS-A20-NC	52.6 [2.071]	152.3 [6]	190.5 [7.5]
PFC-23-GP-DSS-D10-NC	25 [1]	115 [4.528]	200 [7.874]
PFC-23-GP-DSS-D20-NC	51 [2]	165 [6.496]	200 [7.874]
PFC-23-GP-JSS-J10-NC	25 [1]	125 [4.921]	185 [7.283]
PFC-23-GP-JSS-J20-NC	51 [2]	155 [6.102]	185 [7.283]

Figure 9.12 PR-23-GP-A/D/JSS flowcell

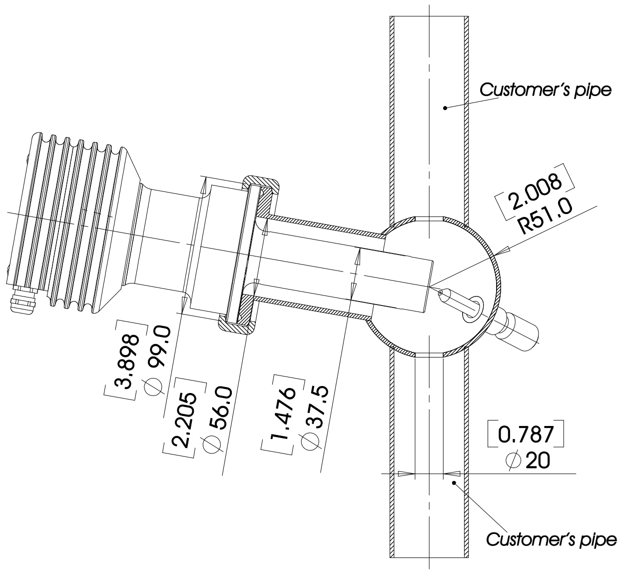
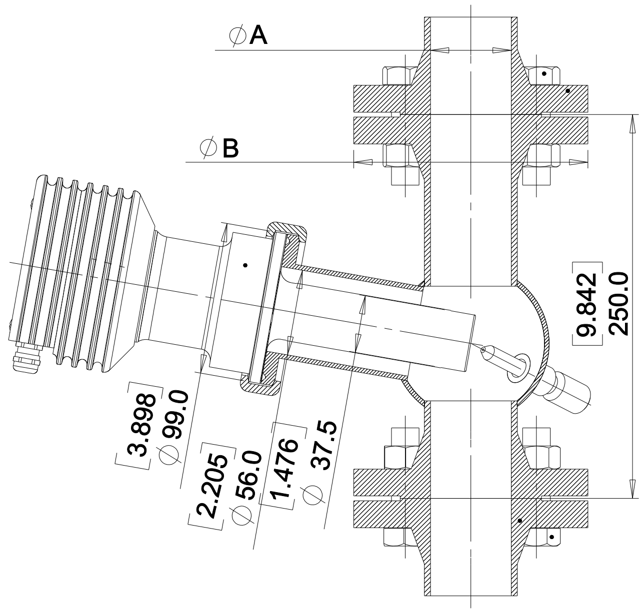


Figure 9.13 PR-23-GP-LSS Y flowcell



Model	A	B
PFC-23-GP-LSS-A10-NC	26.7 [1.051]	108 [4.252]
PFC-23-GP-LSS-A20-NC	52.6 [2.071]	152.4 [6]
PFC-23-GP-LSS-D10-NC	25 [1]	115 [4.528]
PFC-23-GP-LSS-D20-NC	51 [2]	165 [6.496]
PFC-23-GP-LSS-D20-NC	25 [1]	125 [6.102]
PFC-23-GP-LSS-J20-NC	51 [2]	155 [6.102]

Figure 9.14 PR-23-GP-LSS flowcell

9.6 Teflon body refractometer PR-23-M/MS

K-Patents Teflon body refractometer PR-23-M/MS is designed for use in chemically aggressive solutions and ultra-pure fine chemical processes. PR-23-M is an all-purpose model, PR-23-MS is designed especially for the semiconductor industry. The sensor has a built-in flow cell designed to keep all metal and other easily corroding parts from coming into contact with the process liquid. All the wetted parts are made of non-metallic materials, either PTFE (Teflon®) or PVDF (Kynar®), and thus the PR-23-M/MS sensor withstands corrosion very well.

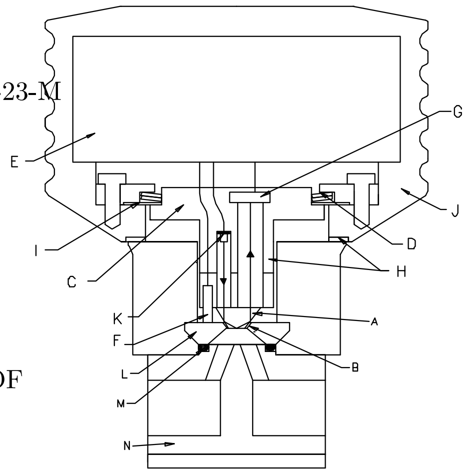


Figure 9.15 The PR-23-M/MS sensor

The flow cell (N) and the sapphire plate (L) are fixed to the stainless steel sensor with four screws. The flow cell (N) is sealed by a Kalrez O-ring (M).
The flow cell prevents any leakage reaching the metal parts, because there is a circular leakage chamber behind the O-ring (M). The chamber connects to a checkport, which has a 1/8" female thread connection.

9.6.1 PR-23-M/MS sensor model code

MODEL AND DESCRIPTION	MODEL
PR-23 = Sensor	PR-23
Sensor model -M = Aggressive medium adapter -MS = Aggressive medium adapter, semiconductor industry	 -M -MS
Refractive Index range limits 62 = n_D 1.320–1.530 (0–100 Conc% b.w.) 74 = n_D 1.260–1.460	 62 74
Process connection -R = Thread (G 1/2 inch) -N = Thread (1/2 inch NPT female)	 -R -N
Line size connection diameter 50=1/2 inch (flow volume 2-8 l/min (0.5-2.1 GPM))	 50
Flow cell wetted parts material -PV = Kynar® (PVDF=Polyvinylidenefluoride) (A) -TF = Teflon® (PTFE=Polytetrafluoroethylene) (A) -TM = Modified PTFE Ultra-Pure (PTFE=Polytetrafluoroethylene) (B)	 -PV -TF -TF
Electrical classification -GP = General purpose	 -GP
Sensor housing -SC = Stainless steel (A) -EC = Epoxy coated aluminium (B)	 -SC -EC

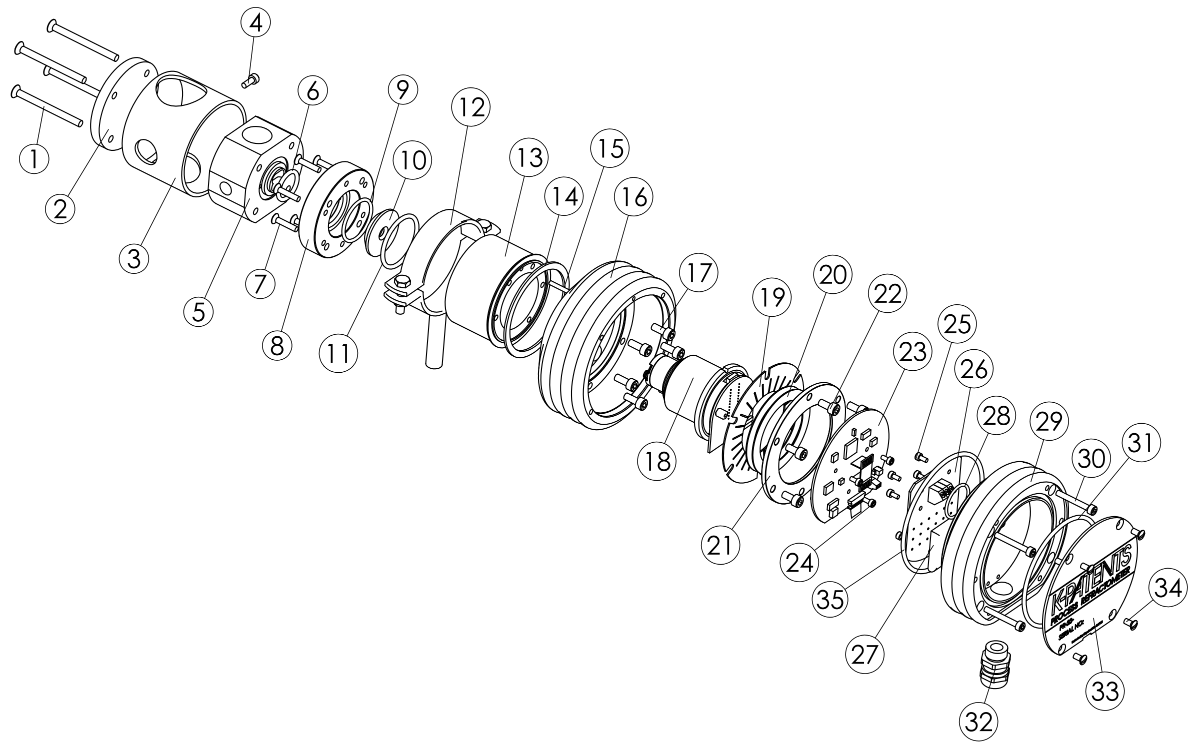
(A) with -M only
(B) with -MS only

Example: Sensor: PR-23-M62-N-050-TF-GP-SC, PR-23-MS-74-F50-TM-GP-EC

9.6.2 PR-23-M/MS specifications

General specifications	
Refractive Index range, standard:	Full range n_D 1.3200–1.5300 (corresponds to hot water – 100% b.w.)
Refractive Index range, option	With sapphire prism n_D 1.2600–1.4600
Accuracy:	Refractive index n_D ± 0.0002 (corresponds typically to ± 0.1 % by weight) Repeatability and stability correspond to accuracy
Speed of response:	1 s undamped, damping time selectable up to 5 min
Calibration:	With Cargille certified refractive index liquids over full range of n_D 1.3200–1.5300
CORE-Optics:	No mechanical adjustments (US Patent No. US6067151)
Digital measurement:	3648 pixel CCD element
Light source:	Light emitting diode (LED) 589 nm wavelength, sodium light
Temperature sensor:	Built-in Pt-1000
Temperature compensation:	Automatic, digital compensation
Instrument verification:	With certified refractive index liquids and K-Patents documented procedure
Ambient temperature:	Sensor: max. 45 °C (113 °F), min. -20 °C (-4 °F) Indicating transmitter: max. 50 °C (122 °F), min. 0 °C (32 °F)
SENSOR PR-23-M/MS:	Teflon body sensor model for aggressive medium
Process connection:	Thread G 1/2" or 1/2" NPT female
Process pressure:	max. 10 bar (145 psi)
Process temperature:	max. 130 °C (266 °F)
Process wetted parts, standard:	Teflon® (PTFE) or Kynar® (PVDF), prism gaskets MTF (Modified Teflon), prism Spinel, O-ring Kalrez, adaptor sapphire
Process wetted parts, option:	prism sapphire
Sensor protection class:	IP67, Nema 4X
Sensor weight:	5.5 kg (12.1 lbs)

9.6.3 PR-23-M/MS parts lists



Item	Pcs.	Part No.	Description
1	4		Screw M5x60 DIN 7991 A4
2	1		PR-23-M endplate
2	1		PR-23-MS endplate
3	1	PR-9129	PR-03/23-M protection cover
3	1	PR-9129-EC	PR-23-MS protection cover
4	1		Screw DIN 912 M4x10 A4
5	1	PR-9120	PR-03/23-M-PV-R05 flow cell (PVDF)
5	1	PR-9121	PR-03/23-M-TF-R05 flow cell (PTFE)
6	1	PR-9240	O-ring seal 19.2 x 3 Kalrez 4079
7	6		Screw M4 x 20 DIN 7991 A4
8	1		PR-03/23-M headring (PVDF)
9	1	PR-9112	O-ring seal 30.3 x 2.4 FPM
10	1	PR-9122	Sapphire plate for PR-03/23-M
11	1	PR-9113	O-ring seal 37.3 x 3 FPM
12	1	PR-9100	Sensor support
12	1	PR-9100-EC	MS Sensor support
13	1	PR-11101	PR-23-M head
13	1	PR-11101-EC	PR-23-MS head
14	1		Thermal insulator PTFE (Teflon®)
15	1		Alignment pin
16	1	PR-10005	PR-23 base
16	1	PR-10005-EC	PR-23-EC base

Item	Pcs.	Part No.	Description
17	6		Screw M5x10 DIN 912 A2
18	1	PR-10012	PR-23 compact sensor CORE module
19	1	PR-9011	Thermal conductor
*	1	PR-9010	Disc spring set
20	2		Disc spring
21	1		Disc spring holder
22	6		Screw DIN 912 M5x12 A2
23	1	PR-10101	Sensor processor card
24	4		Screw M3x6 DIN 912 A2
25	4		Screw M3x6 DIN 912 A2
26	1	PR-10300	Bus terminator card
27	1	PR-9108	Dryer for PR-23
28	1		O-ring seal 24 x 2
29	1	PR-10000	PR-23 cover
29	1	PR-10000-EC	PR-23-EC cover
30	4		Screw M4x30 DIN 912 A4
31	1	PR-10002	O-ring seal 83x3
32	1		Cable gland M16x1.5
33	1		PR-23-M nameplate
34	4		Screw M4x8 DIN 964 A4
35	1		O-ring seal 89.5 x 3

9.6.4 PR-23-M/MS mounting specifics

K-Patents Teflon body refractometer PR-23-M/MS is connected to the process by a G1/2" female or a 1/2" NPT process connection, Figure 9.16 below.

Important: Always install PR-23-M/MS with **sensor support** to prevent the sensor weight from pulling at the non-metallic piping. See Figure 9.16 for support placement.

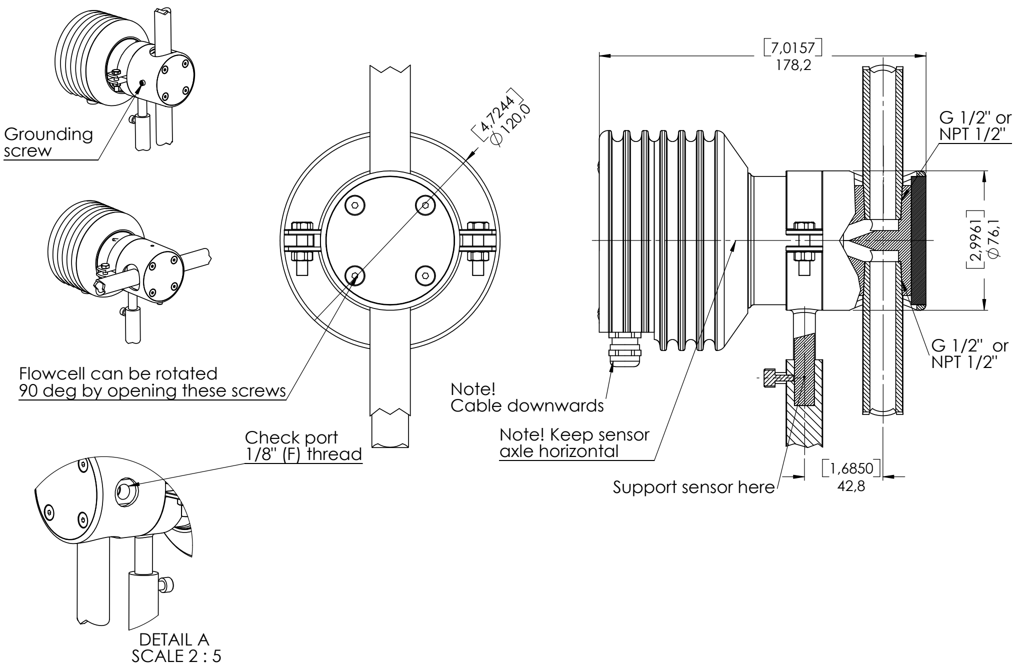


Figure 9.16 G1/2" female process connection (mm [in])

Note: The PR-23-M/MS flowcell is easy to rotate 90° by opening the four screws, turning the flowcell and tightening the screws in this new flowcell position (see Figure 9.16) above.

9.7 Saunders body refractometer PR-23-W

The Saunders body refractometer PR-23-W is a heavy-duty instrument designed for chemically aggressive liquids and ultra-pure fine chemicals in *large-scale production* and in *large pipelines*. The materials and design of the sensor are similar to the Teflon body refractometer PR-23-M, but the Saunders body makes it possible to fit this refractometer into 50, 80 or 100 mm (2", 3" or 4") pipelines.

The Saunders body material is graphite cast iron lined with 3 mm PFA (Fluorinated ethylene propylene) fluoroplastic. The cast iron provides a solid mechanical base and the PFA lining ensures the chemical resistance.

The sensor itself is built just like the PR-23-M sensor (see Section 9.6) and it is fixed to the Saunders body in the same way, with a sapphire plate and a Kalrez O-ring to keep all the metallic parts away from the process liquid.

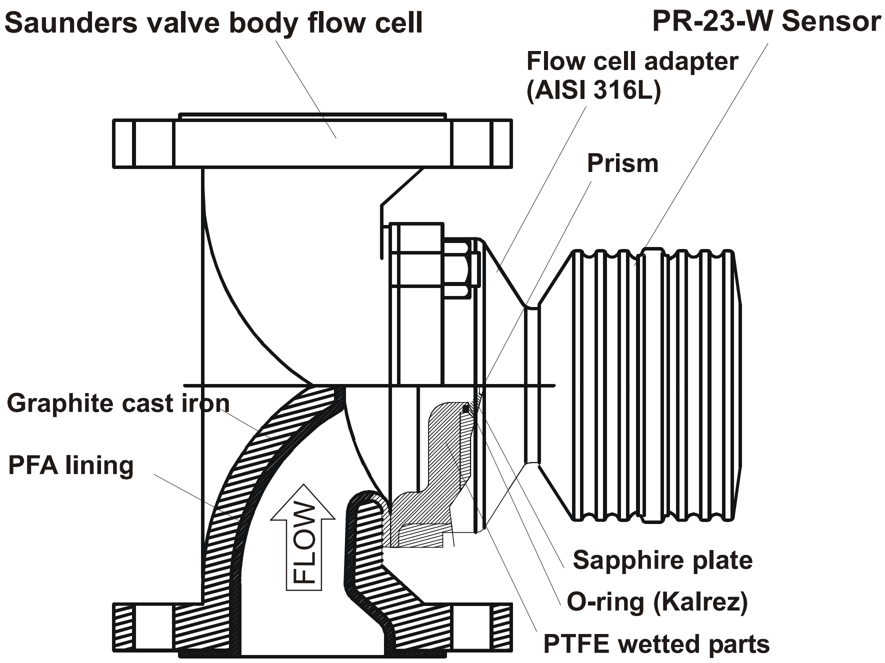


Figure 9.17 PR-23-W Saunders body sensor

9.7.1 PR-23-W sensor model code

MODEL AND DESCRIPTION	MODEL
PR-23 = Sensor	PR-23
Sensor model -W = Aggressive medium Saunders body flow cell	-W
Refractive Index range limits 62 = n_D 1.320–1.530 (0–100 Conc% b.w.) 74 = n_D 1.260–1.4600	62 74
Sensor wetted parts material -TF = Teflon® (PTFE=Plytetrafluoroethylene)	-TF
Sensor/diaphragm valve body connection 4 = Adapter for 4 inch/DN 100 valve body 3 = Adapter for 3 inch/DN 80 valve body 2 = Adapter for 2 inch/DN 50 valve body	4 3 2
Electrical classification -GP = General purpose, Nema 4x	-GP
Sensor housing -SC = Stainless steel	-SC

Example: Sensor: PR-23-W62-TF4-GP-SC

SAUNDERS VALVE BODY FOR SENSOR PR-23-W	MODEL
SVB = Saunders valve body	SVB
Process line connection -A040 = ANSI flange 4 inch 150 lbs -A030 = ANSI flange 3 inch 150 lbs -A020 = ANSI flange 2 inch 150 lbs -D100 = DIN flange DN 100 PN 16 -D080 = DIN flange DN 80 PN 16 -D050 = DIN flange DN 50 PN 16	-A040 -A030 -A020 -D100 -D080 -D050
Valve body material -GC = Graphite cast iron	-GC
Valve body lining material -PFA = PFA (= Fluorinated ethylene propylene)	-PFA

