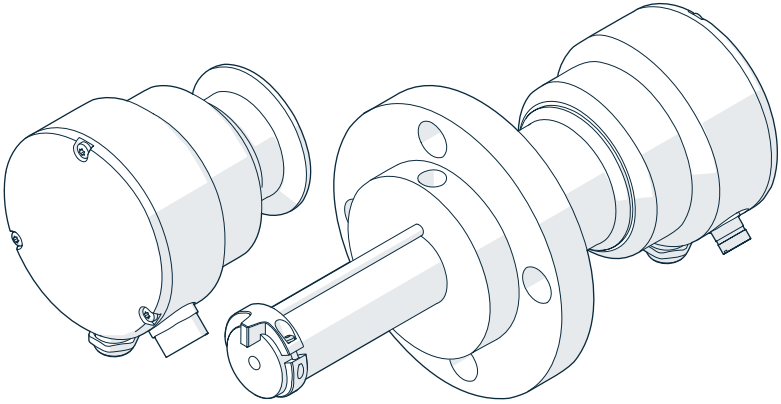
M212898EN-K

User Guide

Vaisala Polaris Process Refractometer

PR53 Series



VAISALA

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1. About this document

1.1 Version information

This document provides instructions for using and maintaining PR53 Series process refractometers.

This is a general manual for all PR53 series process refractometers. For more detailed installation and safety guidelines, refer to the model-specific instructions: Related manuals (page 12).

Table 1 Document versions (English)

Document code	Date	Description
M212898EN-K	July 2026	PR53S Semicon Process Refractometer model added. Analog output lower current limit changed to 3.2 mA. Decimal place selection (starting from firmware version 1.2.3) added. Optical image data Modbus registers and unit conversion information added, HART interface EDD and FDI package information updated. Added sections: • Unit conversion options (page 34) • Measurement reading decimal selection (page 37) • PR53S specifications (page 111) Updated sections: • Related manuals (page 12) • PR53 refractometer models (page 17) • HART (page 29) • PR53 common specifications (page 90) • Spare parts and accessories (page 115) • Modbus registers (page 164)

Document code	Date	Description
M212898EN-J	March 2026	New wash nozzle assembly version added. Updated wash nozzle insertion and removal instructions and added wash connection installation instructions. Recycling information corrections. Added information about event logs and disabling concentration curve warnings (applicable from software version 1.2.1. onwards). Operating environment and input specifications updated. Added sections: • Disabling concentration curve warnings (page 37) • Disabling concentration curve warnings with Insight (page 67) • Insight Diagnostics view (page 64) • SDI5 wash nozzle removal and insertion overview (page 135) • SDI5 wash nozzle assembly parts (page 137) • Removing SDI5 wash nozzle (page 138) • Inserting SDI5 wash nozzle (page 145) • Installing wash connection (page 151) Updated sections: • Modifying concentration curves (page 59) • Recycling instructions (page 117)
M212898EN-H	September 2025	This document. Updated sections: • Related manuals (page 12) • Safety (page 15) • Storing and transporting (page 19) • PR53 refractometer models (page 17) • Refractometer connections (page 20) • Modbus RTU (page 29) • Connecting refractometer to Indigo520 (page 47) • Connecting to Indigo80 (page 55) • Connecting to Insight software (page 61) • Preventive maintenance (page 77) • Cleaning refractometer and prism (page 78)

1.2 Related manuals

For the latest versions of these documents, see docs.vaisala.com.

Table 2 Related manuals

Document code	Name
M212866EN	Vaisala Polaris Process Refractometer PR53AC Installation Guide
M212932EN	Vaisala Polaris Process Refractometer PR53AP Installation Guide
M212931EN	Vaisala Polaris Process Refractometer PR53GC Installation Guide
M212873EN	Vaisala Polaris Process Refractometer PR53GP Installation Guide
M213018EN	Vaisala Polaris Process Refractometer PR53M Installation Guide
M213333EN	Vaisala Polaris Process Refractometer PR53S Installation Guide
M212953EN	Vaisala Polaris PR53SD and SDI5 Safe-Drive Installation and Safety Guide
M213029EN	Vaisala Polaris Process Refractometer PR53W Installation Guide
M212808EN	Vaisala Polaris Process Refractometer PR53 Prism Wash System User Guide
M212287EN	Vaisala Indigo500 Series Transmitters User Guide
M212722EN	Vaisala Indigo80 Handheld Indicator User Guide
M213175EN	Vaisala Polaris Process Refractometer PR53EX Safety Guide (ATEX, IECEx)

1.3 Documentation conventions

WARNING! Alerts you to a serious hazard. If you do not read and follow instructions carefully at this point, there is a risk of injury or even death.

CAUTION! Alerts you to a potential hazard. If you do not read and follow instructions carefully at this point, the product could be damaged or important data could be lost.

Highlights important information on using the product.

Gives information for using the product more efficiently.



Lists tools needed to perform the task.



Indicates that you need to take some notes during the task.

1.4 Trademarks

Vaisala®, Polaris™, and Indigo™ are trademarks of Vaisala Oyj.

Modbus® is a registered trademark of Schneider Automation Inc.

All other product or company names that may be mentioned in this publication are trade names, trademarks, or registered trademarks of their respective owners.

1.5 Patent notice

This product is protected by the following patents and patent applications and their corresponding national rights:

- US2019391074A1

2. Product overview

2.1 Safety

WARNING! If you have a refractometer for potentially explosive environments, read the Safety Guide fully before continuing using the refractometer. The Safety Guide is delivered with the product or it can be found in docs.vaisala.com.

This product has been tested for safety according to IEC 61010-1. Note the following precautions:

WARNING! Only licensed experts may install electrical components. They must adhere to local and state legislation and regulations.

2.1.1 ESD protection

Electrostatic discharge (ESD) can damage electronic circuits. Vaisala products are adequately protected against ESD for their intended use. However, it is possible to damage the product by delivering electrostatic discharges when touching, removing, or inserting any objects in the equipment housing.

To avoid delivering high static voltages to the product:

- Handle ESD-sensitive components on a properly grounded and protected ESD workbench or by grounding yourself to the equipment chassis with a wrist strap and a resistive connection cord.
- If you are unable to take either precaution, touch a conductive part of the equipment chassis with your other hand before touching ESD-sensitive components.
- Hold component boards by the edges and avoid touching component contacts.

2.2 Product nomenclature

Table 3 Product nomenclature

Item	Name
CCD camera	Charge Coupled Device camera, line camera in the refractometer optics.
LA	Light area, sector of an optical image that corresponds to the light that is reflected.
RI	Refractive index, number that indicates how much the path of light is bent, or refracted, when entering a material.

Item	Name
QF	Quality factor, dimensionless value, depicting the quality (sharpness) of the optical image. Changes in QF may indicate coating of the prism.

2.3 PR53 product overview

The PR53 inline process 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.

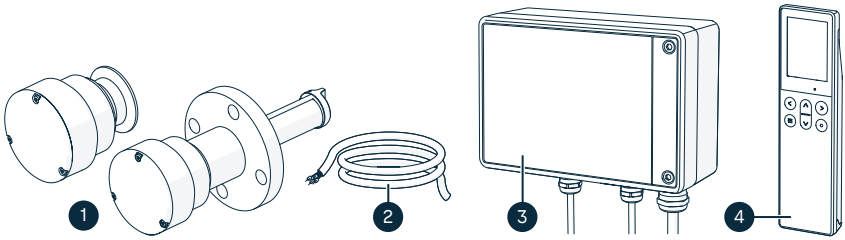


Figure 1 Refractometer equipment

1 Vaisala Polaris™ Process Refractometers
2 Interconnecting cable
3 Vaisala Indigo520 Transmitter (optional)
4 Vaisala Indigo80 Handheld Indicator (optional)

The inline process refractometer (1) measures the refractive index (RI) and the temperature of the process medium. Using a pre-defined concentration model, the refractometer uses the measurement data to calculate the concentration. The output value can be read directly from the refractometer through the configurable integrated analog output channel, through the Modbus RTU interface or HART interface. Alternatively, the refractometer can be connected to the optional Indigo520 Transmitter (3) or Indigo80 Handheld Indicator (4) using the interconnecting cable (2).

Indigo520 is a configurable transmitter, containing 4 configurable analog output channels, 2 binary contact control relays, Modbus TCP/IP output, a web server, and a graphical touch panel display. The current values and trend data can be read from Indigo520, which also contains a local data logger. One or two refractometers can be connected to one Indigo520 transmitter. For service purposes, the PR53 refractometer can be connected to a PC using a USB adapter and Vaisala Insight software.

Vaisala Indigo80 Handheld Indicator is a portable diagnostics tool that accommodates either one or two compatible Vaisala devices, such as refractometers. The indicator can display measurement data and diagnostic information on the spot, configure the measurement device and perform data logging.

More information

- Refractometer LED indicators (page 26)
- Indigo520 user interfaces (page 27)
- Indigo80 handheld indicator (page 28)
- Vaisala Insight PC software (page 28)
- HART (page 29)
- Modbus RTU (page 29)
- Analog output (page 30)

2.4 PR53 refractometer models

There are different PR53 refractometer models. Each model is adapted for different process requirements.

- **The Vaisala Polaris PR53AC** sanitary compact process refractometer is designed to measure liquid concentrations, such as Brix.
- **The Vaisala Polaris PR53AP** sanitary probe process refractometer is designed for food and beverage, dairy and brewery industry customers, and OEMs to measure liquid concentrations, such as Brix, in applications such as jam cookers and mixing tanks.
- **The Vaisala Polaris PR53GC** general-purpose compact process refractometer is designed for measuring concentrations of acids, alkaline solutions, alcohols, hydrocarbons, solvents, and various other solutions.
- **The Vaisala Polaris PR53GP** general-purpose probe process refractometer is designed for measuring concentrations of sugars/Brix, acids, alkaline solutions, hydrocarbons, solvents, and various other solutions.
- **The Vaisala Polaris PR53M** PTFE-body process refractometer is designed to measure concentrations of aggressive chemicals, such as hydrochloric acid (HCl), sodium hydroxide (NaOH), sodium chloride (NaCl), and sulfuric acid (H_2SO_4) in the chemical and semiconductor industries.
- **The Vaisala Polaris PR53S** Semicon Process Refractometer is designed to measure concentrations of semiconductor liquid chemical processes. A compact refractometer with an ultrapure modified PTFE flow cell body for semiconductor liquid chemical processes.
- **The retractable Vaisala Polaris PR53SD** Safe-Drive process refractometer is designed for safety-critical measurements in pulp mills, such as firing liquor concentration. The Safe-Drive system with a PR53SD refractometer enables safe sensor insertion and removal also when the process line is in full operation.
- **The Vaisala Polaris PR53W** valve-body process refractometer is designed to measure concentrations of aggressive chemicals, such as sulfuric acid, hydrochloric acid (HCl), and sodium hydroxide (NaOH) in production pipelines such as in the chemical, biochemical, and pharmaceutical industries.

PR53AC and PR53AP have been designed to be used in food contact applications and meet the 3-A and EHEDG sanitary standard requirements.

If you have a PR53EX refractometer for potentially hazardous locations, the model descriptions can be found in the Safety Guide. The Safety Guide is delivered with the product or it can be found in docs.vaisala.com.

2.5 Refractometer structure

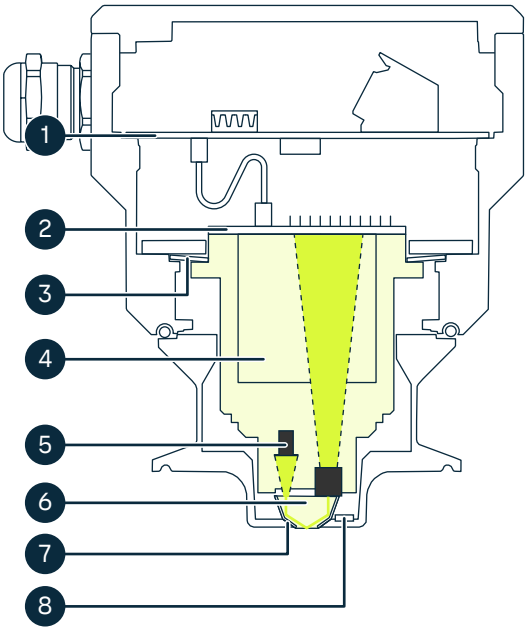


Figure 2 PR53 refractometer structure

1 Main circuit board
2 CCD Charge Coupled Device
3 Disc springs
4 CORE-Module
5 Light source
6 Prism
7 Prism gasket
8 Integrated temperature sensor