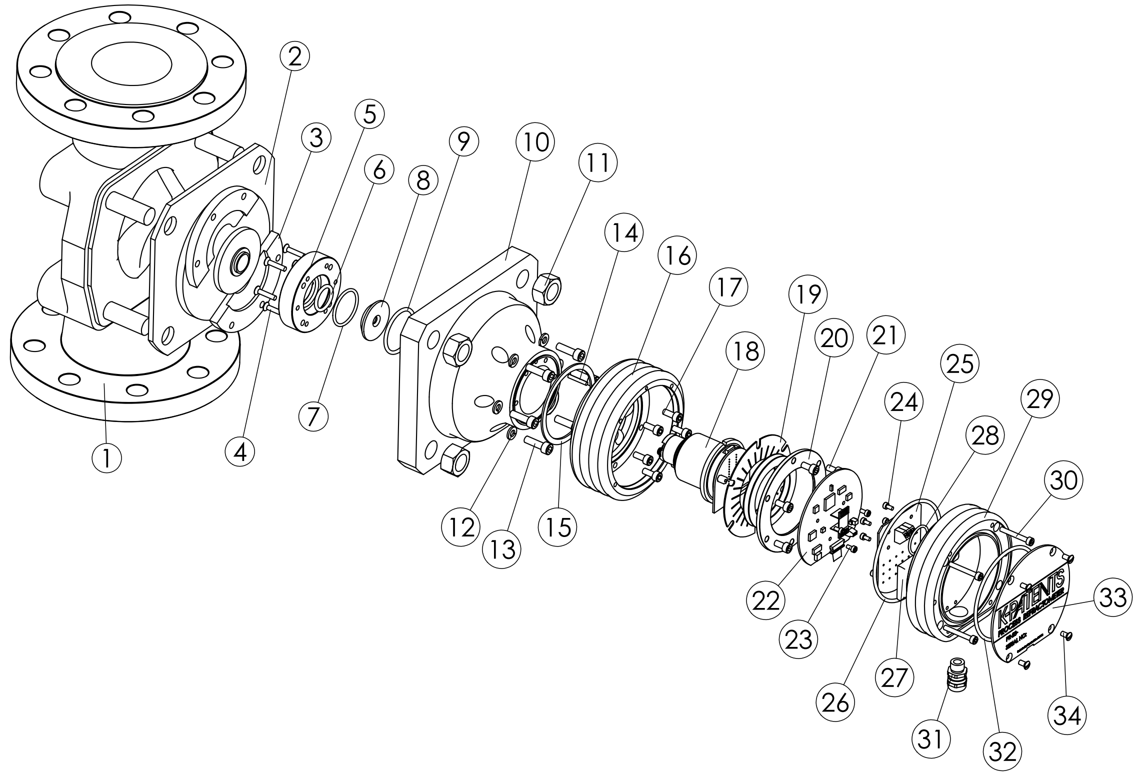
Example: Valve body: SVB-A040-GC-PFA

9.7.2 PR-23-W specifications

General specifications	
Refractive Index range, stand.:	Full range n_D 1.3200–1.5300 (0–100 Conc% b.w.) with Spinel prism
Refractive Index range, option:	n_D 1.2600–1.4600 with sapphire prism
Accuracy:	Refractive index n_D ± 0.0002 (corresponds typically to ± 0.1 % by weight) Repeatability and stability correspond to accuracy
Speed of response:	1 s undamped, damping time selectable up to 5 min
Calibration:	With Cargille certified refractive index liquids over full range of n_D 1.3200–1.5300
CORE-Optics:	No mechanical adjustments (US Patent No. US6067151)
Digital measurement:	3648 pixel CCD element
Light source:	Light emitting diode (LED) 589 nm wavelength, sodium light
Temperature sensor:	Built-in Pt-1000
Temperature compensation:	Automatic, digital compensation
Instrument verification:	With certified refractive index liquids and K-Patents documented procedure
Ambient temperature:	Sensor: max. 45 °C (113 °F), min. -20 °C (-4 °F) Indicating transmitter: max. 50 °C (122 °F), min. 0 °C (32 °F)
SENSOR PR-23-W:	Saunders body sensor for aggressive process medium
Process connection:	With PFA (fluorinated ethylene propylene) lined Saunders valve body 2", 3" or 4"
Process pressure:	max. 10 bar (145 psi)
Process temperature:	-20 °C–+130 °C (-4 °F–+266 °F)
Process wetted parts, stand.:	Teflon® (PTFE), prism spinel or sapphire, prism gaskets MTF (Modified Teflon)
Sensor protection class:	IP67, Nema 4X
Sensor weight:	Sensor and 2" Saunders body 15 kg (33 lbs), sensor and 3" Saunders body 26 kg (57 lbs), sensor and 4" Saunders body 33 kg (73 lbs)
SAUNDERS VALVE BODY	
Valve body material	Graphite cast iron
Valve body lining material	PFA (Fluorinated ethylene propylene)
Process connection	ANSI flange 4 inch 150 lbs / ANSI flange 3 inch 150 lbs / ANSI flange 2 inch 150 lbs

/ DIN flange DN 100 PN 16 / DIN flange DN 80 PN 16 / DIN flange DN 50 PN 16

9.7.3 PR-23-W parts lists

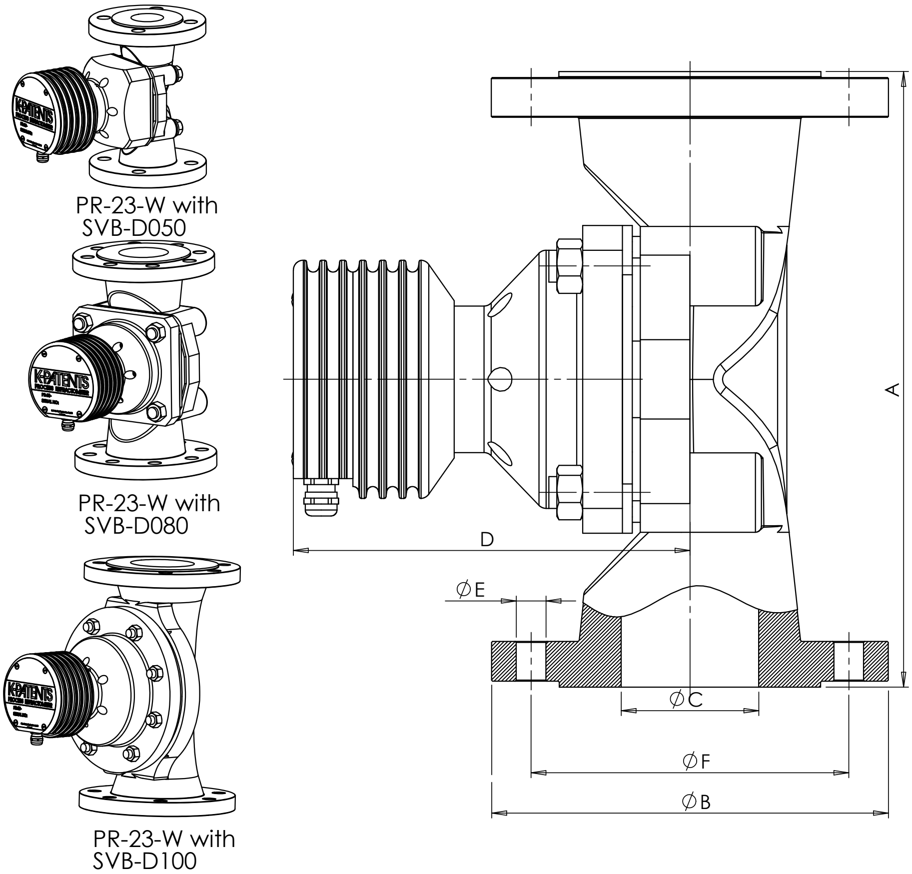


Item	Pcs.	Part No.	Description
1	1		Saunders valve body PFA lining ANSI 2"/DIN 50
1	1		Saunders valve body PFA lining ANSI 3"/DIN 80
1	1		Saunders valve body PFA lining ANSI 4"/DIN 100
2	1		Facing for 2" valve body
2	1		Facing for 3" valve body
2	1		Facing for 4" valve body
3	2		Split disc
4	6		Screw M4x20 DIN 7991 A4
5	1		PR-03/23-W headring (PVDF)
6	1	PR-9240	O-ring seal 19.2 x 3 Kalrez 4079
7	1	PR-9112	O-ring seal 30.3 x 2.4 FPM
8	1	PR-9122	Sapphire plate for PR-03/23-W
9	1	PR-9113	O-ring seal 37.3 x 3 FPM
10	1	PR-10102	PR-23-W 2" head
10	1	PR-10103	PR-23-W 3" head
10	1	PR-10104	PR-23-W 4" head
11	4		Nuts DIN 934 M16 A4
12	6		Washers DIN 127 M6 A4
13	6		Screws DIN 912 M6x20 A4
14	1		Thermal insulator PTFE (Teflon®)
15	1		Alignment pin
16	1	PR-10005	PR-23 base
17	6		Screw M5x10 DIN 912 A2
18	1	PR-10012	PR-23 compact sensor CORE module
19	1	PR-9011	Thermal conductor

Item	Pcs.	Part No.	Description
*	1	PR-9010	Disc spring set
	2		Disc spring
20	1		Disc spring holder
21	6		Screw M5x10 DIN 912 A2
22	1	PR-10100	Sensor processor card
23	4		Screw M3x6 DIN 912 A2
24	4		Screw M3x6 DIN 9112 A2
25	1	PR-10300	Bus terminator card
26	1		O-ring seal 89.5 x 3
27	1	PR-9108	Dryer for PR-23
28	1		O-ring seal 24 x 2
29	1	PR-10000	PR-23 cover
30	4		Screw M4x30 DIN 912 A4
31	1		Cable gland M16x1.5
32	1	PR-10002	O-ring seal 83x3
33	1		PR-23-W nameplate
34	4		Screw M4x8 DIN 964 A4

9.7.4 PR-23-W mounting specifics

PR-23-W Saunders valve body flow cell can be mounted either vertically or horizontally. Special sensor support is not needed as the valve body (piping) supports the sensor. Either way sensor cover should always be horizontal to avoid sedimentation or gas/air pocket on the prism. Also installation after pump, before valve and low installation point will reduce risk of air/gas pocket. Recommended flow velocity is 1.5–6m/s (5–20ft/s).



Saunders valve body	Flange size	A	B	C	D	E	F
SVB-A020	ANSI 2" 150psi	196 [7.72]	152.4 [6]	47 [1.85]	189 [7.40]	19.1 [0.75]	120.7 [4.75]
SVB-D050	DN50 10bar	230 [9.06]	165 [6.50]	50 [1.97]	189 [7.40	18 [0.71]	125 [4.92]
SVB-A030	ANSI 3" 150psi	260 [10.24]	190.5 [7.5]	78 [3.07]	205 [8.07]	19.1 [0.75]	152.4 [6]
SVB-D080	DN80 10bar	310 [12.2]	200 [7.87]	80 [3.15]	205 [8.07]	18 [0.71]	160 [6.30]
SVB-A040	ANSI 4" 150psi	311 [12.24]	228.6 [9]	92 [3.62]	256 [10.08]	19.1 [0.75]	190.5 [7.5]
SVB-D100	DN100 10bar	350 [13.78]	220 [8.66]	100 [3.94]	256 [10.08]	18 [0.71]	180 [7.09]

Figure 9.18 PR-23-W mounting

9.8 PR-23 process refractometers in potentially explosive atmosphere

The PR-23 refractometer series can be used in locations with potentially explosive atmosphere *with following modifications, made by K-Patents Oy*. The refractometer sensor's compliance with the Essential Health and Safety Requirements are assured by complying with standard EN 50 021:1999.

The PR-23-...-AX refractometers have been certified by KEMA Quality B.V. under European ATEX directive 94/9/EC **for ATEX EX II 3 G/Cenelec Eex nA IIC T4**. The EX-Type Certificate Number is KEMA 05ATEX 1183X. The report number is KEMA No. 207 8654.

The PR-23-...-FM refractometers are certified by Factory Mutual Research Corporation, Approval ID 3026104. Equipment Ratings: Nonincendive for use in Class I, Division 1, Groups A, B, C & D, Hazardous (Classified) Locations. Temperature identification rating for PR-23-...-FM is T6 (T_{amb} = 45 °C).

The PR-23-...-CS refractometers are certified by Canadian Standards Association for Class I, Groups A-D. The Certificate Number is 1706327. Equipment Ratings: Nonincendive for use in Class I, Division 2, Groups A, B, C & D, Hazardous (Classified) Locations. Temperature identification rating for PR-23-...-CS is T4 (T_{amb} = 45 °C).

9.8.1 Equipment

The K-Patents refractometer system (Figure 9.19) for potentially explosive atmosphere locations consists of a modified refractometer sensor PR-23-...-AX/FM/CS, a standard Indicating transmitter DTR and a sensor cable PR-8230-...

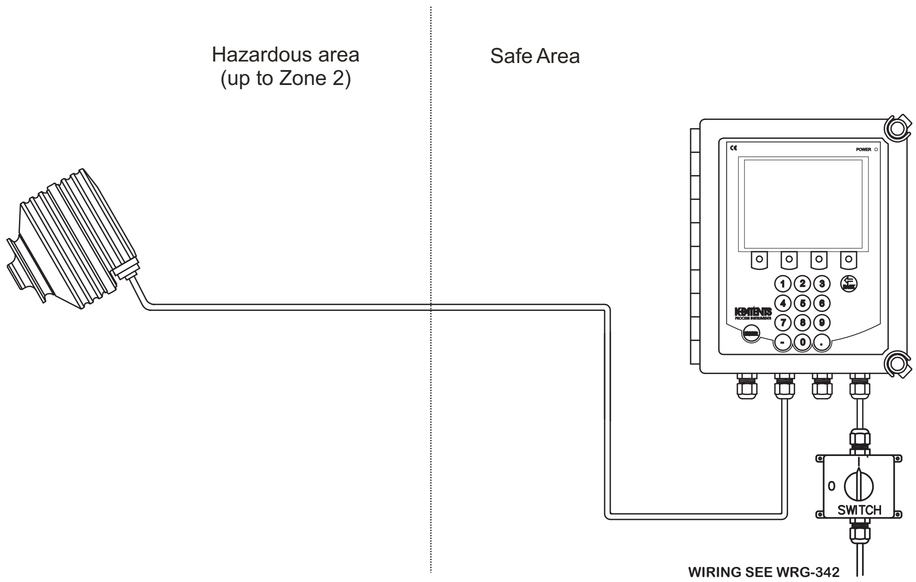
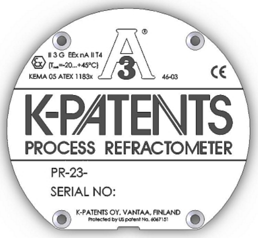


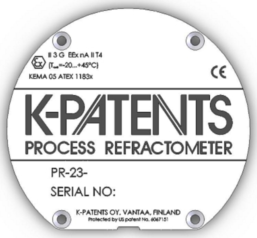
Figure 9.19 Refractometer system PR-23-...-AX/FM/CS

The ATEX/FM/CSA approved sensors PR-23-...-AX/FM/CS are identified by the sensor nameplate, see Figure 9.1. The Indicating transmitter is a standard DTR.

The approvals are valid for sensors PR-23-AC, PR-23-AP, PR-23-GP, PR-23-M and PR-23-W.

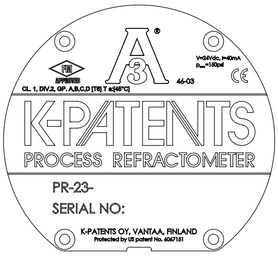


PR-23-AC/AP-...-AX nameplate

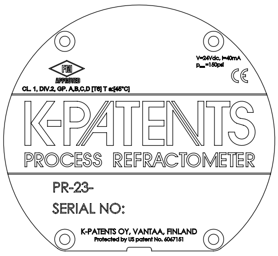


-AX nameplate, all other models

EX approval symbol

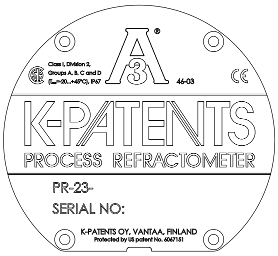


PR-23-AC/AP-...-FM nameplate

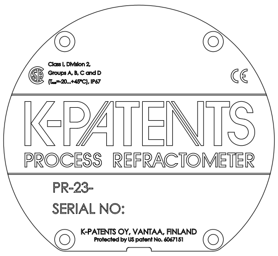


-FM nameplate, all other models

FM approval symbol



PR-23-AC/AP-...-CS nameplate



-CS nameplate, all other models

CSA approval symbol

Figure 9.20 PR-23-...-AX/FM/CS sensor nameplates

9.8.2 Installation

Sensor wiring must follow drawing WRG-342, see Figure 9.21 on next page, Figure 4.2 on page 18 and Figure 4.4 on page 20.

Important: **The FM unit installations** must comply with the relevant requirements of National Electrical Code (ANSI/NFPA 70) for Division 2 Hazardous (Classified) Locations and all instructions in this manual. **All wiring of PR-23-...-FM systems must run in a conduit.**

Important: **Tampering and replacement with other than K-Patents original components is not allowed because this may affect adversely the safe use of the system.**

! **Warning!** Insertion or withdrawal of modules or replacement of fuses is to be accomplished only when the area is known to be free of flammable vapors.

Note: Sensor connector may not be connected or disconnected when the circuits are energized. Switch OFF the power from Indicating transmitter DTR external power switch before disconnecting sensor cable from sensor. After connecting sensor cable back to the sensor you can switch power back on.

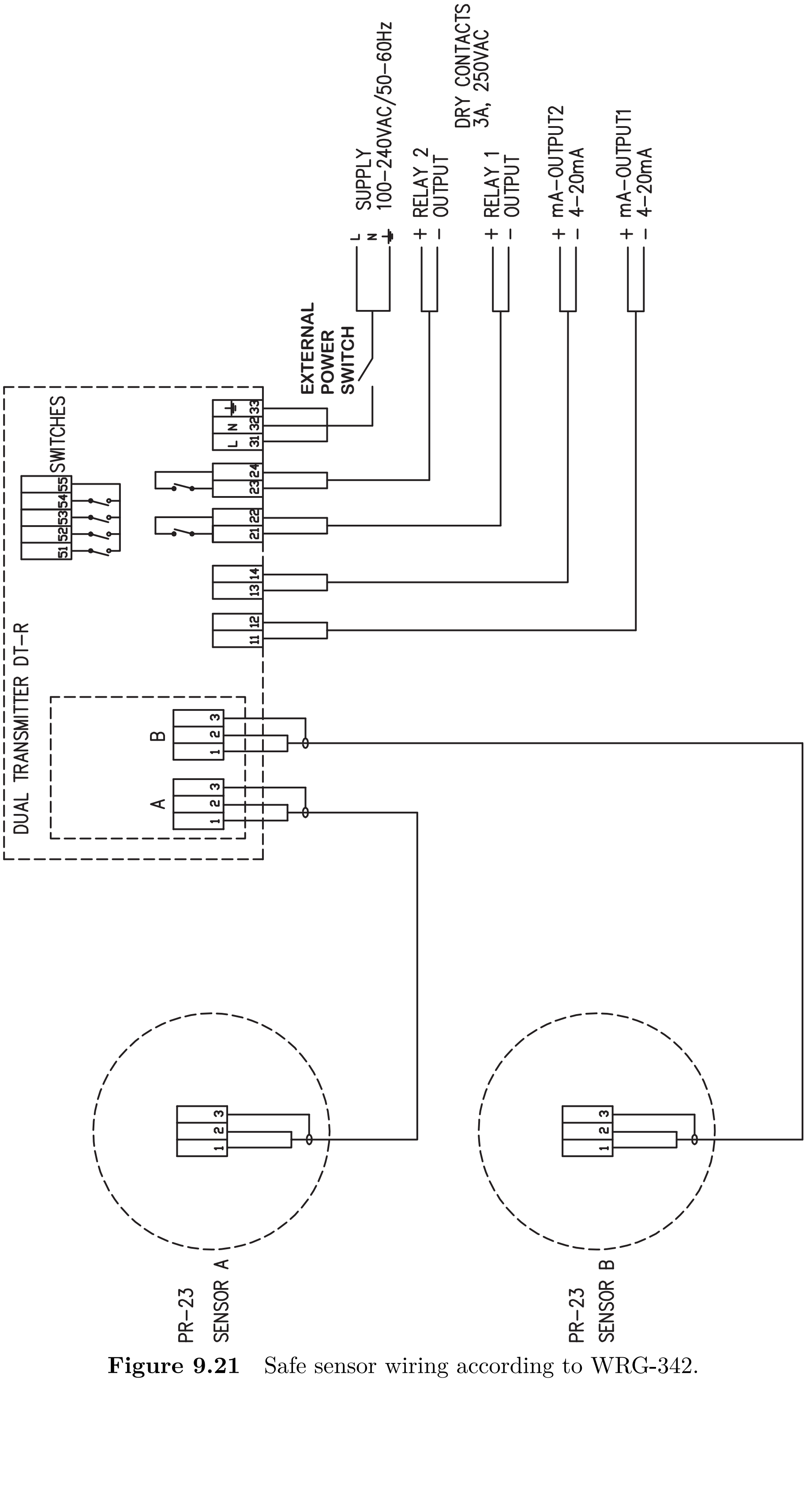


Figure 9.21 Safe sensor wiring according to WRG-342.

9.9 Intrinsically safe refractometers PR-23-...-IA and PR-23-...-IF

Hazardous locations are places where a possibility of fire or explosion exists because of flammable gases, vapors or fine dust.

Zone 0: An area in which an explosive gas-air mixture is continuously present or present for long periods of time.

Zone 1: An area in which an explosive gas-air mixture is likely to occur in normal operation.

The K-Patents Intrinsically Safe Process Refractometer PR-23-...-IA/-IF can be used in hazardous locations in Zone 0 and Zone 1 areas.

The PR-23-...-IA refractometer is certified by VTT under the European ATEX directive 94/9/EC and IEC / EN 60079 **for ATEX II 1G Ex ia IIC T4 Ga (T_{amb} = -20 – +65 °C)**. The EX Type Certificate Number is VTT07ATEX065X. This certification covers following EX standards: EN 60079-0:2006 (that also covers IEC 60079-0:2004) and EN 60079-11:2007 (that also covers IEC 60079-11:2006).

The PR-23-...-IF refractometer is certified by FM under the United States standards **for IS/I/1/ABCD/T4 and I/0/AEx ia/IIC/T4 (T_{amb} = -20 – +45 °C)** The certificate ID Number is 3036400. This certification covers the following US standards: class 3600 1998, class 3610:2007, class 3810:2005, ANSI/ISA-12.00.01:1999, ANSI/ISA-12.02.01:2002, ANSI/ISA-82.02.01:2004, ANSI/NEMA 250:1991 and ANSI/IEC 60529:2004.

The PR-23-...-IF refractometer is certified by FM under the Canadian standards **for IS/I/1/ABCD/T4 and I/0/Ex ia/IIC/T4 (T_{amb} = -20 – +45 °C)**. The certificate ID Number is 3036400C. This certification covers the following Canadian standards: CSA C22.2 No. 94:1999, CSA C22.2 No. 142:2004, CSA C22.2 No. 157:2006, CSA C22.2 No. 60529:2005, CSA C22.2 No. 61010.1-1:2004, CSA E60079-0:2007 and CSA E60079-11:2002.

Note: Servicing of the intrinsically safe PR-23-...-IA/-IF refractometer is only allowed for trained service personnel of K-Patents and its representatives. Servicing must be done according to separate instructions defined by K-Patents and must be reported to K-Patents.

9.9.1 Equipment

The K-Patents Intrinsically Safe Process Refractometer consists of: a modified refractometer sensor PR-23-...-IA/-IF, an Indicating transmitter STR with single sensor connectivity, and IS Isolator and cabling between the refractometer sensor and the transmitter (Figure 9.22).

The equipment is intrinsically safe only if **all** mounting instructions in Section 9.9.2 are followed. If the instrument has been in any way damaged during transportation, return it to your nearest K-Patents service point for checkup before installation. Never install a damaged instrument into the process line.

The intrinsically safe sensor PR-23-...-IA/-IF is identified by the nameplate, see Figure 9.23. The Indicating transmitter is of model STR, for single sensor connection.

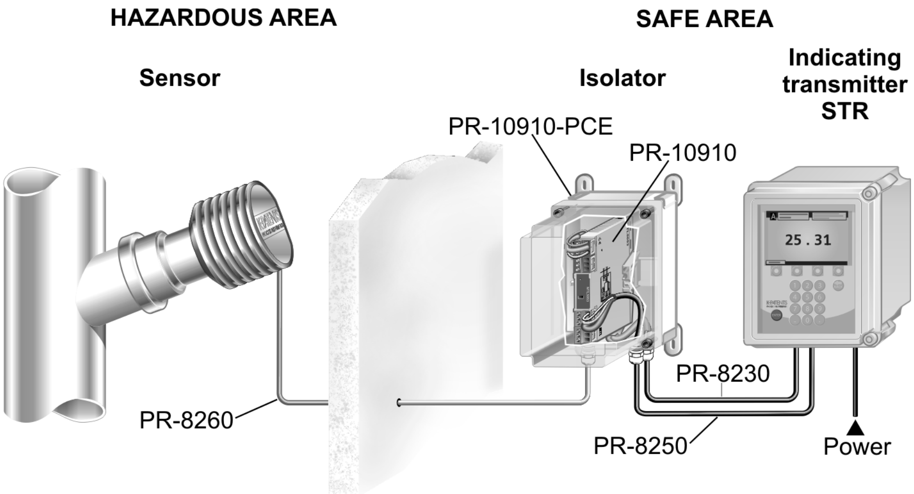
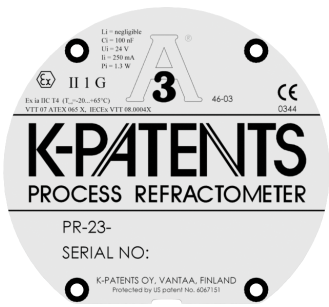
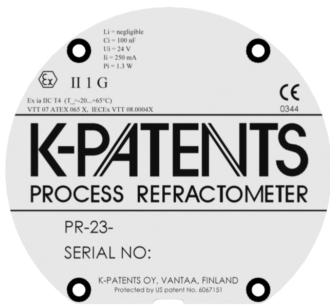


Figure 9.22 Refractometer system PR-23-...-IA/-IF



3-A approved intrinsically safe -IA sensor



Other intrinsically safe -IA sensor

3-A approved intrinsically safe -IF sensor

Other intrinsically safe -IF sensor

Figure 9.23 Intrinsically safe sensor nameplates

An intrinsically safe sensor has a different processor card and a different terminator card than a standard sensor, other parts are as in standard sensor (see earlier in this chapter for full parts lists).

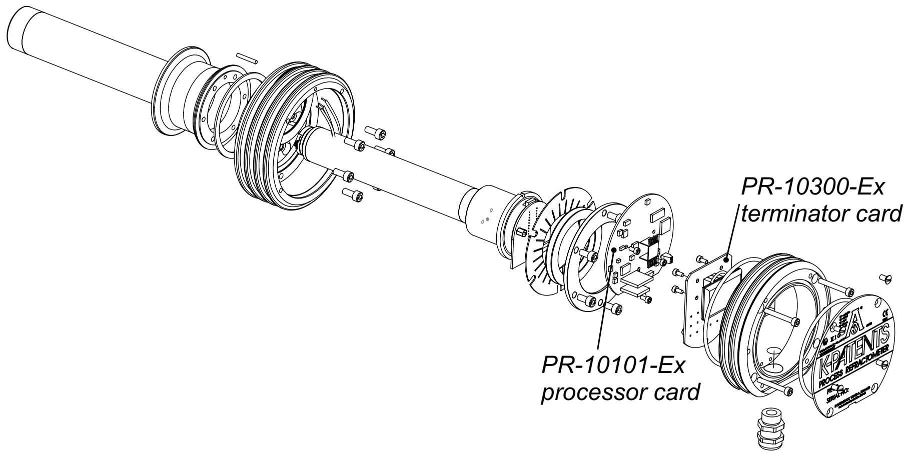


Figure 9.24 Intrinsically safe parts

Warning! Do not replace any part of an intrinsically safe sensor with a standard sensor part.

Important: If the sensor cover is made of aluminium, the refractometer sensor can cause ignition if it hits other metal parts during the installation. An aluminium sensor cover must have a sticker warning about this possibility.

Contains lightmetals
Ignition hazard!
Avoid impact!

Figure 9.25 Warning sticker

9.9.2 Intrinsically safe mounting

Choose the mounting location of the sensor, the isolator/barrier unit and the indicating transmitter so that they are protected from sudden impact and friction. If any of the system parts is affected by a sudden impact, power it off immediately and have it checked by trained K-Patents service personnel before it is used again.

The electrical connections for PR-23-...-IA are described in Figure 9.26. The electrical connections for PR-23-...-IF are described in Figure 9.27.

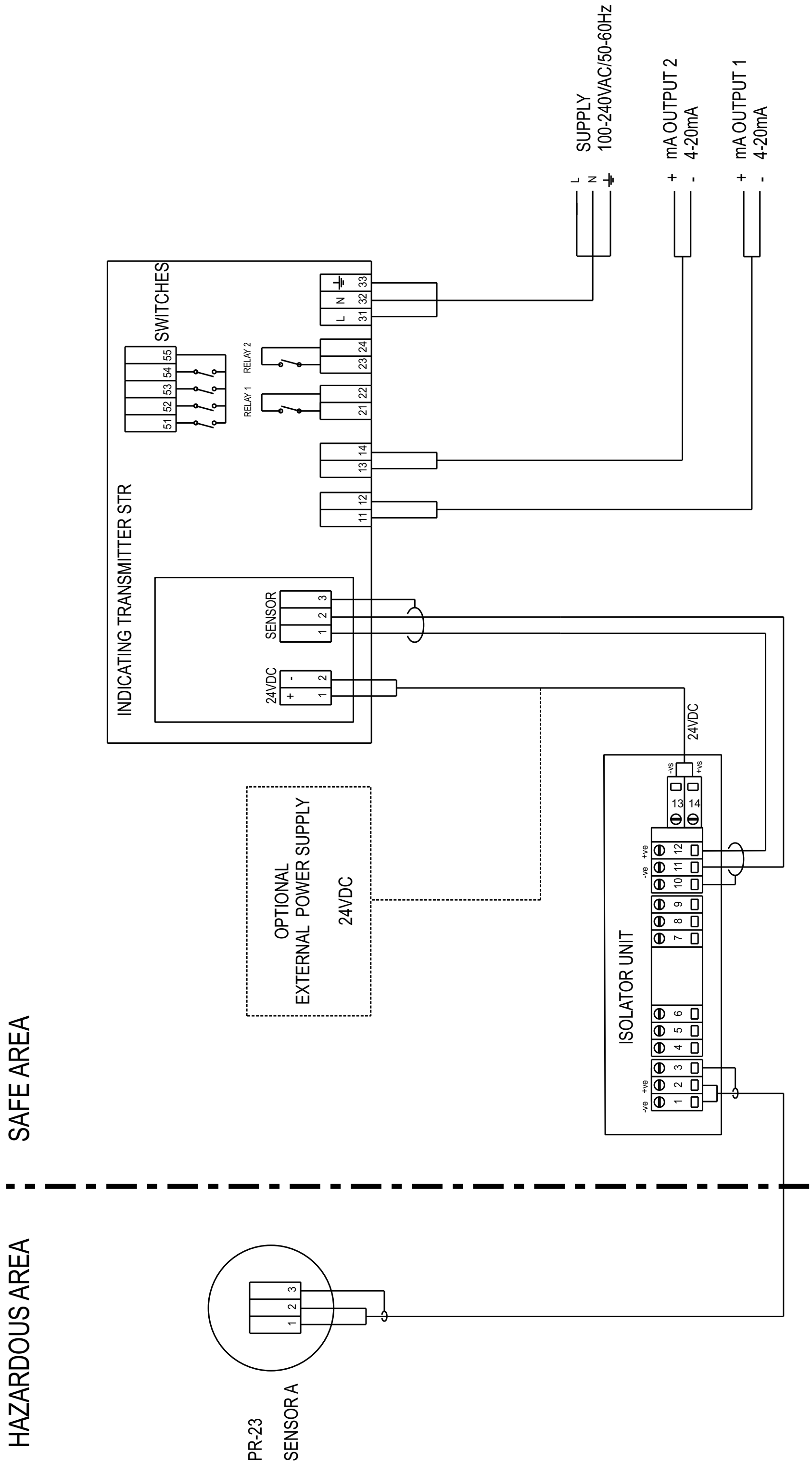


Figure 9.26 Intrinsically safe wiring, PR-23-...-IA

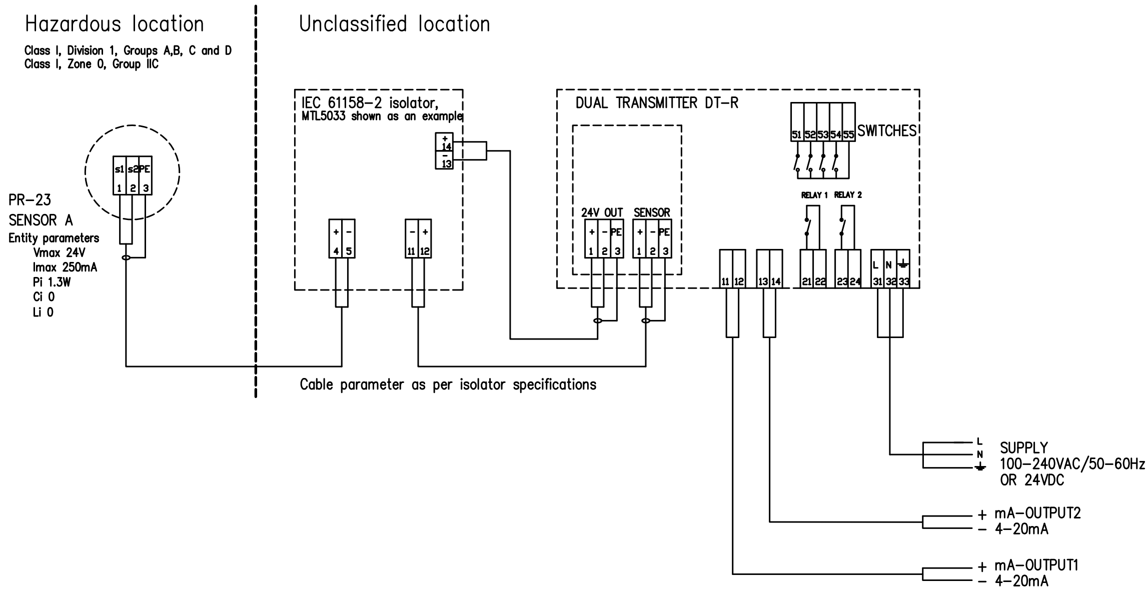


Figure 9.27 Intrinsically safe wiring, PR-23-...-IF

Notes:

In the United States, installation must be in accordance with the applicable requirements of ANSI/ISA RP12.6 and the national electrical code (ANSI/NFPA 70). In Canada installation must be in accordance with the applicable requirements of Canadian electrical code part I C22.2.1 section 18 and appendix F. Associated Apparatus manufacturer's installation drawing shall be followed when installing this equipment.

Ex ia is defined as Intrinsically Safe. The intrinsic safety concept allows the interconnection of two intrinsically safe devices. FM approved and CSA certified entity parameters are not specifically examined in combination as a system when:

Uo or Voc or Vt <= Vmax,
Io or Isc or It <= Imax
Ca or Co >= Ci + Ccable or
La or Lo >= Li + Lcable, Po < Pi.

Control equipment connected to the Associated Apparatus shall not use or generate more than 250 Vrms or Vdc. **Important:** Use supply wires suitable for 5 K above surrounding environment.

For Division 1 installations, the configuration of Associated Apparatus shall be FM Approved/CSA Certified under Entity Concept.

Cables:

- 10 m (33 ft) cable, part number PR-8230-010, connecting the Indicating transmitter STR and the Isolator unit.
  The maximum cable length is 100 m (330 ft).
- 10 m (33 ft) power cable, part number PR-8250-010, connecting the Indicating transmitter STR and the Isolator unit, part number PR-8250-010. The maximum length is 100 m (330 ft).
- The intrinsically safe cable between Isolator unit and sensor, part RP-8260-xxx, where xxx is the cable length in meters. The maximum length is 200 m (660 ft).
  For cable connections see Figures 9.26 and 9.28.

Note: Isolator/Barrier Unit can also use an optional *external* +24V DC power supply instead of the +24V DC power supply from the transmitter. +24V DC is connected to terminals 13 and 14. (If +24V DC is used, the PR-8250 power cable is not used at all.)

9.9.3 Isolator/barriers

Isolator unit wiring is explained below in Figure 9.28.

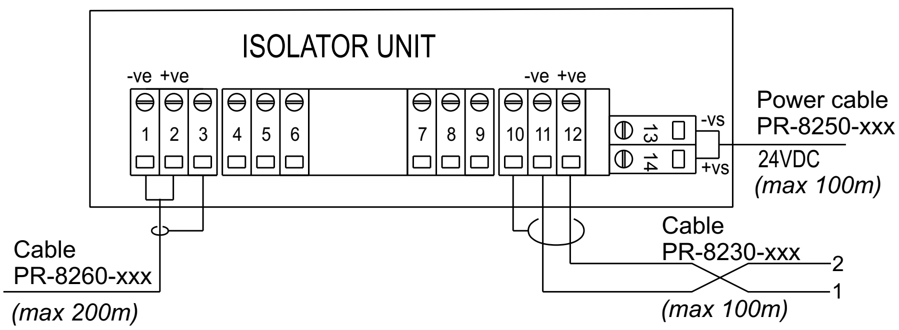


Figure 9.28 Isolator unit wiring

Note: If the power to Isolator unit terminals is not correctly connected, +24V DC to terminal 14 (+vs) and zero to terminal 13 (-vs), the transmitter STR will give the message No signal. Also if terminals 11 and 12 are not correctly connected, sensor cable connecting terminal 2 of the Indicating transmitter STR to the Isolator unit terminal 11 (-ve) and terminal 1 of the STR to Isolator unit terminal 12 (+ve) , the message No signal will appear.

10 Indicating transmitter DTR specifications

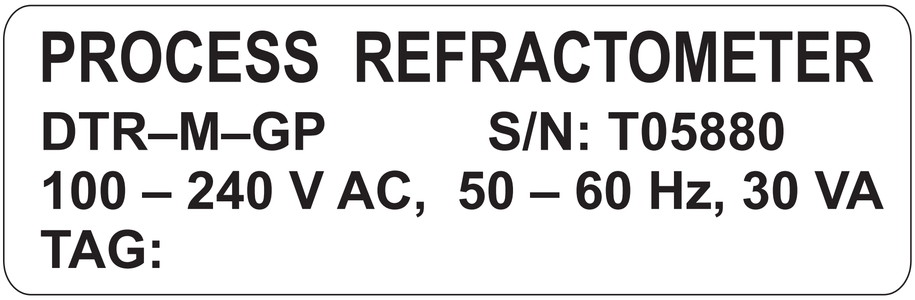


Figure 10.1 Indicating transmitter DTR serial number label

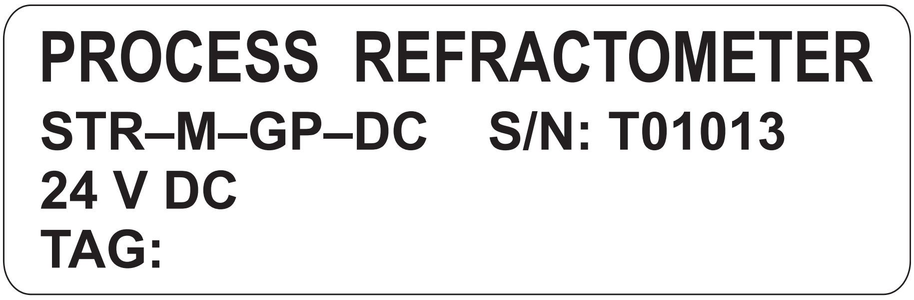


Figure 10.2 Indicating transmitter STR serial number label

10.1 Compatibility

The Indicating transmitter DTR is only compatible with the PR-23 refractometer range. Any one or two PR-23 refractometer sensors can be connected to the DTR. *PR-01 and PR-03 refractometer sensors are not compatible with an Indicating transmitter DTR.*

For intrinsically safe installations (see Section 9.9) there is a single-sensor version of the transmitter (STR). The information given in this chapter applies to STR as well, unless otherwise indicated.

10.1.1 Transmitter program versions

The DTR program version can be updated over the Ethernet connection (see Chapter 12) with K-Patents software. Contact your nearest K-Patents representative for more information on how to update your DTR program version.

Program version 3.0:
The DTR program version 3.0 is compatible with any K-Patents DTR and any PR-23 sensor with program version 1.00 or higher. This DTR program version contains following new features:

- **Single sensor mode** for the intrinsically safe PR-23-...-IA refractometer system (see Section 9.9). This mode combined with a special single connection H1 interface card PR-10705 creates an Indicating transmitter STR.
- **Divert functionality** enables the DTR to function as a part of a Divert Control System used to control black liquor concentration in paper and pulp applications. Divert mode only allows for one sensor per transmitter, but a standard DTR is used.

Program version 2.0:
The DTR program version 2.0 is compatible with any K-Patents DTR and any PR-23 sensor with program version 1.00 or higher. This DTR program version contains following new features:

- **Instrument homepage** with a fully functional remote panel, see Section 12.4.
- **Multi-lingual user interface**, enabling the user to switch between the available DTR interface languages, see Section 5.2.2.
- **Linear damping** for processes with fast changes, see Section 6.1.2.
- **Field sample soft key** for easier and more exact field calibration, see Section 6.2.3.
- **Printable verification certificate**, from program version 2.10 onwards; see Section 12.4.2.