The measurement prism (6) is flush-mounted to the surface of the probe tip. The prism (6) and all the other optical components are fixed to the solid CORE-Module (4), which is springloaded (3) against the prism gasket (8). The light source (5) is a yellow LED, emitting light with 589 nm wavelength (Sodium D-line wavelength), which is a standard in refractive index values in literature. The main circuit board (1) receives the raw data from the CCD Charge Coupled Device (2) and the process temperature sensor (7), and then calculates the refractive index RI, the process temperature T, and process concentration according to a predefined concentration curve. This information is transmitted to the user with integrated analog output channel, digital Modbus RTU, or Indigo520 transmitter.

2.6 Storing and transporting

Soft shell packaging prevents damage to the components of the refractometer. Transport the device in its original packaging.

Before storing, remove any dirt and grease from the refractometer and make sure that it is dry.

Storage conditions:

- Temperature:
  −40 ... +65 °C (−40 ... +149 °F)
- Humidity: Non-condensing

3. Refractometer connections

3.1 Refractometer connections

WARNING! If you have a refractometer for potentially explosive environments, read the Safety Guide fully before continuing using the refractometer. The Safety Guide is delivered with the product or it can be found in docs.vaisala.com.

The refractometer has built-in isolated 4–20 mA analog output channel, which represents the output of the refractometer. The output range and the engineering unit depend on the concentration curve used; for example, if the unit is configured with 0–100 °Brix output, the scaling of the output channel is 4 mA = 0 °Brix and 20 mA = 100 °Brix. The default error state indication level is 3.6 mA. The output is configurable: scaling and error status indication level can be configured using the Vaisala Insight software and a USB adapter.

The connection header also has an RS-485 port. This allows using the refractometer directly as a Modbus RTU server device. Alternatively, the same port is used to connect the refractometer to an Indigo520 transmitter.

For digital communications, see Modbus RTU (page 29).

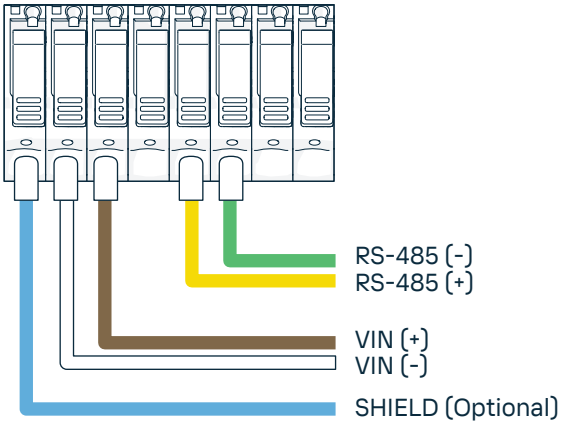


Figure 3 Connecting wires inside the refractometer (Modbus RTU or Indigo520)

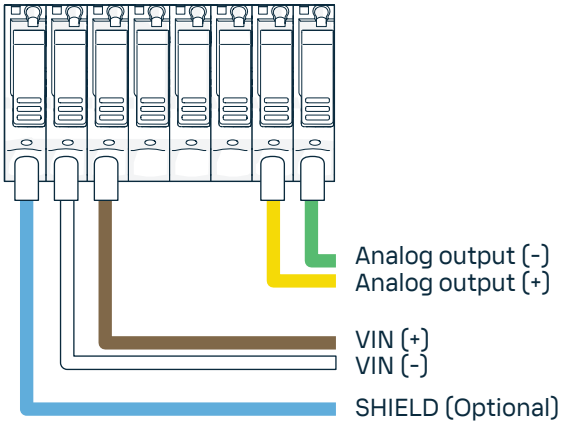


Figure 4 Connecting wires inside the refractometer (analog output)

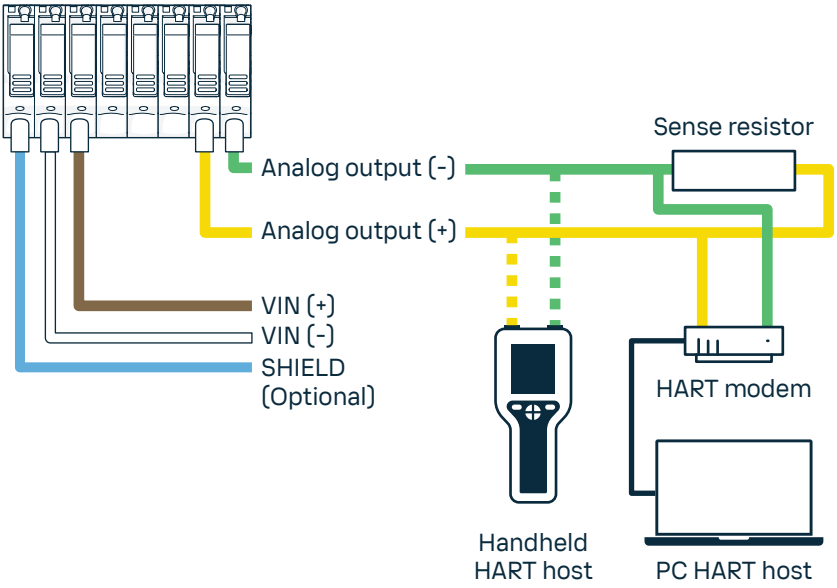


Figure 5 Connecting wires inside the refractometer (HART)

A sense resistor needs to be connected to the analog output. The HART host's probes are connected across the sense resistor. The recommended sense resistor value for HART is 250 Ω. Check for the maximum loop impedance from the PR53 datasheet.

More information

- Starting up stand-alone refractometer (page 45)
- Starting up refractometer with Indigo520 (page 45)
- Starting up refractometer with HART (page 46)

3.2 System wiring

CAUTION! Do not connect the power cable (VIN+/VIN-) to the analog output terminals. This can damage the refractometer.

The analog and Modbus RTU wiring configurations are examples of system wiring. Your system may differ from the wiring examples presented here.

It is recommended to connect Shield into the cable gland or metal thread adapter.

Indigo520 wiring

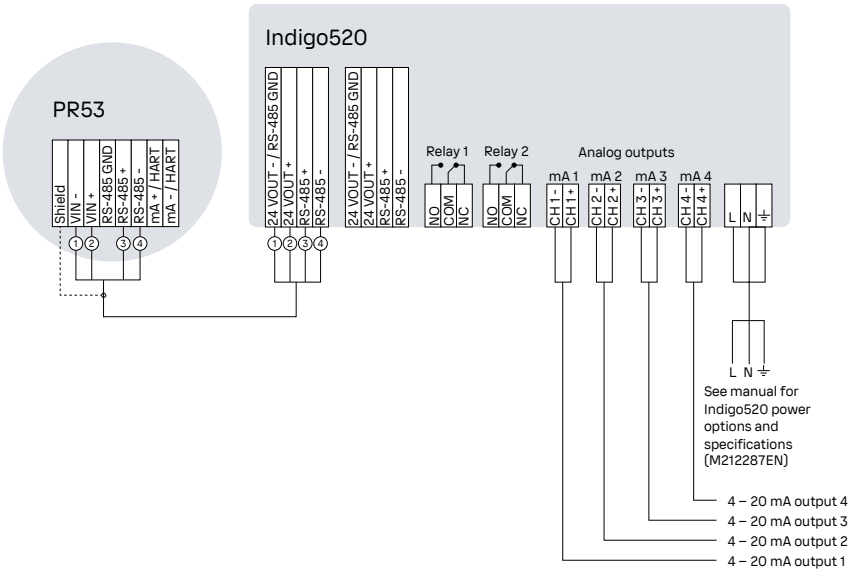


Figure 6 Wiring diagram for PR53 and Indigo520

Analog system and optional HART communication

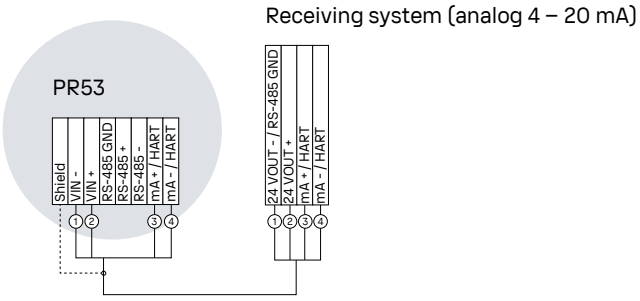


Figure 7 Wiring diagram for PR53 analog output and optional HART communication

Modbus RTU system

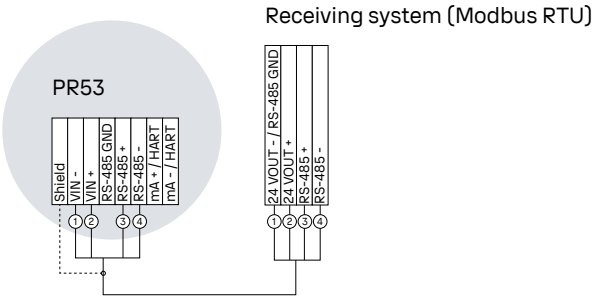


Figure 8 Wiring diagram for PR53 and Modbus RTU

More information

- Configuring Modbus communication settings with Insight (page 75)

3.3 Wiring considerations

The chassis ground and ground terminal are electrically connected. Grounding can be done either by connecting the cable shield to the respective terminal in the wiring header, or alternatively by connecting the cable shield to the cable gland.

The integrated mA signal is galvanically isolated from the power supply in order to minimize the possibility of ground loops.

The signal ground of the integrated RS485 bus signal ground is galvanically connected to the power supply ground. Consider grounding to avoid the effect of ground loops in the RS485 bus.

The signal cable shield should be connected to the PR53 chassis ground. Grounding through the cable gland is recommended. Alternatively, the cable shield can be connected to the SHIELD pin in the wiring header.

Consider the grounding of the PR53 refractometer in situations where the device is connected to non-conductive (such as glass fiber) pipelines in order to avoid static electricity.

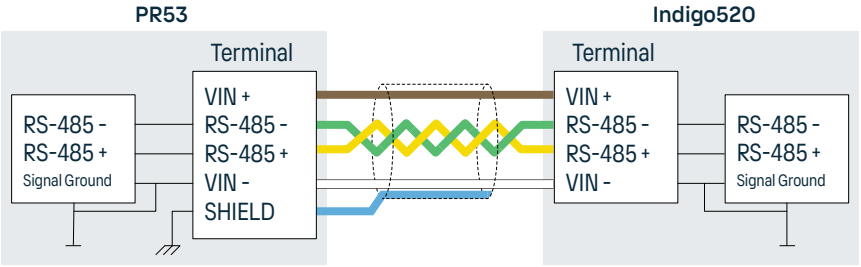


Figure 9 Wiring PR53 to Indigo520

4. User interfaces

4.1 Refractometer LED indicators

The LED indicators are used to indicate the status of the refractometer when used without a graphical user interface.

The color of the LED corresponds to the severity:

- **Green** indicates normal operation and power on.
- **Blinking green** indicates successful digital communication to the RS485 port. When the green LED blinks, the refractometer has successfully received and responded to a Modbus request, or received successful communication from the Indigo520 transmitter or Indigo80 handheld indicator.
- **Yellow** indicates warning status. You need to attach the refractometer to Modbus, the Indigo520 transmitter, Indigo80 handheld indicator, or Insight software.
- **Red** indicates a critical failure where user interference is required. When the red LED is on, the refractometer may need to be sent to Vaisala for service. Contact helpdesk@vaisala.com.

The error codes can be read either through the Indigo520 transmitter, Indigo80 handheld indicator, Modbus RTU port, or Vaisala Insight software with a USB adapter.