10.2 Model code

10.2.1 Transmitter model code

MODEL AND DESCRIPTION	MODEL
DTR = Indicating transmitter (dual connectivity)	DTR
Cable connection -U = 1/2 inch NPT-type conduit hubs -M = M20x1.5 metric cable glands (with -GP option only)	 -U -M
Electrical classification -GP = General purpose	 -GP
Transmitter options -DC = Power supply 24 V DC	 -DC

Table 10.1 DTR model code

10.2.2 STR model code

MODEL AND DESCRIPTION	MODEL
STR = Indicating transmitter (single-sensor connectivity)	STR
Cable connection -U = 1/2 inch NPT-type conduit hubs -M = M20x1.5 metric cable glands (with -GP option only)	 -U -M
Electrical classification -GP = General purpose	 -GP
Transmitter options -DC = Power supply 24 V DC	 -DC

Table 10.2 STR model code

10.2.3 Interconnecting cable model code

PART NUMBER AND DESCRIPTION		PART NO.
PR-8230 =	Interconnecting cable between transmitter and sensor	PR-8230
Cable length -010 = -_ _ _ =	 10 meters (33 feet), standard length Specify cable length in meters with 10 meter increments. Max. length is 200 meters (660 feet)	 -010 -_ _ _

Table 10.3 Interconnecting cable model code

10.3 Specifications

10.3.1 Indicating transmitter specifications

Display:	320x240 pixel graphical LCD with LED backlight
Keypad:	18 membrane keys
Current output:	Two independent current sources, 4-20 mA, max. load 1000 Ohm, galvanic isolation 1500 VDC or AC (peak), hold function during prism wash
Power:	AC input 100-240 VAC/50-60 Hz/30 VA, optional 24 VDC
Alarms/Wash relays:	Two built-in signal relays, max. 250 V/3 A
Input switches:	Four switch inputs.
Current outputs:	Two current outputs configurable independently to indicate process concentration or temperature of either sensor.
Sensor connectivity, DTR:	One or two sensors can be connected to the transmitter. Sensors independent of each other: own parameter sets and usable in different applications.
Sensor connectivity, STR:	Only one sensor can be connected to the transmitter. Used with the Intrinsically safe sensor PR-23-...-IA.
Transmitter protection class:	Enclosure IP66, Nema 4X
Indicating transmitter weight:	4.5 kg (10 lbs)

10.3.2 Interconnecting cable specifications

Cable:	IEC 61158-2 compliant two-wire cable: two signal wires and shield copper area 0.8 mm^2 (18 AWG) cable resistance 24 Ohm/km (per wire) cable attenuation 3.0 dB/km @ 28 kHz
Cable length:	Standard 10 m (33 ft), max. total length 200 m (660 ft)

Note: For information on the *intrinsically safe cabling* for PR-23-...-IA, see Section 9.9.2 on page 101.

10.4 Transmitter parts list

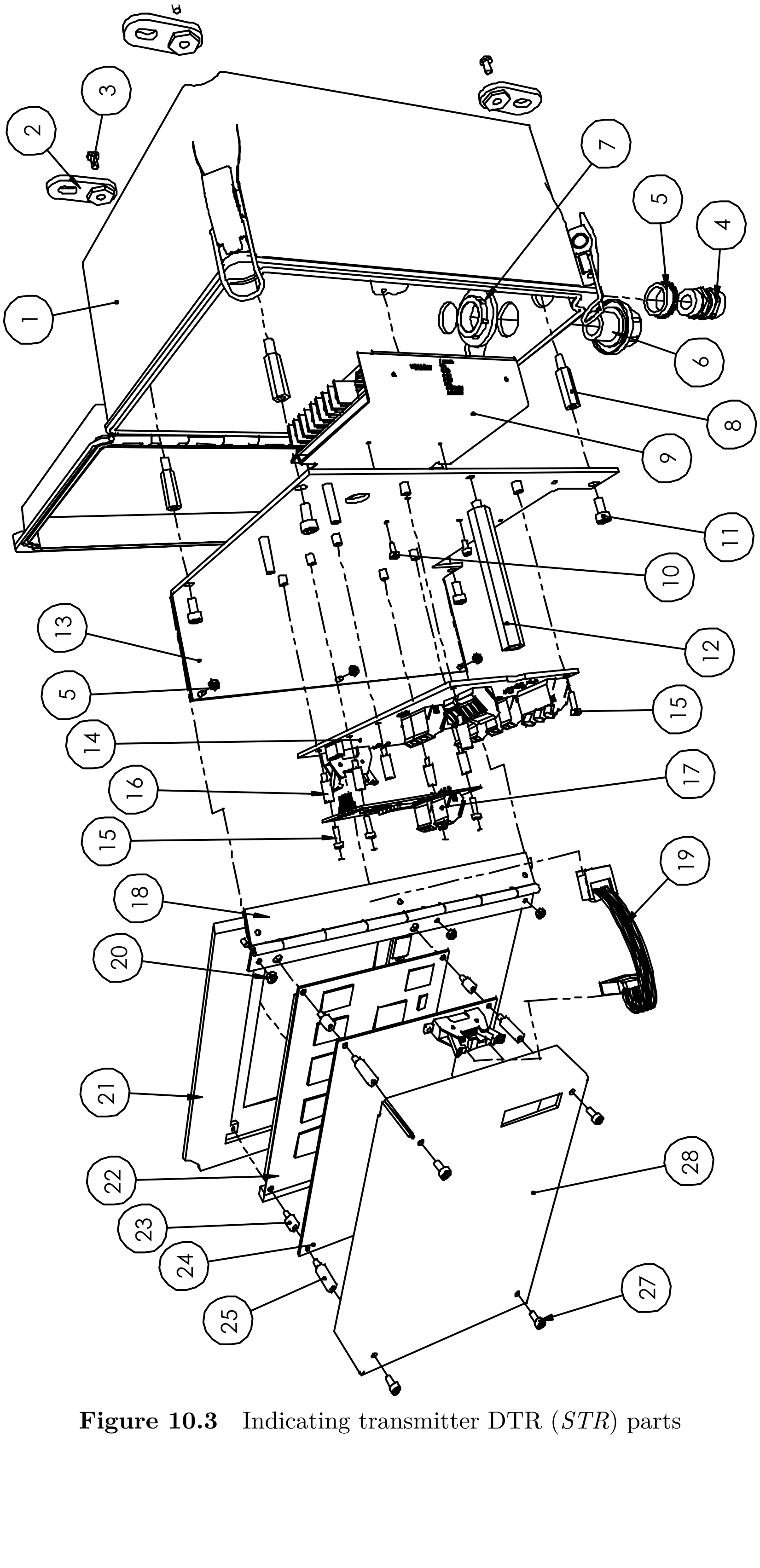


Figure 10.3 Indicating transmitter DTR (*STR*) parts

Item	Pcs.	Part No.	Description
1	1	PR-7602	Enclosure
2	4		Mounting feet
3	4		Screw 10-32 pan head
4	7		Cable gland PG11 (European)
5	7		Cable gland nut
6	7		Conduit hub 1/2 NPT-type ST-1 (US)
6	7		Cable gland M20x1.5 (European)
7	7		Conduit hub nut
8	4		Tower screw 10-32/M4
9	1	PR-10810	Power supply module 100-240 V AC 50-60 Hz
9	1	PR-10820	Power supply module 24 V DC
10	2		Screw M3x6 DIN 912 A2
11	4		Screw M4x10 DIN 912 A2
12	1		Tower screw M4x
13	1		Frame plate
14	1	PR-10600	Transmitter motherboard

Item	Pcs.	Part No.	Description
15	1		Screw M3x6 DIN 912 A2
16	6		Tower screw M3x13
17	1	PR-10701	H1 interface card
17	1	*PR-10705*	*Single sensor H1 interface card*
			For intrinsically safe system PR-23-...-IA
18	1		Piano hinge
19	1		Ribbon cable
20	6		M3 Nut A2
21	1		Keyboard panel
22	1		Display card
23	1		Tower screw M3x
24	1	PR-10500	Transmitter processor card
25	1		Tower screw
26	1		Cover
27	4		Screw M3x6 DIN 912 A2

11 Safe-Drive™

The K-Patents Safe-Drive™ system is used for safe insertion and removal of a refractometer sensor while the process line is under full process flow and pressure. The Safe-Drive™ system is typically used in a continuous process with infrequent shutdowns and large pipe size, diameter 50 mm (2") or above, e.g. in wood pulp industry.

11.1 System description

The Safe-Drive™ system consists of a Safe-Drive™ isolation valve welded to the process pipe, a PR-23-SD refractometer sensor and a Safe-Drive™ retractor used for sensor insertion and removal. The two-part Retractor can be kept separately in clean storage and all installed PR-23-SD sensors can be inserted and removed with one and same tool.

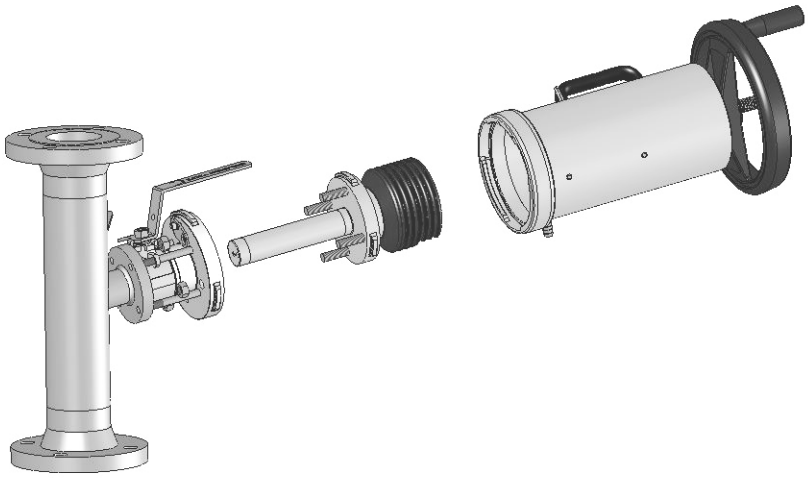


Figure 11.1 The Safe-Drive™ system:
Isolation valve, PR-23-SD sensor, Retractor

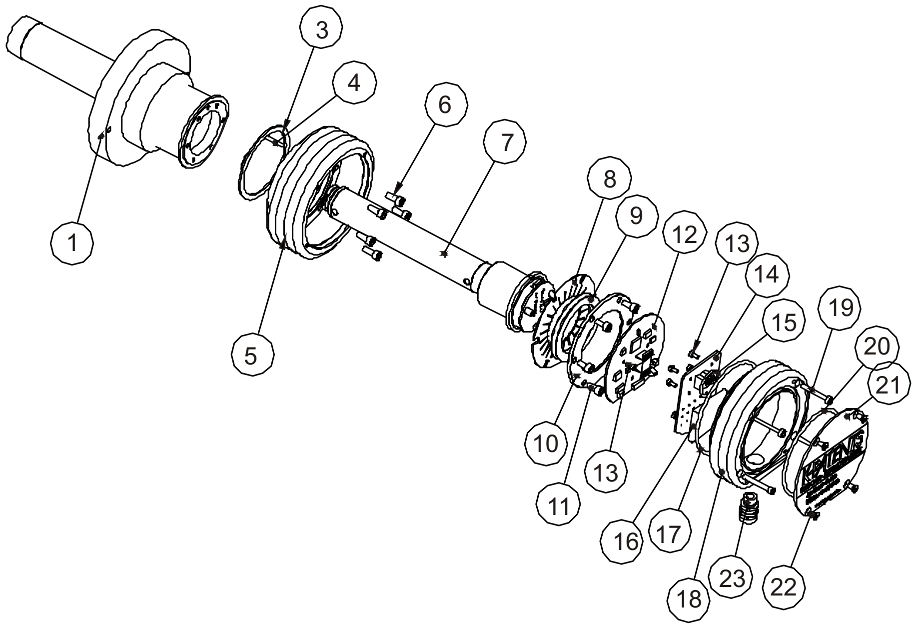
11.2 Specifications

Refractive Index range:	Full range n_D 1.3200–1.5300 (corresponds to hot water – 100 Brix)
Accuracy:	Refractive index n_D ± 0.0002 (corresponds typically to ± 0.1 % by weight) Repeatability and stability correspond to accuracy
Speed of response:	1 s undamped, damping time selectable up to 5 min
Calibration:	With Cargille certified refractive index liquids over full range of n_D 1.3200–1.5300
CORE-Optics:	No mechanical adjustments (US Patent No. US6067151)
Digital measurement:	3648 pixel CCD element
Light source:	Light emitting diode (LED) 589 nm wavelength, sodium light
Temperature sensor:	Built-in Pt-1000
Temperature compensation:	Automatic, digital compensation
Instrument verification:	With certified refractive index liquids and K-Patents documented procedure
Ambient temperature:	Sensor: max. 45 °C (113 °F), min. -20 °C (-4 °F); Indicating transmitter: max. 50 °C (122 °F), min. 0 °C (32 °F)
SAFE-DRIVE™ SENSOR PR-23-SD AND ISOLATION VALVE SDI-23	(Patent Pending)
Isolation valve connection:	Safe-Drive™ flange DN 40 PN40 (Patent pending)
Process pressure:	Static pressure up to 40 bar (580 psi), operational pressure up to 10 bar (140 psi)
Process temperature:	-20°C–170°C (-4°F–340°F)
Sensor process wetted parts,	SAF 2205, Duplex steel SS 2377, Werkstoff-Nr.
standard:	1.4462, UNS S31803, prism spinel, prism gaskets MTF (Modified Teflon)
Sensor protection class:	IP67, Nema 4X
Isolation valve	SAF 2205, Duplex steel SS 2377, Werkstoff-Nr.
process wetted parts:	1.4462, UNS S31803, AISI 316 L, flange gasket Viton®, lip seals Bronze Teflon® and ELGILOY, AISI 301 spring

Isolation valve	By welding to pipe sizes of 2"–24", for both
process connection:	vertical and horizontal pipe lines
Prism wash:	Retractable steam wash nozzle with check valves
Sensor and valve weight:	10.5 kg (23 lbs)
SAFE-DRIVE™ RETRACTOR SDR-23	(Patent pending)
Retractor weight:	7.7 kg (17 lbs)

11.3 Parts lists

11.3.1 PR-23-SD sensor

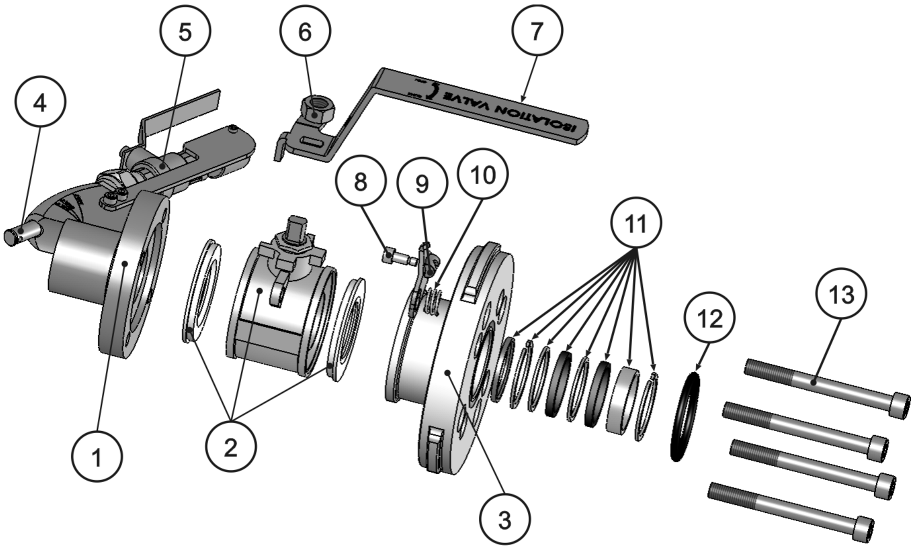


Item	Pcs.	Part No.	Description
1	1	PR-10015	PR-23-SD head
2	1		Safe-Drive™ flange
3	1		Thermal insulator Teflon®
4	1		Alignment pin
5	1	PR-10005	PR-23 base
6	6		Screw M5x10 DIN 912 A2
7	1	PR-10022	PR-23-P core
8	1	PR-9011	Thermal conductor
*	1	PR-9010	Disc spring set
9	2		Disc spring
10	1		Disc spring holder

Item	Pcs.	Part No.	Description
11	6		Screw M5x10 DIN 912 A2
12	1	PR-10101	Sensor processor card
13	8		Screw M3x5 DIN 7380 A4
14	1	PR-10300	Bus terminator card
15	1		O-ring seal 24x2
16	1	PR-9108	Dryer for PR-23
17	1		O-ring seal 89.5x3
18	1	PR-10000	PR-23 cover
19	4		Screw M4x30 DIN 912 A4
20	1	PR-10002	O-ring seal 83x3
21	1		PR-23-SD nameplate
22	4		Screw M4x8 DIN 964 A4
23	1		Cable gland M16x1.5

For PR-23-SD sensor CORE parts see Section ??.

11.3.2 Safe-Drive™ Isolation valve



Item	Pcs.	Part No.	Description
1	1	PR-11000	SDI flange and nozzle weld assembly SAF 2205
2	1	PR-11001	DN 40 ball valve
3	1		SDI body
4	1	PR-11010	SDI steam wash nozzle SN
4	1	PR-11011	SDI high pressure wash nozzle WP
5	1	PR-11015	SDI nozzle ball valve 3/8
6	1		M12 nut A4

Item	Pcs.	Part No.	Description
7	1		SDI isolation valve handle
8	1		Safety lock screw
9	1		Safety lock
10	1		Spring 1.5x14x20 Lesjöfors no. 2371
11	1	PR-11002	SDI box packing set
12	1	PR-11003	O-ring 50x5 EPDM
13	4		DIN 912 screw

11.3.3 Safe-Drive™ Retractor

The Safe-Drive™ Retractor consists of Inner casing and Outer casing. The Inner casing is attached to the sensor flange with bayonet mounting. The Outer casing is attached to the isolation valve body with bayonet mounting. When the hand-wheel is turned, the Inner casing moves inside the Outer casing along the screw thread.

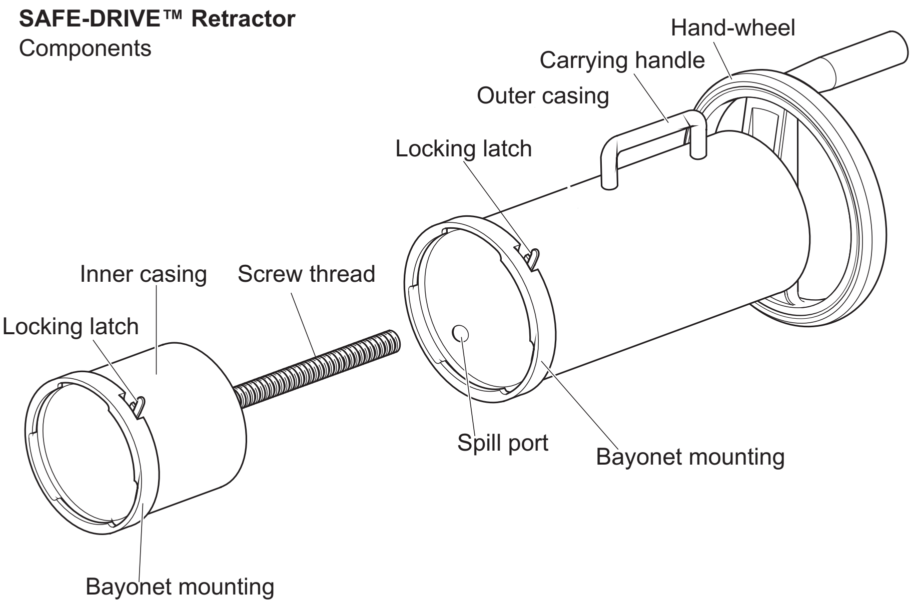


Figure 11.2 The Safe-Drive™ Retractor

11.4 Mounting

A standard Safe-Drive™ system delivery contains a Safe-Drive™ Sensor (PR-23-SD) with a Indicating transmitter DTR, a Safe-Drive™ Isolation valve to be welded onto customer's pipe and a Safe-Drive™ Retractor for sensor insertion and removal. A welding guide sticker is also provided for accurate cutting and welding.
By special order the Safe-Drive™ Isolation valve can also be welded to a suitable length of pipe at the K-Patents factory to be part of the piping on site.

The Safe-Drive™ system is mounted on a vertical pipe or horizontal pipe. When choosing mounting location, keep in mind that you have to be able to lift the Retractor with sensor inside over and off the isolation valve for sensor insertion and removal.

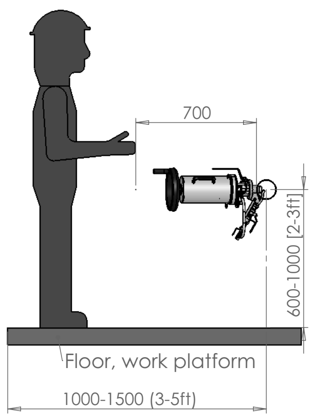


Figure 11.3 Selecting mounting location

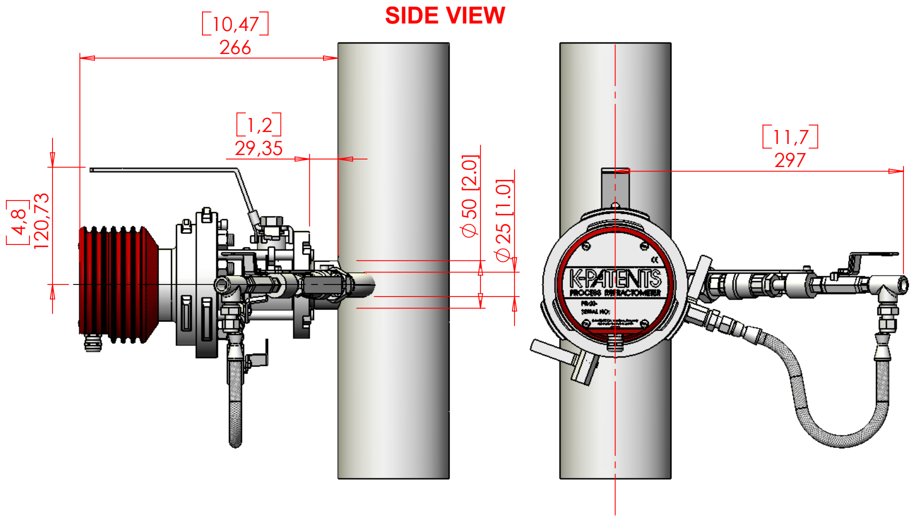


Figure 11.4 Mounting on a vertical pipe

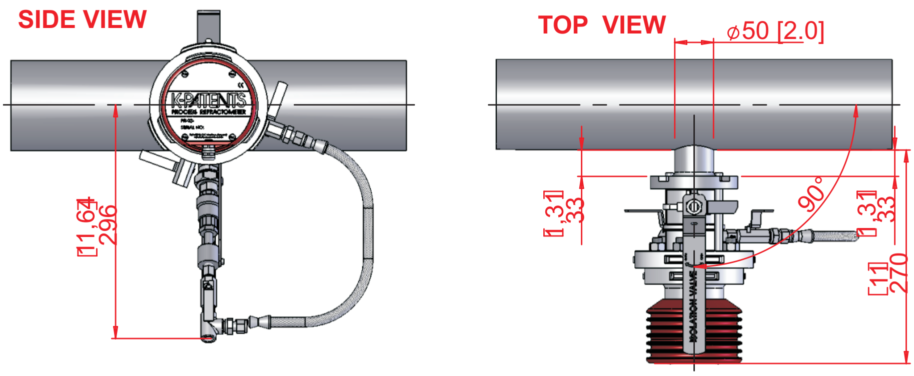
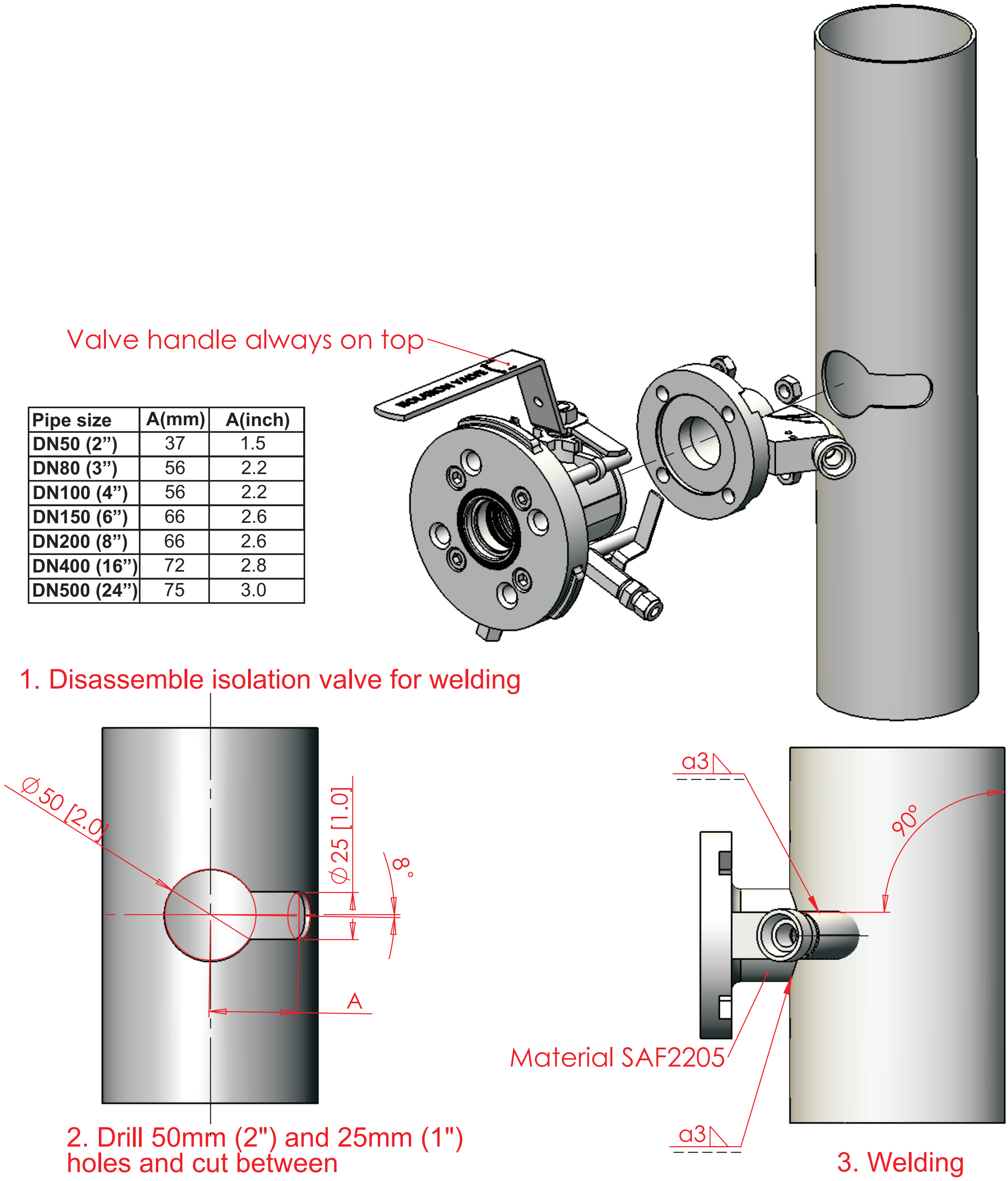


Figure 11.5 Mounting on a horizontal pipe

11.4.1 Welding isolation valve to pipe

For the Safe-Drive™ Isolation valve, two holes - 50 mm (2") and 25 mm (1") - are drilled to the pipe and the bridge between the holes is then removed. To help you place the holes correctly, K-Patents delivers with the valve an installation guide sticker (see Figure 11.10). Clean the surface of the pipe around the installation area and stick the guide across the pipe, making sure that flow marker is parallel to the pipe and points to the correct flow direction. Now can cut the installation opening as guided by the sticker. Then remove the rest of the sticker and weld the valve to the pipe.



Pipe size	A(mm)	A(inch)
DN50 (2”)	37	1.5
DN80 (3”)	56	2.2
DN100 (4”)	56	2.2
DN150 (6”)	66	2.6
DN200 (8”)	66	2.6
DN400 (16”)	72	2.8
DN500 (24”)	75	3.0

Figure 11.6 Welding the Safe-Drive™ isolation valve to the pipe

11.4.2 Wiring

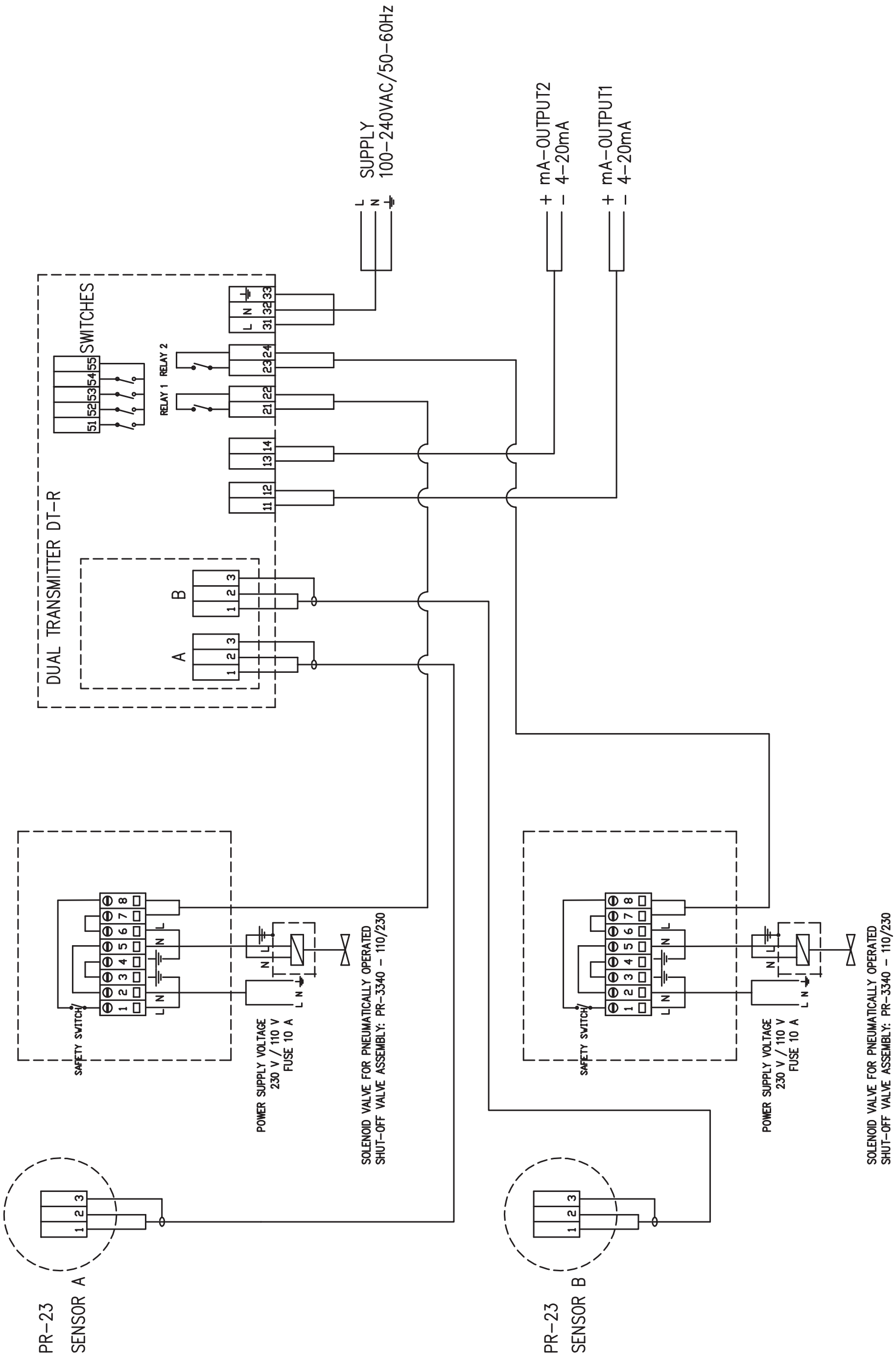
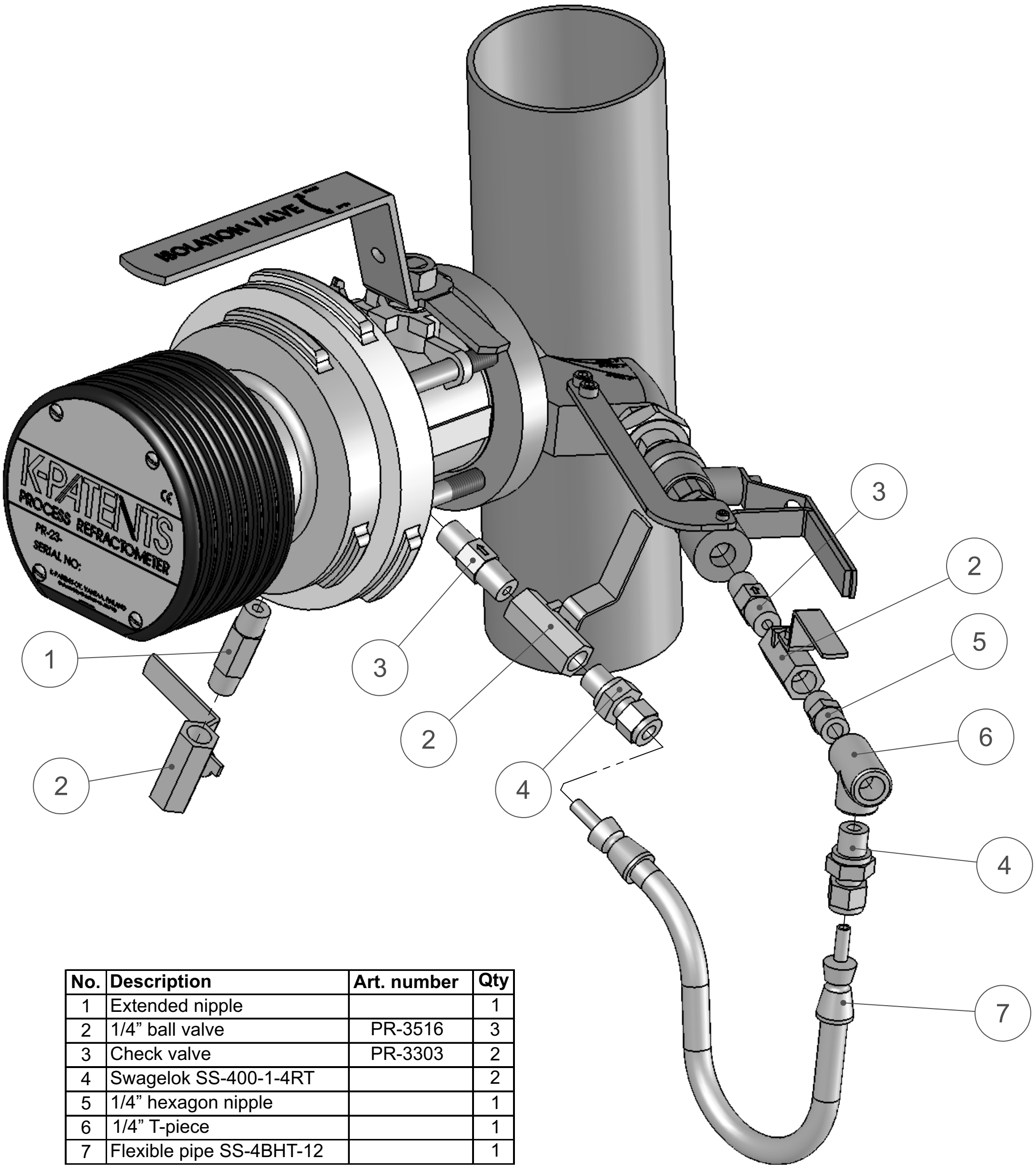


Figure 11.7 PR-23-SD system wiring

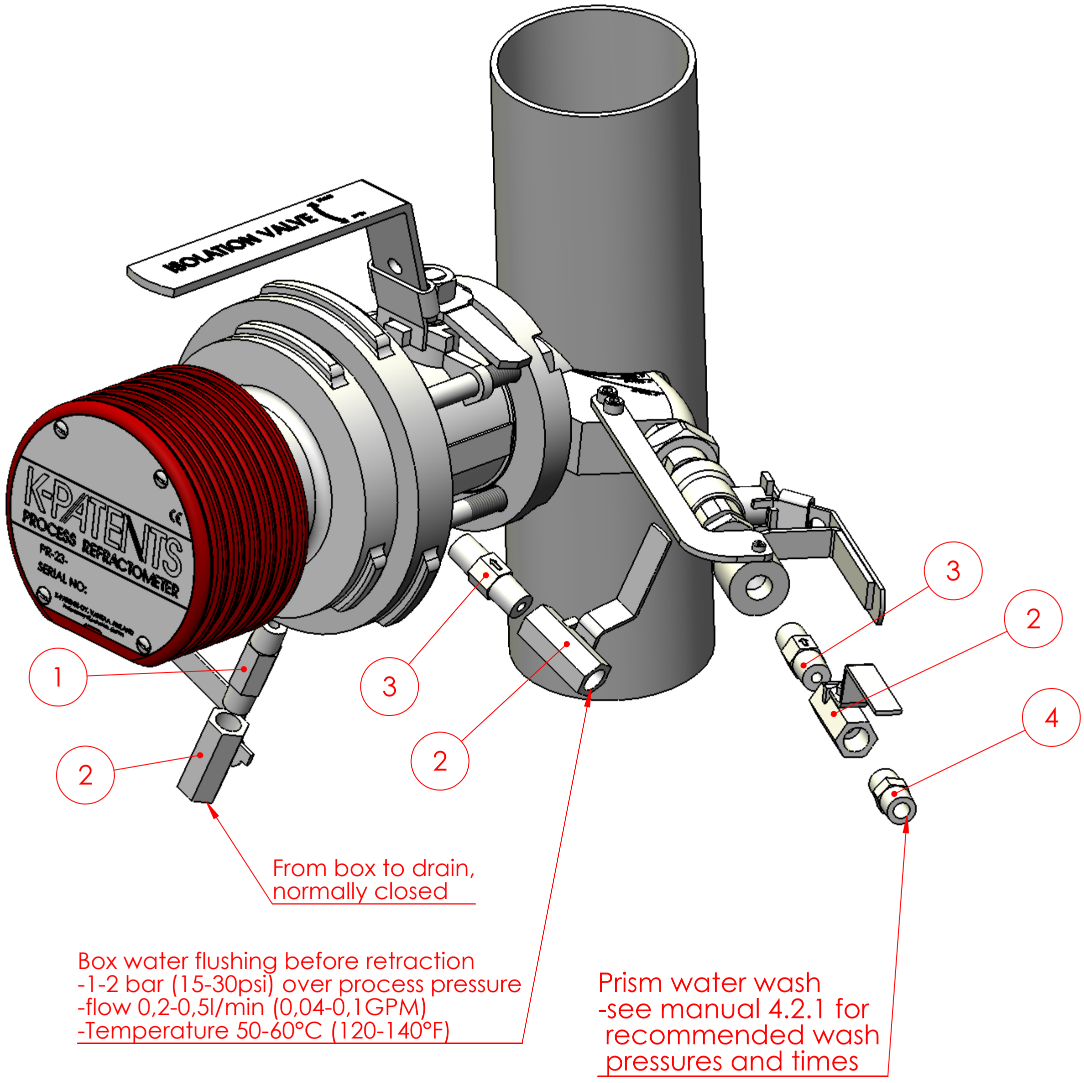
11.4.3 Steam piping for SDI (eg weak and black liquor)



No.	Description	Art. number	Qty
1	Extended nipple		1
2	1/4" ball valve	PR-3516	3
3	Check valve	PR-3303	2
4	Swagelok SS-400-1-4RT		2
5	1/4" hexagon nipple		1
6	1/4" T-piece		1
7	Flexible pipe SS-4BHT-12		1

Figure 11.8 Mounting steam wash to isolation valve

11.4.4 High pressure water piping for SDI (eg green liquor)



No.	Description	Art. number	Qty
1	Nipple for SD		1
2	1/4" ball valve	PR-3516	3
3	Check valve	PR-3303	2
4	1/4" hexagon nipple		1

Figure 11.9 Mounting high pressure water wash to isolation valve

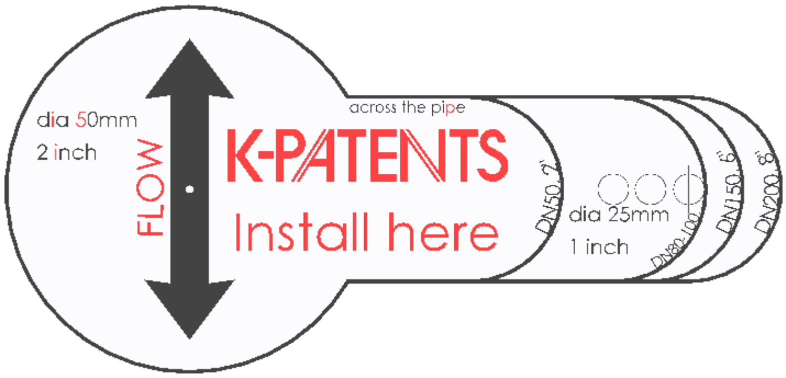


Figure 11.10 A Safe-Drive™ isolation valve installation guide sticker

11.5 Safe sensor insertion and removal

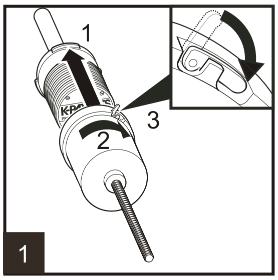
! **Warning! Always use the Safe-Drive™ Retractor for sensor insertion and removal!** Safe sensor insertion and removal can only be guaranteed when the Retractor tool is used and these instructions are carefully followed. Removing the sensor without the Retractor tool may cause a life-threatening situation if there's any pressure in the pipe. Also, the lip seal damages easily if Retractor is not used.