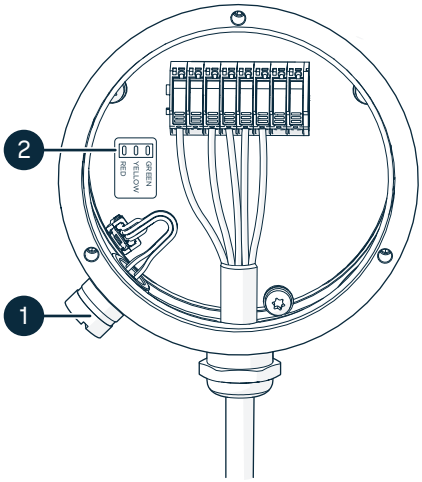


Figure 10 PR53 main circuit board

1 Service port
2 LED indicators

4.2 Indigo520 user interfaces

Vaisala Indigo520 is a configurable transmitter that accommodates either one or two PR53 series refractometers. The transmitter can display measurement data and diagnostic information on the spot, as well as transmit them to automation systems through analog signals, control relays, or Modbus TCP/IP protocol.

Indigo520 can be used with two interfaces:

- Touchscreen display
- Web interface

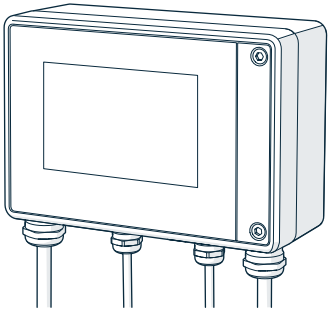


Figure 11 Indigo520 transmitter

Indigo520 provides:

- Easy-to-use touchscreen display
- Web-based user interface
- Data logging
- Status and diagnostics info
- Optical image diagnostics
- Wash system control

The PR53 prism wash system is controlled and configured with Indigo520. In most applications the prism keeps clean due to the self-cleaning effect. If coating occurs, your application may require a wash system.

For more information on the use of Indigo520, see Indigo500 User Guide (M212287EN).

More information

- Connecting refractometer to Indigo520 (page 47)
- Vaisala Indigo520 transmitter (page 47)

4.3 Indigo80 handheld indicator

Vaisala Indigo80 Handheld Indicator is a portable diagnostics tool that accommodates up to two Vaisala Indigo-compatible or other supported devices for measuring a wide range of parameters.

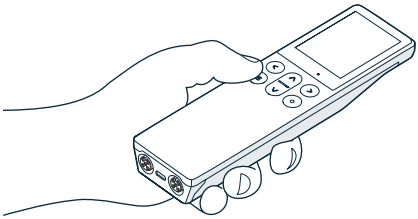


Figure 12 Indigo80 handheld indicator

For more information on the use of Indigo80, for example, editing the measurement views and performing data logging, see Indigo80 User Guide (M212722EN).

More information

- Vaisala Indigo80 handheld indicator (page 54)
- Connecting to Indigo80 (page 55)

4.4 Vaisala Insight PC software

Vaisala Insight PC software is a configuration and calibration software for Vaisala devices. Insight is available for the Windows operating system (64-bit only). For a full list of supported operating system versions, see vaisala.com/insight.

With Insight, you can:

- See device information and status.
- See real-time measurement data.
- Manage concentration curves.
- Calibrate and adjust the device.
- Perform short-term data logging for laboratory testing or evaluation purposes, for example.

To ensure support for your device, download the latest version of Insight at vaisala.com/insight.

The refractometer can be connected to Insight using a Vaisala Indigo USB adapter (item code USB2).

More information

- Connecting to Insight software (page 61)

4.5 HART

The HART protocol is a standardized industrial automation protocol that can be used to transfer measurement and diagnostic values and perform some limited device configuration. A HART bus works along with a 4–20 mA analog output channel either in point-to-point connection, in which the bus provides measurement information both in an analog and digital channel, or in multidrop mode, in which communication happens only in a digital channel. PR53 complies with HART protocol version 7.

The HART features supported by PR53 are described in HART Field Device Specification. Electronic Device Description (EDD) file and FDI package for HART DD hosts are available in the FieldComm Group package repository at the fieldcommgroup.org website.

The EDD and FDI packages are also hosted at docs.vaisala.com (FDI 01.01.00 and FDI 02.01.00).

More information

- Starting up refractometer with HART (page 46)

4.6 Modbus RTU

The Modbus RTU protocol is available through the RS-485 port. The RS-485 port can be used as a Modbus RTU server device. The supported Modbus function codes are 3 (Read Holding Registers) and 16 (Write Multiple Registers). The default Modbus ID is 240. The ID can be changed through the service port using Vaisala Insight software and a USB adapter.

The following table lists the default communication settings used when Modbus is enabled at the factory.

Table 4 Default Modbus communication settings

Description	Default value
Baud rate	19200
Parity	No parity
Number of data bits	8

Description	Default value
Number of stop bits	2

More information

- Configuring Modbus communication settings with Insight (page 75)

4.7 Analog output

The PR53 process refractometers provide one scalable analog output channel with 4–20 mA current output loop. The output range and the engineering unit depend on the concentration curve used: if the unit is configured with Brix 0–100 ° output, the scaling of the output channel is 4 mA = 0 °Brix and 20 mA = 100 °Brix.

The output is configurable: The output variable (refractive index, temperature, concentration, quality factor), scaling, and error status indication level can be configured using the Vaisala Insight software and a USB adapter. The engineering unit of the concentration is defined by the concentration curve, and can only be changed by modifying the concentration curve.

When PR53 is connected to Indigo520, 4 analog output channels are available. The signal type (0–1/5/10 V, 0/4–20 mA) in Indigo520 is user configurable. The integrated analog output channel and the Indigo520 analog outputs are independent from each other, and can also be used simultaneously.

PR53 process refractometers have two configurable error state levels.

- Default: 3.4 mA
- Secondary error state (No liquid error state): Enabled, 3.2 mA

For configuring the analog output with Indigo520, see Indigo500 User Guide (M212287EN).

For configuring the analog output with Insight, see Configuring analog output (page 73).

More information

- Configuring analog output (page 73)
- Error statuses (page 84)

5. Concentration measurement

5.1 Overview of concentration measurement

The concentration measurement is organized in 6 layers.

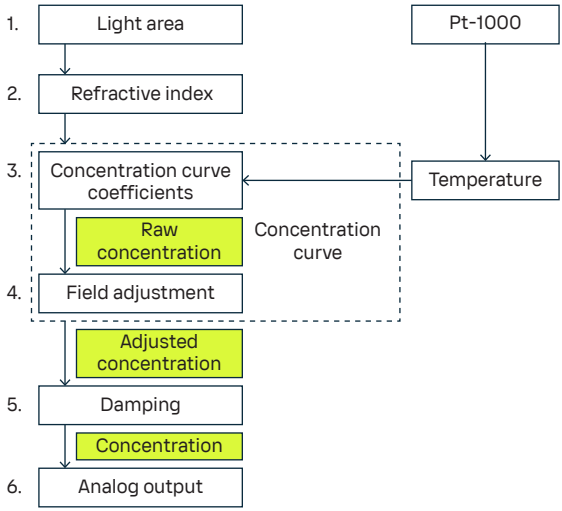


Figure 13 Concentration measurement layers

1 Light area information comes from the CCD element and temperature information from Pt-1000 temperature element. The position of the shadow edge is light area and scaled 0–100 %.
2 RI adjustment: The actual refractive index RI is calculated from the light area. The temperature is calculated from the Pt-1000 resistance. The RI measurement of each refractometer can be verified using standard nominal reference liquids.
3 Concentration curve: The refractometer calculates raw concentration from RI and temperature according to the chemical curve. The result is a temperature-compensated raw concentration value.
4 Field adjustment: Adjustment of the raw concentration value may be required to compensate for some process conditions or to fit the measurement to the laboratory results. The field adjustment parameters are used to convert raw concentration into adjusted concentration. The adjusted concentration is called concentration. If there is no adjustment, raw concentration and adjusted concentration are equal.
5 Damping: You can apply signal damping to diminish the influence of process noise.
6 Output signal: The range of the 4–20 mA signal is defined by the range of the particular concentration curve.

More information

- Principle of measurement (page 174)

5.2 Concentration curve

Concentration curve consists of:

- Actual concentration curve parameters (C-parameters, engineering unit, valid temperature and concentration ranges)
- Related field adjustment parameters (F-parameters)
- Alias name

5.2.1 Concentration curve parameters

Concentration curve is the theoretical concentration curve based on RI and temperature. It is defined by a set of 16 parameters, C-parameters.

A concentration curve is specific to the given process medium, for example, sucrose or sodium hydroxide. The set of parameters is given by Vaisala. Do not alter the C-parameters, except if you are changing to another process medium.

The refractometer is able to hold 4 different concentration curves in its memory. The used concentration curve can be switched using the Indigo520 transmitter, Vaisala Insight software, HART, or Modbus RTU write function.

The primary method for correcting the concentration measurement is field adjustment. However, in some cases the linear field adjustment may not be enough and the C-parameters may require fine-tuning. In this case, contact Vaisala help desk for support. Concentration curve contains also other information besides the C-parameters (for example, measurement unit, valid concentration and temperature ranges, and similar).

Table 5 C-parameters

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}

More information

- Field adjustment parameters (page 35)
- Changing concentration curves with Indigo520 (page 50)

5.2.2 Unit conversion options

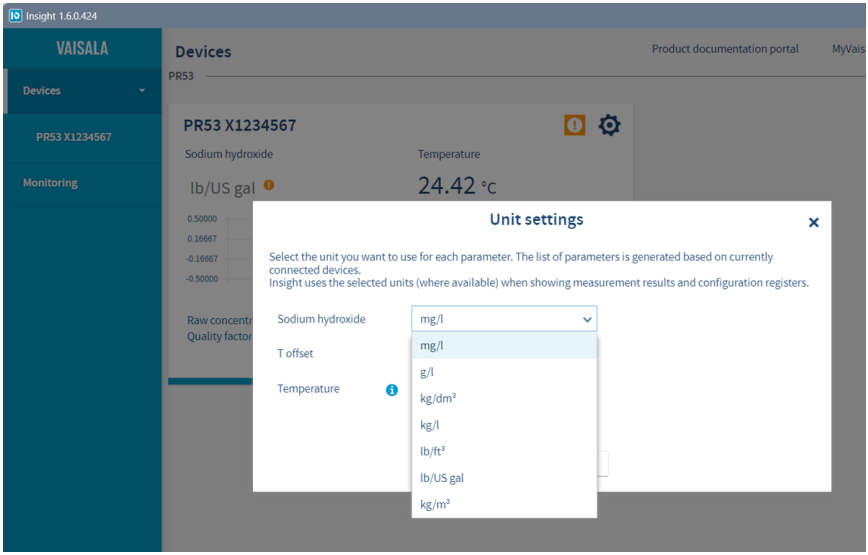


Figure 14 Unit settings menu in Insight PC software, weight per volume unit selection

You can change the unit in which the measurement is displayed from the unit settings of the configuration tool you are using (for example, Insight PC software or Indgo80 Handheld Indicator). The table below lists the available unit options.

Measurement	Unit options
Weight per volume	• g/l • kg/m^3 • mg/l • kg/l • kg/dm^3 • lb/ft^3 • lb/gal • g/ml
Temperature	• °C • °F
Molar concentration	• mol/dm^3 • mol/l • mol/m^3 • mol/ft^3 • mol/gal

Measurement	Unit options
Brix curve	°Bx, percentage by weight (%wt)
Percentage by weight (%wt) curve	%wt only: cannot be converted to Brix (°Bx)

Note that you can convert the unit from Brix (°Bx) to %wt (percentage by weight) when using a Brix curve. However, if the type of the concentration curve is %wt (percentage by weight), the unit can not be changed to Brix (°Bx).

5.2.3 Field adjustment parameters

The field adjustment can be calculated with the following pattern: **Adjusted concentration = Raw concentration × Field gain + Field offset**

Each concentration curve has its own field adjustment. If you change the concentration curve, field adjustment is no longer the same.

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

- Field adjustments are used to cancel out any inaccuracy of the concentration model, or process condition related factors. The field sample values must be taken from the particular unit that is to be adjusted, not from a laboratory unit, for example.
- 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 raw concentration value at exactly the same time with sampling.
  The easiest way of doing this is to use the Field sample feature. The value of each sample is the average of 10 consequent measurements to increase accuracy and reduce possible process noise.
- Use a tight container for the sample to avoid evaporation.