Important: Safe-Drive™ is designed to protect user from process liquid and to safely insert and remove the sensor. However, do not underestimate or neglect the factory safety requirements:

- Use safety clothing since the process liquid can be either hot, corrosive or both
- Use safety goggles
- Use a hard hat
- Use protective gloves
- Before you start, locate the nearest emergency shower or water tap
- Never use the Safe-Drive™ Retractor alone

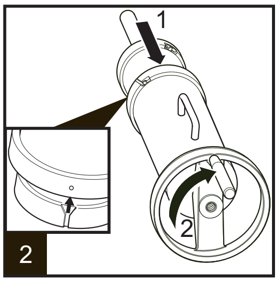
11.5.1 Sensor insertion

1



1 Insert the sensor to the Inner casing. Make sure that the sensor cable gland has been taken off and that the latch on the Inner casing is unlocked. Match the bayonet closing with sensor flange so that the latch is slightly to the left of top and sensor cable passage is straight down.
2 When sensor flange is flush with the bottom of the Inner casing, **turn Inner casing 60 degrees** (1/6 turn) **clockwise** to lock i t to the flange.
3 Push down the locking latch to secure the connection.

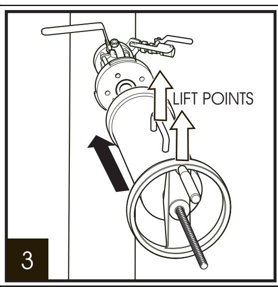
2



1 Put the Inner casing with sensor on a table or similar raised surface and **fit the Outer casing over the Inner casing**. To match the casings, check that the groove on the Inner casing matches the dot on the Outer casing. The latch of the Inner casing should be slightly to the right from top and the handle of the Outer casing should point up.

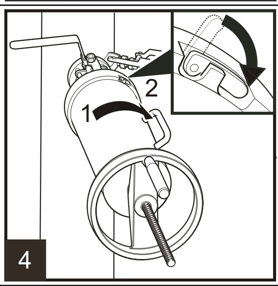
2 Turn the hand-wheel clockwise until it stops to draw the sensor into the Retractor. The sensor should now be inside the Retractor and about 14 cm (5 1/2") of the screw thread should stick out of the middle of the wheel.

3



Take a firm hold of the hand-wheel and the handle and lift the Retractor (with sensor) over the isolation valve flange. Keep handle up and make sure that the latch on the Outer casing is open.

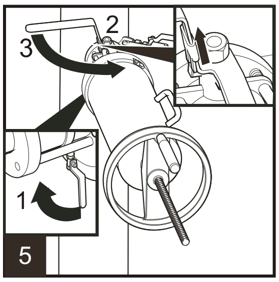
4



1 Turn the Retractor 60 degrees clockwise (i.e. to the right) to lock the bayonet.

2 Push down the latch on the Outer casing to secure the connection.

5

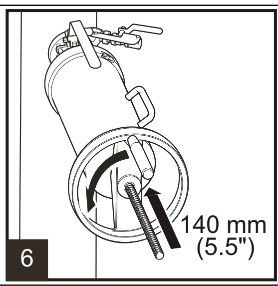


1 Close the blow-out ball valve underneath the Isolation valve.

2 Lift up the Isolation valve handle locking plate.

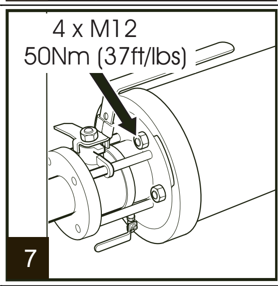
3 Open the Isolation valve by turning the valve handle 90 degrees counterclockwise (i.e. to the right). The valve is open when the ball valve handle is parallel to the Retractor and sensor.

6



Now sensor can be inserted into the process. **Turn the hand-wheel counterclockwise until it stops**, i.e. until the sensor flange connects with the Isolation valve and only the end of the screw thread is visible.

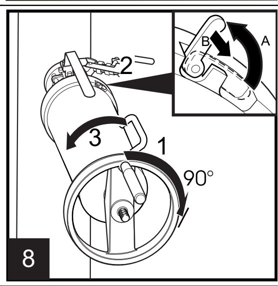
7



Fit the four M12 nuts to the bolts holding the sensor to the Isolation valve and screw them on with a 19 mm or 3/4" wrench.

Important: Do not tighten the nuts too hard, set the torque at 50 Nm.

8

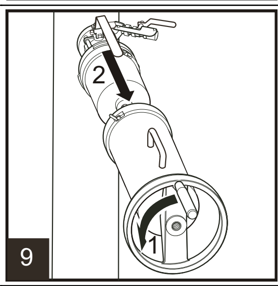


1 Turn the wheel 90 degrees (a quarter turn) **clockwise.**

2 Unlock the latch of the Outer casing.

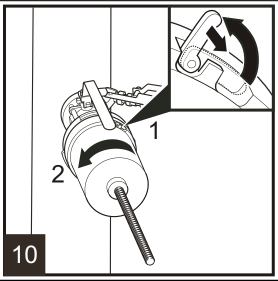
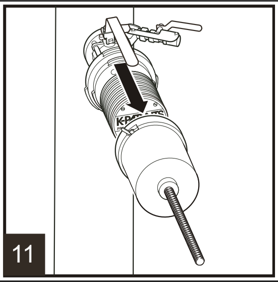
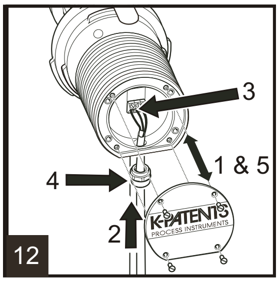
3 Turn the casing 60 degrees counterclockwise i.e. until the handle is up on top.

9

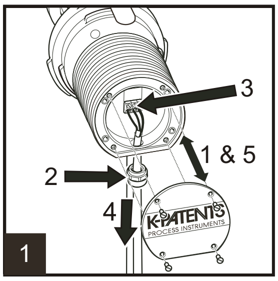
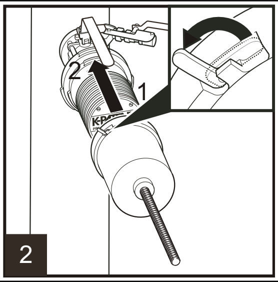
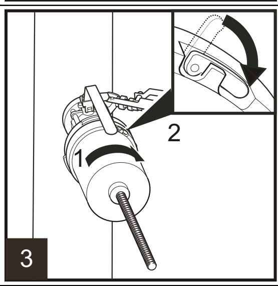
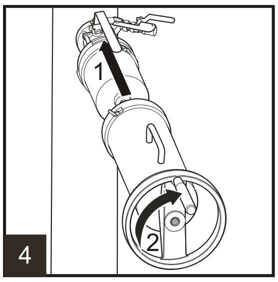


1 Turn the hand-wheel counterclockwise to drop the thread.

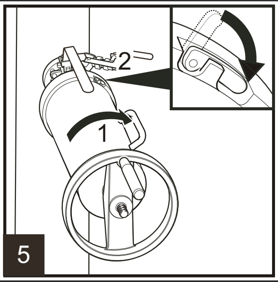
2 Lift off the Outer casing.

10		**1 Lift up the latch of the Inner casing to unlock.** **2 Turn the casing 60 degrees counterclockwise to release it from the flange.**
11		**Lift the Inner casing away from the sensor head.**
12		Power off the DTR. Connect sensor cable to the DTR. **1 Take off sensor nameplate and the gasket underneath.** **2 Put interconnecting cable through the cable gland.** **3 Connect the interconnecting cable to the sensor.** **4 Screw the cable gland to the sensor.** **5 Fit the gasket and nameplate onto the sensor and screw the nameplate back on.** Turn on DTR power to power up the Safe-Drive™ system.

11.5.2 Sensor removal

1		Switch off the DTR to cut off power from the sensor. **1 Remove the sensor nameplate and the gasket underneath.** **2 Screw off the cable gland.** **3 Disconnect the interconnecting cable.** **4 Remove the cable from sensor.** **5 Place gasket and nameplate on the sensor head and screw the sensor nameplate back on.** **Note:** If another inline sensor is connected to the same DTR, disconnect the loose cable from the DTR and turn power on again.
2		**1 Unlock the latch on Inner casing.** **2 Lift the Inner casing over the sensor head.** Connect the casing to the sensor flange bayonet.
3		**1 Turn the casing 60 degrees** (1/6 turn) **clockwise** (to the right) to lock it onto the flange. **2 Lock the Inner casing latch.**
4		**1 Grab the Outer casing with one hand on the handle and the other hand on the wheel. Fit the Outer casing over the Inner casing** and all the way to the Isolation valve bayonet keeping the handle upwards. **2 Rotate the hand wheel clockwise** to get thread of the Inner casing running through the wheel.

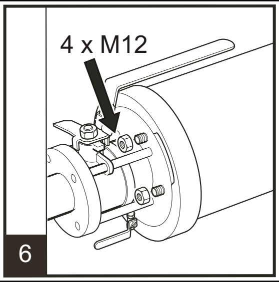
5



1 Turn the Outer casing 60 degrees clockwise (i.e. to the right) to lock it onto the Isolation valve.

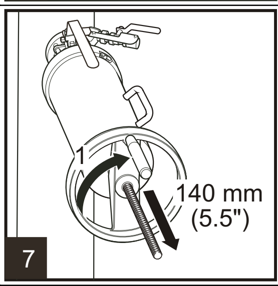
2 Push down the Outer casing latch to keep the Outer casing locked.

6



Open and remove the four M12 nuts on the bolts holding the sensor to the Isolation valve using a 19 mm or 3/4" wrench.

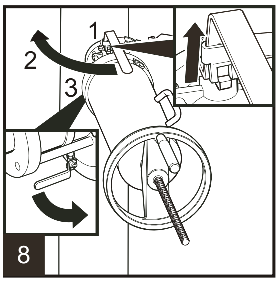
7



1 Turn the hand wheel clockwise until it stops to remove the sensor from process.

2 At this stage about 140 mm (5.5") of the thread should stick out from the middle of the wheel.

8



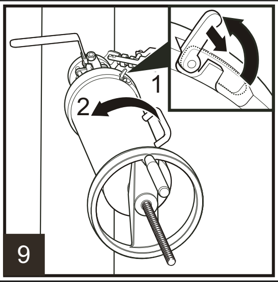
1 Lift up the isolation valve handle locking plate.

2 Close the Isolation valve on by turning the handle 90 degrees (a quarter turn) **to the left.**
Important: The Isolation valve is properly closed when the handle points away from the sensor and the locking plate drops down over the handle.

3 Open the blow-out valve under the Isolation valve for box cleaning to get rid of any process liquid inside the isolation valve.

! **Warning!** Some process liquid will leak out through the small ball valve; beware of splashing!

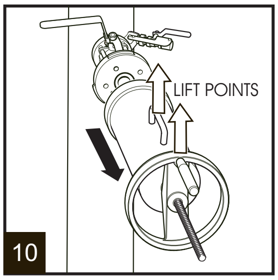
9



1 Lift the Outer casing locking latch.

2 Turn the Outer casing 60 degrees counterclockwise (i.e. to the left) so that the handle comes up on top.

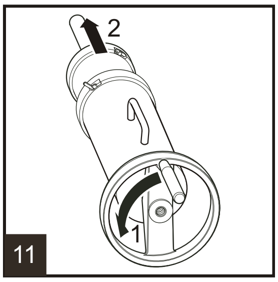
10



Take a good grip on the hand wheel and the handle and pull out the Safe-Drive™ Retractor with the sensor inside.
A Firm hold of the tool is essential as the combination of the tool and the sensor is noticeably heavier than Retractor alone.

Note: To ensure the isolation valve after the Safe-Drive tool with the sensor have been removed, you can bolt a standard ANSI 1.5" 105 lbs blind flange to it with 1/2" (M12) bolts and nuts.

11

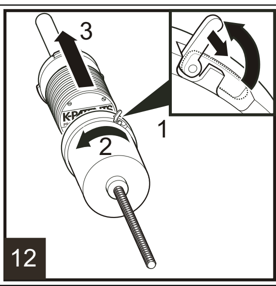


Put the Safe-Drive™ Retractor with sensor onto a table or similar surface so that the hand wheel has space to turn.

1 Turn the wheel counterclockwise until the trapezoidal thread is all the way inside the Outer casing and loose from the wheel, i.e. the Outer casing is no longer connected to the parts inside.

2 Pull the Outer casing off.

12



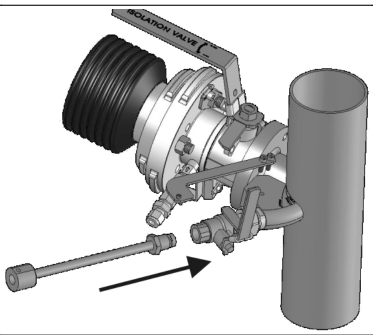
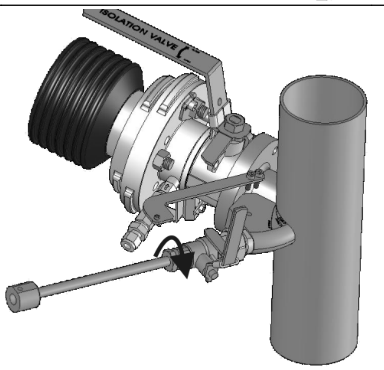
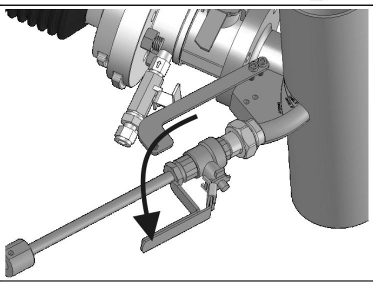
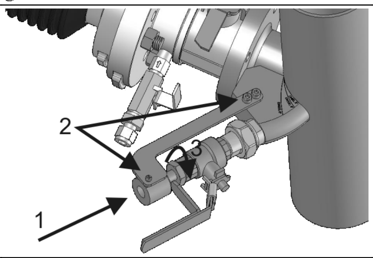
1 Open the latch on the Inner casing.

2 Keep sensor steady with one hand and **turn the Inner casing counterclockwise** with the other hand to unlock the Inner casing from sensor.

3 Pull off the sensor.

11.6 Wash nozzle insertion and removal

11.6.1 Wash nozzle insertion

1		Fasten the nozzle to the 3/8" isolation valve.
2		Tighten the nozzle nut.
3		Carefully open the 3/8" nozzle isolation valve. If there is any leakage, close nozzle isolation valve and tighten the nozzle nut some more.
4		1 Push nozzle into the process pipe. 2 Fasten the nozzle guide. 3 Tighten up nozzle nut.
5		1 Attach steam pipe to 1/4" ball valve. 2 Open the 1/4" ball valve. 3 Open the steam supply.

11.6.2 Wash nozzle removal

1		Close the steam supply.
2		Close the 1/4" ball valve. Remove the incoming steam pipe from the 1/4" ball valve.
3		1 Remove the nozzle guide. 2 Take a 22 mm wrench. Loosen the nozzle nozzle nut 1/4 turn at time until you can pull the nozzle about 150 mm outwards. **Important:** Do not open the nozzle nut more than 2 full turns. 3 Close the 3/8" ball valve. 4 Loosen the nozzle nut entirely.
4		Pull the nozzle out of the isolation valve.

12 Ethernet connection specification

The Ethernet connection enables data download from a DTR to a computer. The connection works both directly between DTR and computer or via a hub or switch, local area network (LAN), wireless network (WLAN) or fiber Ethernet.

Any type of computer (PC, Mac, PDA, mainframe...) with a compatible network connection can be configured to download data from the DTR. This document gives all the specifications necessary to write a communications program for downloading purposes. It is also possible to get a ready-to-install communications software from K-Patents.

12.1 Cable requirements and connection

12.1.1 Ethernet cable specification

The DTR uses a standard Ethernet cable (10/100BASE-T Cat 5e cable with RJ45 connectors). The maximum cable length is 100 m.

Ethernet connection is similar to that of a computer/PC:
Use cross-over Ethernet cable to connect the DTR directly to a computer (Figure 12.1). If you are connecting the DTR to a LAN (Local Area Network) via a wall socket, use straight-through Ethernet cable (Figure 12.2).

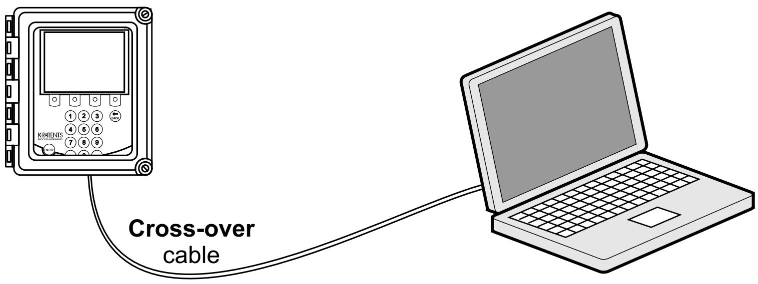


Figure 12.1 Connecting DTR to a computer.

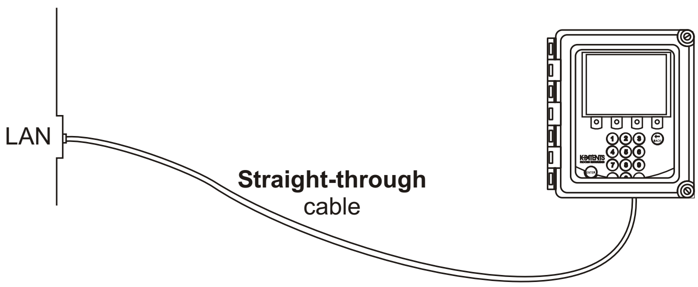


Figure 12.2 Connecting DTR to LAN.

If you are connecting the DTR to a hub or switch or WLAN access point, please consult the user's guide of your hub/switch/access point for the correct cable type (Figures 12.3 and 12.4).

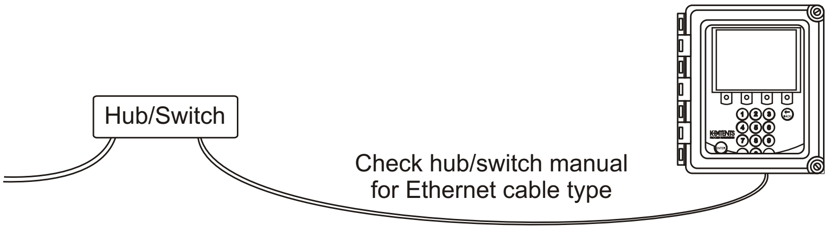


Figure 12.3 Connecting a DTR to a hub or a switch.

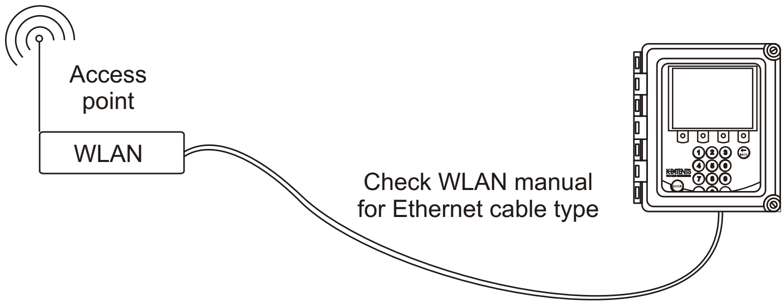


Figure 12.4 Connecting DTR to WLAN.

If you need a longer cable or the environment is electrically noisy, use fiber optics Ethernet with media converters (Figure 12.5).

12.1.2 Connecting the Ethernet cable

To connect the Ethernet cable to the DTR, open the DTR's enclosure cover, loosen the front panel screw and open the front panel. The Ethernet connector is **behind the front panel**, see Figure 12.6. Plug one end of an appropriate Ethernet cable into the connector. Plug the other end into your PC/LAN socket/hub/switch/access point.

! **Warning!** While it is possible to connect and disconnect the Ethernet cable when the DTR is powered on, for your safety we recommend that you turn off the power (by unplugging the power supply cord or turning off the power from an external power switch) before opening the DTR's front panel.

Note: The DTR has automatic speed negotiation, i.e. it will automatically find out what the optimal speed for the connection is and choose accordingly either 10 Mbit/s or 100 Mbit/s speed.

12.2 Connection settings

12.2.1 IP settings for DTR

The DTR uses the IP protocol to communicate over the Ethernet. The **factory setting** for the DTR's IP address is **192.168.23.254** (a private network address).

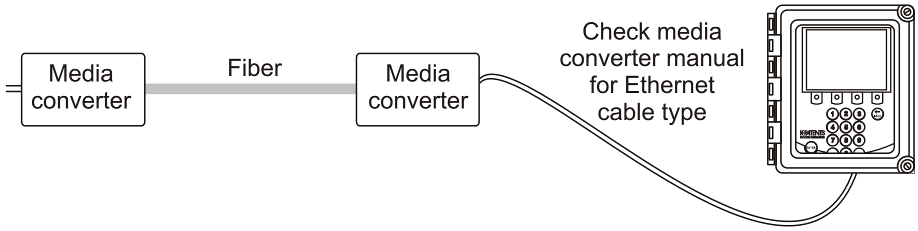


Figure 12.5 Using fiber optics Ethernet.

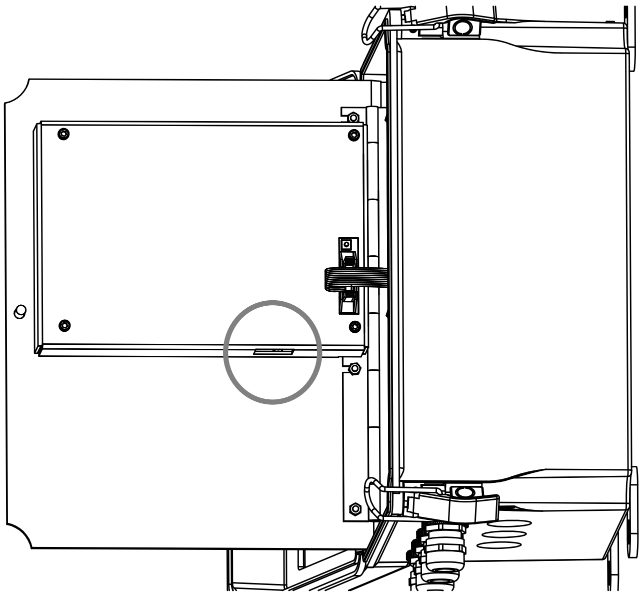


Figure 12.6 Ethernet connector on the underside of the Front panel.

Note: If you connect the DTR to an existing network, the address must be changed to fit the network before making the connection. To prevent conflicts, consult your network administration to find a suitable IP address for the DTR in question.

The DTR address is changed manually through the Calibration menu via the following path: 5 Calibration – 2 Output – 6 Network. Type the new IP address and press the Enter button to change the address.

12.2.2 IP settings for stand-alone computer

If you connect a non-networking (stand-alone) computer directly to a DTR with a cross-over cable, the easiest solution is to check the computer's network settings and conform the DTR's settings to it.
Note: If the DTR is in a factory network, contact the system admin on how to connect to the DTR. The stand-alone method may not be the best one in this kind of case.

If you are using Windows 2000/XP/Vista (or Mac OS X 10.3 or newer or any recent Linux distribution) and the computer has the default network settings, change the **DTR IP address** to 169.254.x.y, where x=1–254 and y=1–254, for example 169.254.100.100 or 169.254.123.1. This way the DTR address will be suitably paired with the address your computer automatically generates for itself.

If in doubt, you can get your Windows computer's network settings by opening the command window (command prompt) and by typing the command `ipconfig` at the command prompt (press Enter to give the command), see figure 12.7 (in Mac OS X and Linux the same command is called `ifconfig`). The result will give you your computer's IP address, so you can change the DTR to match; the connection should always work if you match the first three groups of numbers and just change the last number.

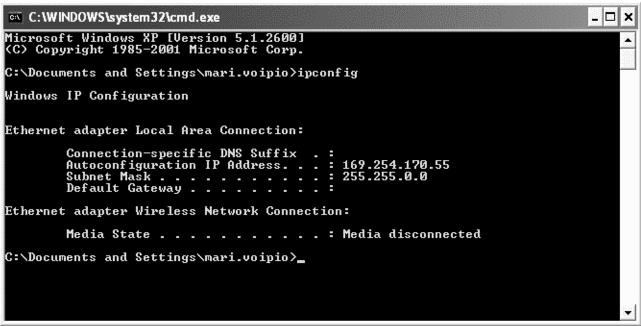


Figure 12.7 Typical IP configuration for a stand-alone laptop when connected to a DTR; laptop wireless (WLAN) is turned off

Note: You may have to connect the cross-over cable and power on the DTR before your computer generates an IP address for the ethernet connection (computer reboot may also be required). Note also that the connection will not work if the computer and the DTR have exactly the same IP address.

Note: Please make sure that your WLAN (Wireless network connection) is not active when you connect to the DTR. If the WLAN is active, the computer's Ethernet connection may not function as expected.

When you have set the DTR (and/or the computer) according to instructions above, you can proceed to test the connection as instructed below in Section 12.3.

12.3 Testing the Ethernet connection

On the Ethernet connector inside the DTR there are two **diagnostic LEDs**. The **green LED indicates that the physical connection is working**, i.e. that both ends of the Ethernet cable are plugged in, the device in each end is powered and the cable is of correct type. The **orange LED indicates traffic in the cable**, i.e. that DTR receives data.

The IP address can be tested with a *ping* command after the physical Ethernet connection has been set up and the DTR is powered. In Windows systems *ping* is available by using the Command Prompt (usually found in the Accessories). The usage of *ping* is very simple: go to the command interface (for example the

Command Prompt), type the name of the command and the IP address you want to check and press Enter. If the Ethernet connection is good, the DTR is powered on and the address given to ping is correct, the DTR will answer to ping and return any data packets sent to it, see Figure 12.8.

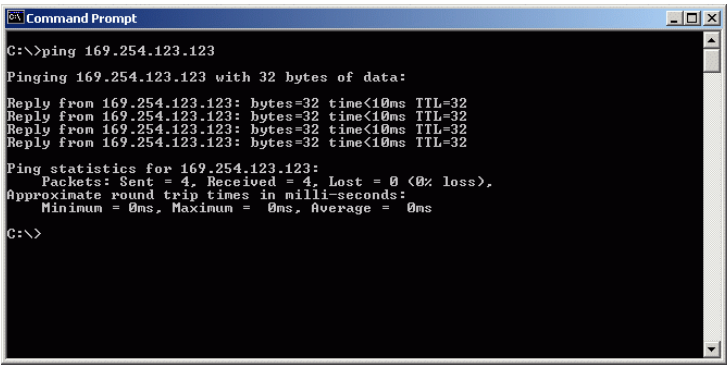


Figure 12.8 Ping OK.

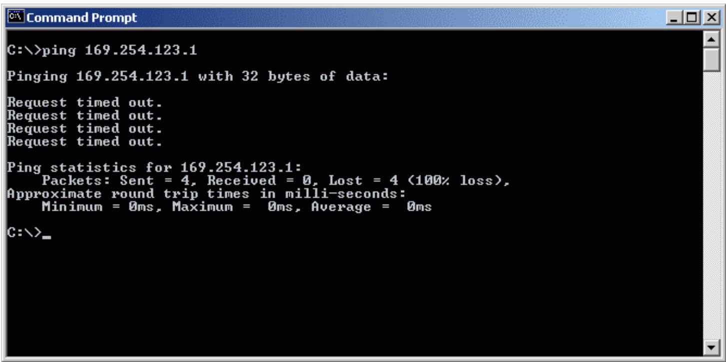


Figure 12.9 Ping error message.

12.3.1 Troubleshooting the connection

If you get an error message from a *ping* command (for example Request timed out like in Figure 12.9), check your connections.

First open the DTR cover and front panel and check the diagnostic LEDs of the Ethernet connector (see Section 12.1.2). **Note:** Keep both the DTR and your computer powered while you check the diagnostic LEDs.

If you cannot see any LED lights, something is physically wrong with your connection. Check the following

- both the DTR and the device in the other end of the cable are powered on
- the Ethernet cable is properly inserted in both ends
- the Ethernet cable is of the correct type (cross-over cable for direct DTR-to-computer connection)

If the green LED is lit, your Ethernet connection is made correctly with the right type of cable. In this case, try *ping*ing the DTR and check if the orange LED flashes during ping.

If the LED does not flash, re-check the IP address (so that you are really pinging the DTR in question). In case the DTR is not connected directly to the computer, there may be a routing problem. Please consult your network administrator to solve the problem.

Note: A firewall software (especially that of Windows XP) with tight settings may stop you from connecting to a DTR. If you are connecting directly to the DTR (and not in a network), the easiest way of solving this problem is to turn off the firewall temporarily while working with the DTR. Remember to turn on the firewall before connecting to a network again!

12.4 Instrument homepage

From DTR program version 2.0 onwards every DTR has its own built-in instrument homepage that contains information about the instrument and a remote panel with full functionality. The instrument functions just like a web server, so you only need a working ethernet connection to the DTR and any web browser to access the instrument homepage.

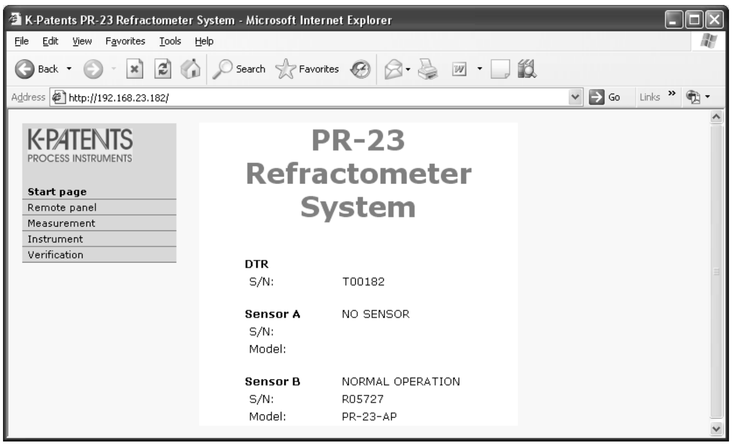


Figure 12.10 Instrument homepage open in a browser

Opening the instrument homepage:

1. Establish a working Ethernet connection (see above) to the DTR.
2. Start your preferred web browser (for example Internet Explorer, Mozilla Firefox, Safari, Opera or Chrome).
3. The address (URL) of the instrument homepage is the DTR's IP address, for a factory set DTR it is http://192.168.23.254/ (the figure 12.10 above uses a different address, not the default). Give the address to the browser just like you'd enter any other address (for example http://www.kpatents.com/)
4. Wait until the homepage is loaded, this may take a few seconds.
   If the page looks strange in the first try, refresh/reload the page and it should settle to look approximately like in Figure 12.10; the exact look of the page depends on your browser and screen settings so slight variation can be expected.
5. Use the links in the link bar on the left side of the page to find more extensive information on the instrument.

12.4.1 Remote panel

The instrument remote panel is a fully functional virtual DTR where keys on the keyboard are clicked with a mouse. The DTR doesn't make any difference between commands coming from the actual keyboard and from a remote panel. All commands are executed in the order the DTR gets them, independent of where they come from.

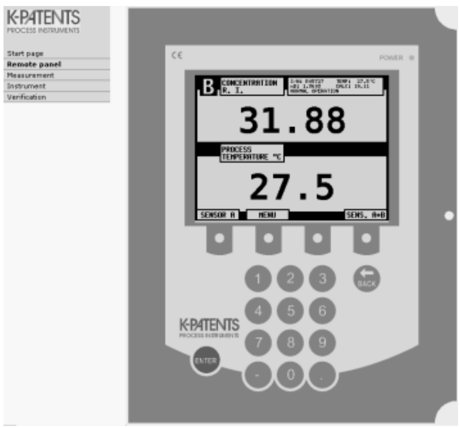


Figure 12.11 DTR remote panel

Note: The DTR display picture on the remote panel sometimes has a slight lag (of few seconds) before it refreshes. This depends on many factors like the computer and network used. If the DTR seems to 'skip' displays, it may be that it is executing mouse-click keyboard commands faster than your browser updates the picture.

12.4.2 Sensor verification certificate

A sensor verification certificate can be viewed and printed by following the Verification link on the link bar. For more information on instrument verification, see Chapter 13.

12.5 Collecting data via Ethernet

The main purpose of the Ethernet connection is to collect measurement data from the instrument. For this data acquisition, you'll need to have suitable software on your computer. One solution is to get the software package from K-Patents. The package contains a ready-to-use data acquisition program for Windows 2000/XP/Vista.

However, if you need a tailored system, you can also program a downloading facility yourself following the specifications below.

Note: K-Patents guarantees that the specifications are correct, but cannot assume any responsibility or provide support for other software than the unmodified K-Patents software.

12.5.1 Communication protocol

The communications protocol is based on **UDP/IP** to **port 50023**. It is a client/server protocol, where the DTR is the server and thus only sends information when the client (i.e. your computer) requests it. The server should answer to all requests within five seconds (5000 ms) from the request, usually the response time is below 100 ms.

Request format

The client to server communication, i.e. the requests sent from your computer to the DTR, is in binary format. The request packets contain the following binary data (all integers are in the network order, MSB first):

- 32-bit integer: packet number
- 32-bit integer: request ID
- (any): request data (depends on the request)
- (any): fill-in data

Important: The maximum size of the message is 1472 octets (bytes).

The **packet number** is echoed back by the DTR, but not processed in any way. The packet numbers do not have to be sequential, any 32-bit value is valid.

The **request ID** is a 32-bit value that identifies the requested function, for example sensor information. See Section 12.5.2 for request IDs.

The **request data** consists of 0 to 1464 octets of additional data associated with the request.

The **fill-in data** can be used to increase the number of octets in a message. Any number of NULL characters (0x00) may be added to the end of the request as long as the total size of the message does not exceed the maximum of 1472 octets. This may be useful, for example, if the client implementation uses fixed-length packets.

Response format

The response data sent by the DTR is in ASCII format. With the exception of the packet number, the data is human-readable. The data structure is very simple:

- packet number (32-bit integer)
- zero or more lines of ASCII (text) keys and values associated with these keys (for example temperature key and process temperature in Celsius)

The **packet number** is echoed back without change. The client (software on computer) can use the packet number to check the response against the packet number of the request.

The **message text** consists of lines of text, each line a single key (of one word) and its value or values. The values are separated from the key by an equal sign (=) and multiple values are separated by a comma. White space (space or tabulator) is allowed anywhere except within a single value or key name.

If the response consists of a character string, it is enclosed in double quotes (").

For example all these are valid message text lines:

```
ok
temp=23.45
headhum = 13.32
LEDcnt = 8341
ChemCurve = 1.234, 3.21, 0.00, 4.37, 1.11, 0.00002, 2.1345
StatusMessage = "Normal Operation"
```

Note: All the key identifiers (see Section 12.5.2 for additional information) are case-insensitive. However, K-Patents recommends that they are written as in this specification.

The server (DTR) may send the response keys in any order. It will send the mandatory keys (marked with an asterisk in Section 12.5.2) of the specific request, but it may omit any other keys. The server may also send keys that are not specified in this document, but the client (computer) may ignore them.

Request and response errors

When the server (DTR) detects an error, it responds with an error message (for more information see Section 12.5.3). An error message can be caused for example by an unknown request or inability to collect data for the mandatory keys of a response.

12.5.2 Request-response pair specification

The list below describes the *query messages*, i.e. request-response pairs, used for data collection via Ethernet. **Mandatory response keys are preceded by an asterisk (*).**
Note: Even when multiple request data options are available, only one can be used at a time. For example each sensor status request must be directed to either sensor A or sensor B, not both.

NULL message

The null message is included in the query messages for debugging purposes as it can be used to check whether the server is listening. The message gives a high-level 'ping' functionality.

Request ID	`0x00000000`	
Request data	`(none)`	
Response key	`IP`	: IP address
	`MAC`	: Ethernet MAC address

Protocol version

The version query is responded with a value representing the server (DTR) protocol version.

Request ID	`0x00000001`	
Request data	`(none)`	
Response key	`*Version`	: integer, the server protocol version (currently 3)

DTR information

The DTR information query gives the basic information of the DTR assembly.

Request ID	`0x00000002`	
Request data	`(none)`	
Response keys	`*DTRserial`	: string, DTR serial number
	`*ProcessorSerial`	: string, processor card serial number
	`*ProgramVersion`	: string, main program version
	`*MBSerial`	: string, motherboard serial number
	`*MBVersion`	: string, motherboard program version
	`IFSerial`	: string, sensor interface serial number
	`IFVersion`	: string, sensor interface card program version

The IFSerial and IFVersion are only supplied if the information is available.

Sensor information

The sensor information query gives the basic information of the chosen sensor.

Request ID	`0x00000003`	
Request data	`0x00000000`	: sensor A
Request data	`0x00000001`	: sensor B
Response keys	`*SensorSerial`	: string, sensor serial number
	`*SProcSerial`	: string, sensor processor card serial number
	`*SensorVersion`	: string, software version number
	`SensorCurrent`	: integer, sensor current in milliamps

Measurement results

The measurement result query gives the measured and calculated measurement values from the chosen sensor.

Request ID	`0x00000004`	
Request data	`0x00000000`	: sensor A
Request data	`0x00000001`	: sensor B
Response keys	`Status`	: string, sensor status message
	`Slope`	: float, image quality factor (QF)
	`PTraw`	: integer, PT1000 value
	`LED`	: float, sensor led value
	`RHsens`	: float, sensor internal humidity
	`nD`	: float, calculated n_D value
	`CONC`	: float, final concentration value
	`Tsens`	: float, sensor internal temperature
	`T`	: float, process temperature (with temperature bias)
	`Traw`	: float, process temperature (without bias)
	`CCD`	: float, image shadow edge
	`CALC`	: float, calculated concentration value

DTR status

Request ID	`0x00000006`	
Request data	`(none)`	
Response key	`*Volt1`	: float, DTR internal voltage 1
	`*Volt2`	: float, DTR internal voltage 2
	`*DTRtemp`	: float, DTR internal temperature
	`Out1uA`	: integer, mA output 1 in uA
	`Out2uA`	: integer, mA output 2 in uA
	`Switches`	: hex string (e.g. "0x00"), switch status as a bit field

12.5.3 Error message specification

If the server (DTR) does not recognize the request or cannot fulfill it, it responds with an error message. The error message has the following keys:

`*Error`	: integer, error code	`0x00000001`	: Unknown request
`*Error`	: integer, error code	`0x00000002`	: Invalid request (request recognized, invalid request data)
`*Error`	: integer, error code	`0x00000003`	: No sensor (sensor(s) not connected to DTR)
`ErrorMsg`	: string, error details		

There may also be error-dependent extra keys.

13 Sensor verification

A company maintaining quality system according to ISO 9000 quality standards must have defined procedures for controlling and calibrating its measuring equipment. Such procedures are needed to demonstrate the conformance of the final product to specified requirements. The company should

- Identify the required accuracy and select appropriate equipment for measurements.
- Establish calibration procedures including a check method and acceptance criteria.
- calibrate the equipment at prescribed intervals against certified equipment having a known valid relationship to nationally recognized standards. In cases where no such standards exist, the basis used for calibration must be documented.

K-Patents verifies the calibration of all delivered instruments according to a procedure similar to the one described Section 13.1. K-Patents quality system is ISO 9001 certified by Det Norske Veritas.

13.1 Refractive index n_D verification

The verification of the PR-23 sensor calibration is made using a set of standard refractive index liquids with the nominal values at 25 °C:

- 1.330
- 1.370
- 1.420
- 1.470
- 1.520

The accuracy of the certified standard refractive index liquids is ±0.0002 and they can be traced back to national standards: N.I.S.T Standards #1823 and #1823 II. As the specified accuracy of PR-23 is ±0.0002, then the representative level is the sum of the two accuracy specifications, that is ±0.0004.

K-Patents provides a set of standard R.I. liquids, PR-2300, containing these five liquids. The set can be ordered directly from K-Patents or through your K-Patents representative.

13.2 Verification procedure

Select VERIFICATION from the Main menu. Instructions for the two verification steps are given on the display, Figure 13.1.

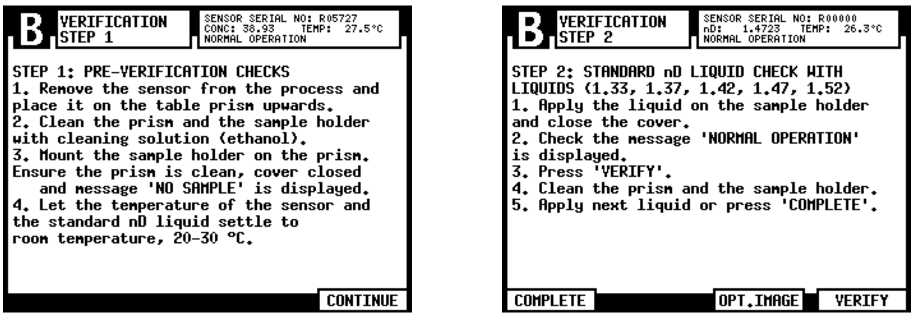
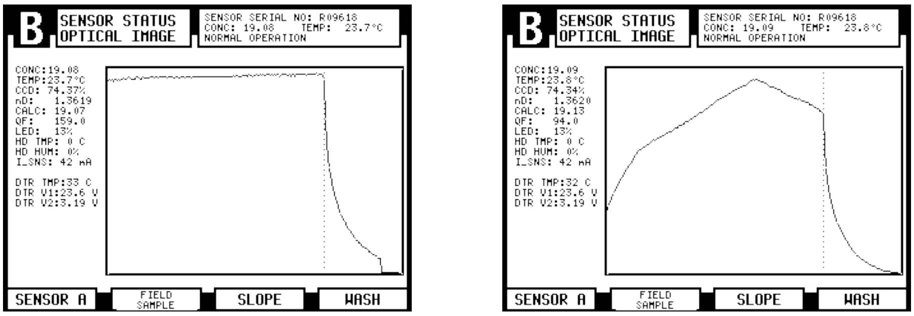


Figure 13.1 The two verification steps

To check that the standard liquid is properly wetting the prism, it is possible to press soft key OPT. IMAGE. The optical image should show a sharp shadow edge, as e.g. in Figure 13.2. For more information on the optical image, please see section 5.4.1.