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 aging sample which is not representative
- Outside light reaching the prism

More information

- Concentration curve parameters (page 33)
- Changing concentration curves with Indigo520 (page 50)
- Taking a field sample with Indigo520 (page 50)
- Changing concentration curves with Insight (page 65)

5.2.4 Managing concentration curves

There are 3 different cases in which you may need to change the concentration curve:

- Switching active concentration curve to another curve that has been configured in the refractometer. For example, switching between Brix, Oeschle, NaOH. This can be done using Indigo520, Insight, HART, or Modbus RTU.
- Changing a preconfigured concentration curve or adding a completely new curve. For example, changing from Brix 0–100 °Bx to NaOH 0–50 g/l. This is done by using the Insight software.
- Fine-tuning the C-parameters of a preconfigured concentration curve. This can be done by using Indigo520 or Insight.

More information

- Changing concentration curves with Insight (page 65)
- Uploading concentration curves (page 66)

5.2.4.1 Measurement reading decimal selection

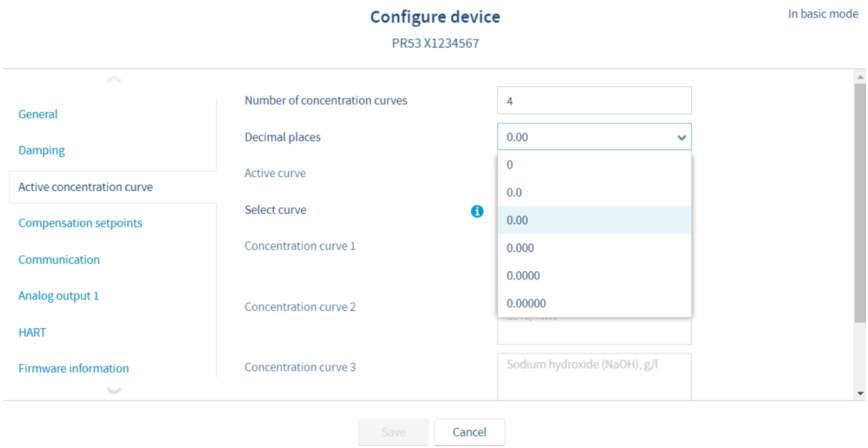


Figure 15 Decimal place selection in Insight PC software

If needed, you can configure the number of decimals shown in the concentration curve measurement with Insight PC software, Indigo80 handheld indicator, or Modbus (see register number 1032 (0x0407) in Table 57 (page 167)). The decimal selection is applicable from firmware version 1.2.3 onwards. All other curves can be configured to show 0–5 decimals, except RI or SG curves, which show the measurement in 6 decimals.

5.2.4.2 Disabling concentration curve warnings

A warning is displayed if the measured temperature or the measured concentration is outside of the concentration curve range.

If necessary, you can disable the concentration curve warnings (concentration range and temperature range) using Insight PC software or Indigo80 handheld indicator.

More information

- Disabling concentration curve warnings with Insight (page 67)
- Modifying concentration curves (page 59)

5.3 Field calibration support

If the linear offset / gain field adjustment is not sufficient, non-linear adjustment is needed. If the adjustment requires improving temperature compensation (fine-tuning the C-parameters), contact helpdesk@vaisala.com.

If you want to measure something that does not have a ready-made concentration curve, a new curve can be defined using a field sample and laboratory results. A new curve can also be defined at Vaisala using laboratory methods. Contact helpdesk@vaisala.com.

5.4 Calibration

Calibration ensures that the measurement of the refractometer is accurate.

The refractometer comes with a traceable calibration certificate which ensures that it has fulfilled the measurement criteria when sent from the factory.

There are two ways to ensure measurement accuracy: comparing online measurement with laboratory reference (field sampling), and RI calibration.

The refractometer is a very stable instrument. Calibration interval is defined according to the application, requirement of accuracy, ambient conditions, and quality system or, for example, third party requirements.

Online measurement vs. laboratory results is the primary method because it validates the complete measurement, including the effects of ambient conditions to the measurement position and, for example, possible coating of the prism. It is also a simple method because you do not need to remove the refractometer from the process.



The following circumstances affect the calibration:
- Accuracy and repeatability of the laboratory reference
- Traceability of the laboratory reference and its own calibrations
- Sampling and the possible errors related to it (representativeness of the sample and changing of the sample, evaporation, for example)
- Measurement range; the method based on the laboratory reference may not cover the whole measurement range.

Calibration is needed when the optics of the device is serviced and RI adjustment needs to be performed. Calibration is done to find out if there is measurement error in the device in the defined measurement area; RI adjustment is performed to fix the error.



RI adjustment can only be performed with Insight.

RI calibration is a secondary method which can be performed with nominal reference RI liquids. It is an offline method and requires the refractometer to be removed from the process.

RI calibration validates the whole measurement range and verifies the technical condition of the refractometer, the erosion of the prism, for example.

However, RI calibration does not acknowledge other sources of uncertainty in concentration measurement, such as ambient conditions and accuracy of the concentration curve.

More information

- RI calibration (page 51)
- RI adjustment (page 70)

5.5 RI adjustment

The refractometer has been adjusted at the factory. Usually there is no need to readjust the refractometer unless the main circuit board has been removed, or the prism has been changed in service.

Vaisala provides a service for checking the functionality of the refractometer, and adjusting the device as a factory maintenance service, if needed.

Each refractometer has its own unique RI adjustment parameters that have been calculated at the Vaisala factory. These are the A-parameters. The A-parameters change as a result of the adjustment.

The adjustment of the refractometer is done by performing as accurate RI calibration as possible. This can be done using either Vaisala Insight or Indigo520. After RI calibration, RI adjustment can be done using Insight. This adjusts how the refractive index is calculated.

The quality of the adjustment depends on the RI calibration and circumstances related to the RI calibration. Contact your local distributor or helpdesk@vaisala.com if your device needs adjustment.

Usually there is no need to adjust the temperature measurement of the refractometer. Field offset should be sufficient. However, temperature adjustment can be done using Insight.

More information

- Temperature adjustment (page 71)

5.6 Measurement damping

With PR53 refractometers it is possible to use configurable measurement damping.

Measurement damping reduces noise in measurement and adjusts the response time of the measurement to correspond to the response time of the process and the related control circuits.