A verification data collection method is implemented in the DTR. The instrument measures each verification data point ten times and uses the average of these measurements. Measuring each verification liquid takes a few seconds, during which the measurement progress display (Figure 13.3) is shown. Please wait until the verification step 2 display reappears before proceeding to next verification liquid.

The sample holder keeps the sample on the prism surface and also blocks the ambient light from reaching the prism. The K-Patents universal sample holder PR-1012 (Figure 13.4) can be used with any K-Patents sensor.



Sharp optical image (with IDS) Sharp optical image (without IDS)

Figure 13.2 Typical optical images

Figure 13.3 Verification in process

The limit for acceptance is that all measurements must be within ±0.0004 of the nominal values, Figure 13.5.

Note: The sensor verification concerns only the refractive index n_D measurement. The calculation of concentration from n_D and process temperature TEMP is not included, see Section 6.2, "Calibrating the concentration measurement".

13.2.1 Corrective action

If VERIFICATION FAILED, first check that the prism **and** the sample holder are absolutely clean and the sample holder sits tightly on the sensor tip before a standard liquid is applied. Make sure the standard liquids are in good condition and not past their expiration date. Also, inspect the prism surface, checking that it is flat and glossy without any scratches.

Repeat the verification procedure. If the verification still fails, fill in the form **PR-23 sensor verification form**, found in the end of this manual. The sensor's serial number is shown in the upper right corner of each display. The list of CCD and TEMP values are found on the Verification results display (Figure 13.5). Send the form (preferably by fax) to K-Patents or your nearest K-Patents representative or email the collected data to <info@kpatents.com> and wait for further instructions.

Figure 13.4 The K-Patents universal sample holder PR-1012

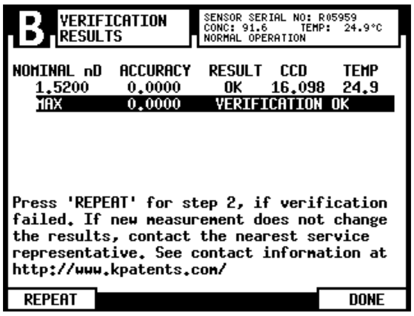


Figure 13.5 Verification results

13.2.2 Sensor verification certificate

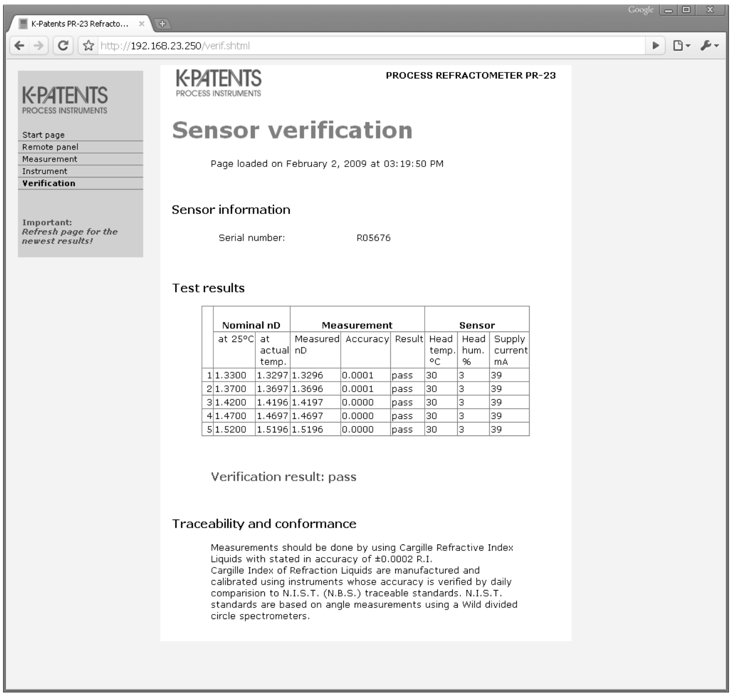
The DTR stores the most recent verification done on the DTR and the results of that verification can be viewed on the instrument homepage by following the Verification link on the link bar. (For more information on the instrument homepage, see Chapter 12.)

Important: When you have performed a verification on a sensor, reload/refresh the verification page to view the newest results. **The date given on the verification page is the page load date**, not necessarily the verification date.

The date and time settings are taken from the browser, i.e. the computer used to view the verification certificate. The DTR doesn't have timekeeping functionality.

To print the verification certificate, simply use your browser's print function. The page is designed so that with browser default settings it normally fits onto a single sheet of A4 or letter sized paper; the navigation bar is omitted for cleaner printout (Figure 13.7).

Note: If you need to verify two sensors connected to one DTR, you need to verify one and then to save or print the certificate, as the results from the verification of the second sensor will overwrite the results of the first sensor. Check the sensor serial number on the certificate to see that you have correct results on screen and reload/refresh if needed.



	Nominal nD		Measurement			Sensor		
	at 25°C	at actual temp.	Measured nD	Accuracy	Result	Head temp. °C	Head hum. %	Supply current mA
1	1.3300	1.3297	1.3296	0.0001	pass	30	3	39
2	1.3700	1.3697	1.3696	0.0001	pass	30	3	39
3	1.4200	1.4196	1.4197	0.0000	pass	30	3	39
4	1.4700	1.4697	1.4697	0.0000	pass	30	3	39
5	1.5200	1.5196	1.5196	0.0000	pass	30	3	39

Figure 13.6 Instrument verification page open in a browser

K-Patents PR-23 Refractometer System: Sensor verification http://192.168.23.250/verif.shtml

K-PATENTS
PROCESS INSTRUMENTS

PROCESS REFRACTOMETER PR-23

Sensor verification

Page loaded on February 2, 2009 at 03:19:28 PM

Sensor information

Serial number: R05676

Test results

	Nominal nD		Measurement			Sensor		
	at 25°C	at actual temp.	Measured nD	Accuracy	Result	Head temp. °C	Head hum. %	Supply current mA
1	1.3300	1.3297	1.3296	0.0001	pass	30	3	39
2	1.3700	1.3697	1.3696	0.0001	pass	30	3	39
3	1.4200	1.4196	1.4197	0.0000	pass	30	3	39
4	1.4700	1.4697	1.4697	0.0000	pass	30	3	39
5	1.5200	1.5196	1.5196	0.0000	pass	30	3	39

Verification result: pass

Traceability and conformance

Measurements should be done by using Cargille Refractive Index Liquids with stated in accuracy of ±0.0002 R.I.
Cargille Index of Refraction Liquids are manufactured and calibrated using instruments whose accuracy is verified by daily comparision to N.I.S.T. (N.B.S.) traceable standards. N.I.S.T. standards are based on angle measurements using a Wild divided circle spectrometers.

1 of 1 2.2.2009 15:21

Figure 13.7 Instrument verification certificate

A Glossary and abbreviations

- CCD = **C**harge **C**ouple **D**evice, sensor optical element
- CORE, CORE Optics = **C**ompact **O**ptical **R**igid **E**lement: All measuring components are in one solid module, the CORE (Optics) module.
- DTR = Indicating transmitter DTR, Dual sensor indicating transmitter of a K-Patents PR-23 refractometer system.
- LCD = **L**iquid **C**rystal **D**isplay, used as transmitter display.
- LED = **L**ight **E**mitting **D**iode, the light source in a K-Patents refractometer sensor.
- n_D = Refractive index (of a liquid), see Section 1.2.
- Sensor code:
  -AC = 3A approved, Compact model
  -AP = 3A approved, Probe model
  -GP = General purpose, Probe model
  -M = Teflon body refractometer for chemically aggressive liquids in small pipes
  -MS = Teflon body refractometer for semiconductor liquid chemical processes
  -SD = Safe-Drive™ sensor for the K-Patents Safe-Drive™ system for safe sensor insertion and removal
  -W = Saunders body refractometer for chemically aggressive liquids in large pipes
  -...-AX = ATEX approved sensor, modified for use in potentially explosive atmosphere
  -...-CS = CS approved sensor, modified for use in potentially explosive atmosphere
  -...-FM = FM approved sensor, modified for use in potentially explosive atmosphere
  -...-IA = ATEX approved sensor for hazardous locations in Zone 0 and Zone 1
- STR = Indicating transmitter STR, Single sensor indicating transmitter for hazardous locations and divert control systems

B Index

C PR-23 sensor verification instructions

Equipment

Before starting the verifications procedures, make sure that you have a K-Patents PR-23 sample holder at hand. Also check the condition of your standard refractive index liquids. You'll also need a cleaning solution (ethanol) to clean the sensor prism and the sample holder.

The sample holder keeps the sample on the prism surface and also keeps the ambient light out. The K-Patents universal sample holder PR-1012 (Figure C.1) can be used with any K-Patents sensor.

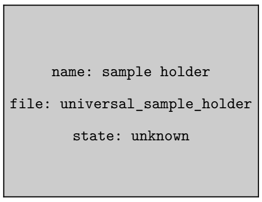


Figure C.1 The universal sample holder PR-1012

The verification of the PR-23 sensor calibration is made using a set of standard refractive index liquids with the nominal values at 25 °C:

- 1.330
- 1.370
- 1.420
- 1.470
- 1.520

The accuracy of the certified standard refractive index liquids is ± 0.0002 and they can be traced back to national standards: N.I.S.T Standards # 1823 and # 1823 II.

The repeatability of PR-23 sensor, i.e. the deviation from the latest n_D calibration, is within ± 0.0002.

As the specified accuracy of PR-23 is ± 0.0002, then the representative level is the sum of the three accuracy specifications, that is ± 0.0004.

K-Patents provides a set of standard R.I. liquids, PR-2300, containing these five liquids. The set can be ordered directly from K-Patents or through your nearest K-Patents representative.

Preparations

To start the verification process, select 1 VERIFICATION in the Main menu of your sensor. The first verification display instructs you on the pre-verification procedure:

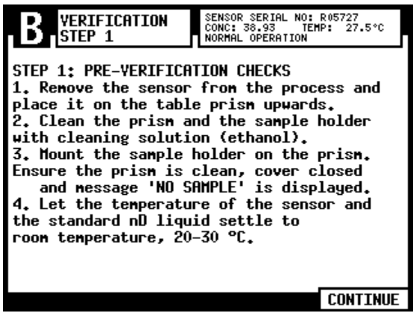


Figure C.2 Verification, pre-verificaton checks

When you are finished with the preparations, press CONTINUE (right-most soft key) to start the verification process.

Verification

The verification itself is done by the refractometer system, you only have to follow the instructions on screen and apply one RI liquid at a time on the sensor and press VERIFY (right-most soft key). See Figure C.3.

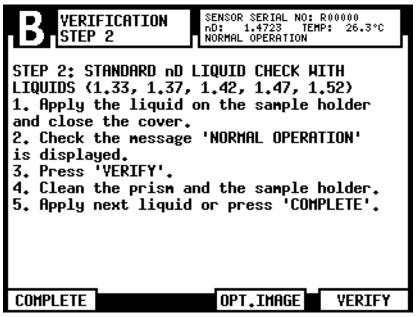


Figure C.3 Verification display

Important: Clean the prism and the sample holder very carefully between the RI liquids.

Note: A new verification data collection method is implemented from DTR program version 2.0 onwards. The instrument measures each verification data point ten times and uses the average of these measurements. Measuring each verification liquid takes a few seconds, during which a measurement progress display is shown (Figure 6.8). Please wait until the verification step 2 display reappears before proceeding to next verification liquid.

When you have verified all five standard RI liquids, press the left-most soft key COMPLETE.

Verification results

Pressing COMPLETE in the verification display finishes the verification procedure and calls up the verification results.

If verification is successful, i.e. all measurements are within ± 0.0004 of the nominal values, you get the message VERIFICATION OK, see Figure C.4 below.

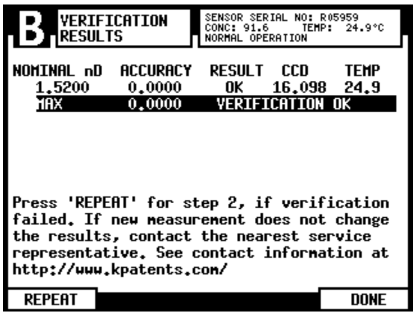


Figure C.4 Verification completed successfully (here only with one RI liquid)

Note: If the DTR has program version 2.10 or higher, you also have access to a *printable verification certificate* over the ethernet connection. See Section 12.4.2, page 137.

If you get the message VERIFICATION FAILED (Figure C.5), first check that the prism **and** the sample holder are absolutely clean and the sample holder sits tightly on the sensor tip before a standard liquid is applied. Make sure the standard liquids are in good condition and not past their expiration date. Also, inspect the prism surface, checking that it is smooth and glossy without any scratches. Then go back to the Verification step 2 by pressing soft key REPEAT and repeat the whole verification procedure.

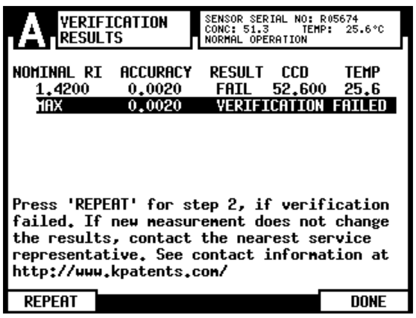


Figure C.5 Verification failed

Using PR-23 sensor verification form

If verification fails even on the repetition of the verification procedure, fill in the **PR-23 sensor verification form** and send it (preferably by fax) to K-Patents or your nearest K-Patents representative or email the collected information to <info@kpatents.com> and wait for further instructions.

For the sensor verification form, you need to collect data from the Verification step 2 display and the Verification results display. The sensor's serial number is shown in the upper right corner of each display. The measured n_D (RI) is given when VERIFY has been pressed in Verification step 2. The list of CCD and TEMP values are found on the verification results display, see (Figure C.6)

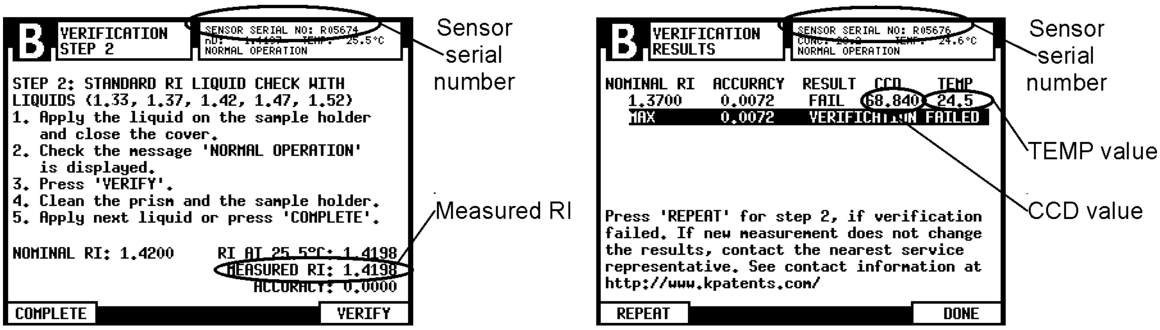


Figure C.6 Finding verification information for PR-23 sensor verification form

D PR-23 sensor verification form

Fill in this form and fax it to K-Patents Oy or to your local service representative. For contact information, please see *<http://www.kpatents.com/>*.

Sensor serial no: ________________

Customer: ________________

Address: ________________

Fax: ________________

Email: ________________

Date: ________________

Verification made by: ________________

	VERIFICATION RESULTS DISPLAY			
Sample no	Nominal n_D	Measured n_D	CCD	Temp
1	1.3300			
2	1.3700			
3	1.4200			
4	1.4700			
5	1.5200			

E PR-23 field calibration form

Fill in this form and fax it to K-Patents Oy or to your local service representative. For contact information, please see *<http://www.kpatents.com/>*.

Sensor serial no: ______________________________

Customer: ______________________________

Address: ______________________________

Fax: ______________________________

Email: ______________________________

Sample description: ______________________________

Solvent (water/other): ______________________________

Laboratory method: ______________________________

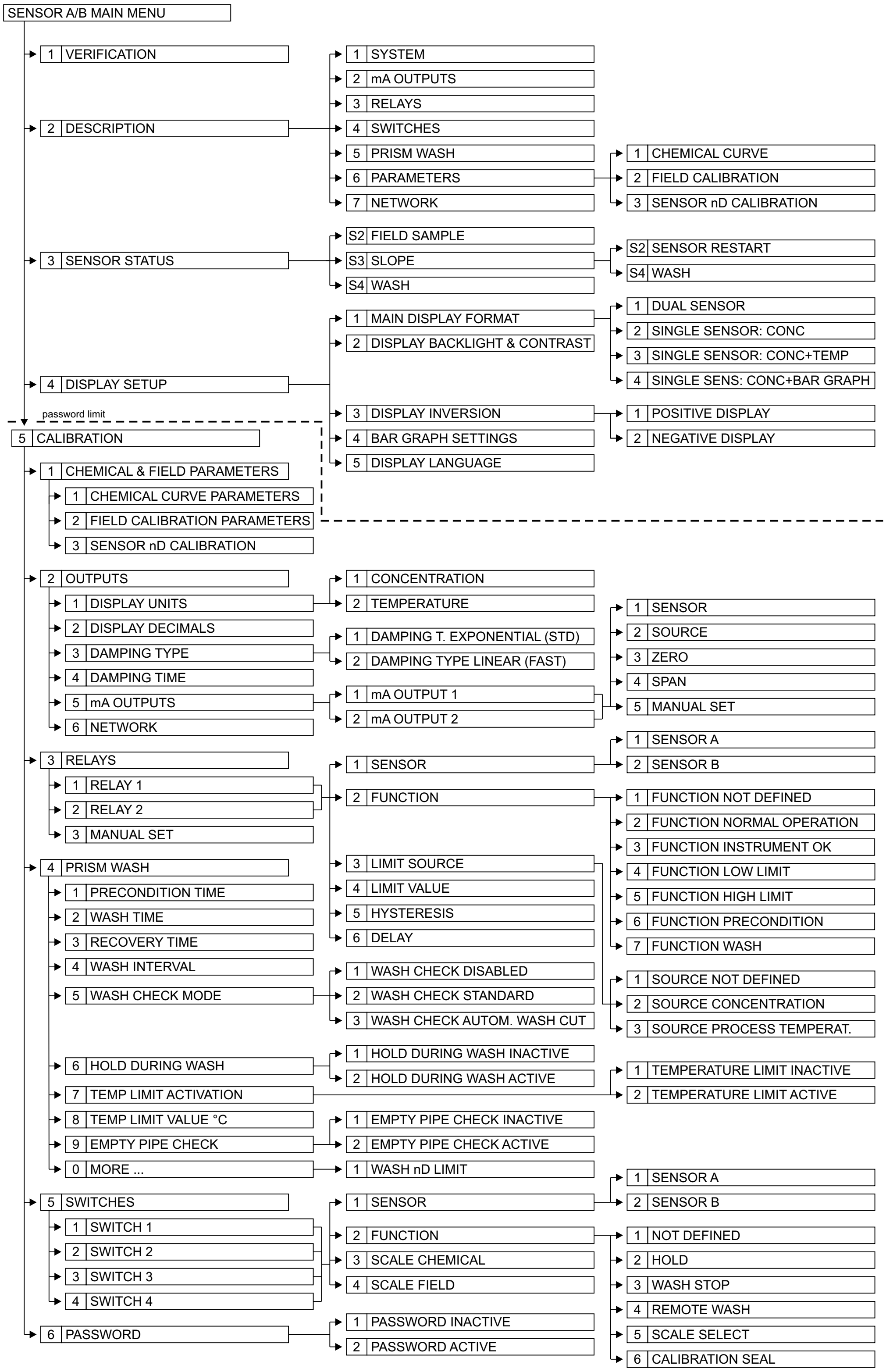
Date: ______________________________

Data collected by: ______________________________

		DTR DISPLAY VALUES			
Sample no	LAB%	CALC	T	n_D	CONC

For instructions on field calibration, see PR-23 instruction manual, Chapter 6.

F DTR command selection tree



G STR/Divert mode command selection tree