There are 3 types of measurement damping:

- Exponential damping
- Linear damping
- Slew rate

The default damping settings for PR53 refractometers are:

- Damping type: exponential
- Damping time: 20 s
- Tolerance time: 5 s
- Slew rate: 10.0.

More information

- Configuring measurement damping with Indigo520 (page 53)
- Configuring measurement damping with Insight (page 74)

5.6.1 Exponential damping

Exponential damping works for most processes and is the standard choice for slow and continuous processes. The factory setting is always exponential damping.

In exponential 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 raw concentration changes from 50 % to 60 % and damping time is 10 s, it takes 10 s for the concentration to change to 55 %. A damping time of 5–15 s works best in most cases, the factory setting is 5 s.

The following figure shows how exponential damping time affects the measurement.

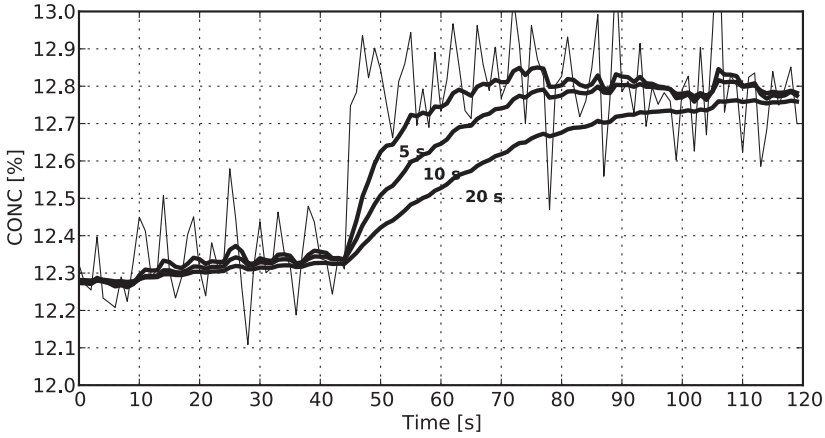


Figure 16 Exponential damping

5.6.2 Linear damping

If the process has fast step changes, linear (fast) damping gives shorter settling time.

In linear damping, the output is the running average of the signal during the damping time. After a step change the signal rises linearly and reaches the final value after the damping time. Linear damping gives the best trade-off between random noise suppression and step change response time.

For similar noise suppression, you have to specify a longer damping time than for exponential damping.

The following figure shows how linear damping time affects the measurement.

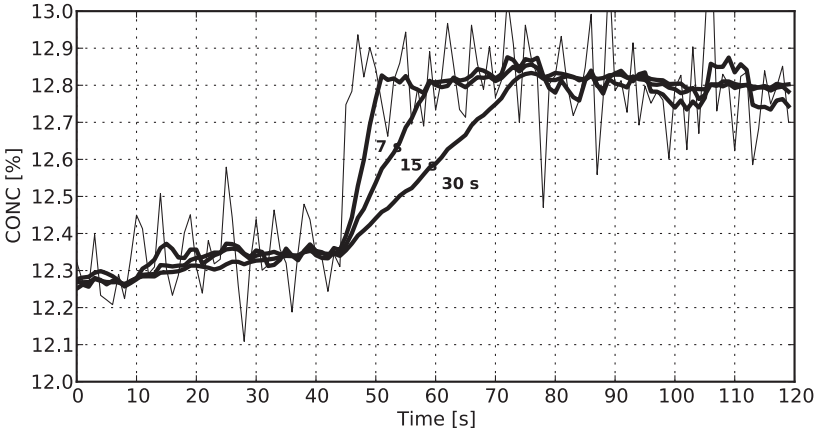


Figure 17 Linear damping

5.6.3 Slew rate

If the process signal has short erroneous high or low peaks, slew rate limiting can be used to cut their effects.

Slew rate damping limits the maximum change for the output signal in 1 s. Slew rate damping is recommended for random noise suppression as it is non-linear.

The following figure gives an example of different slew rate limits.

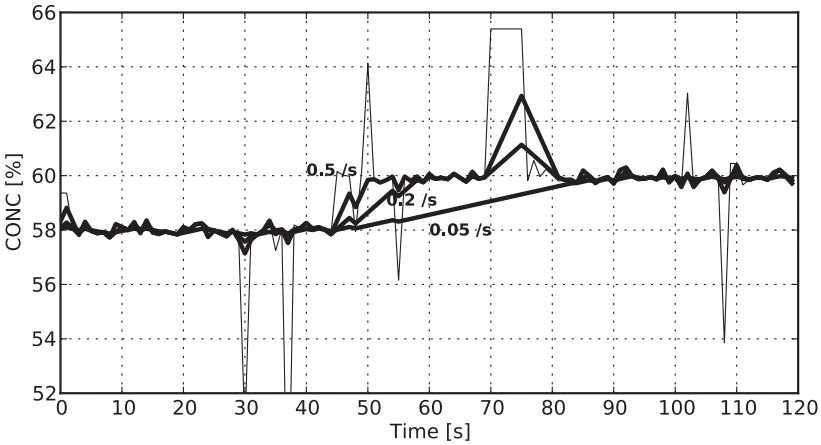


Figure 18 Slew rate damping

To avoid overdamping, do not make the signal insensitive.

5.6.4 Tolerance time

The tolerance time setting can be used in processes with intermittent breaks in the measurement due to non-representative sample on the prism. This typically occurs when there are large voids in the process liquid.

If the optical image can be interpreted, the tolerance time setting does not have any effect. When the optical image can no longer be interpreted (status messages, for example, **No liquid detected.**; **No optical image.**; **Prism coating detected.**), the measurement is held for the given number of seconds.

For example, a setting of 10 seconds ensures that any **No liquid detected.** state which is shorter than 10 s does not cause a dip into the output signal. The factory setting is 5 s. To see the tolerance time, go to **Calibration > Outputs > Tolerance time**.

The tolerance time counter is always reset when there is a representative sample on the prism (for example, the RI can be determined). The following figure shows this behavior with an intermittent measurement signal.

- When the signal drop is shorter than the tolerance time (for example, at t = 10 s or t = 35 s in the figure), the output signal does not drop.

- If the signal drop is so long that the tolerance time counter reaches zero, there is a drop in the output signal (at t = 80 s in the figure).

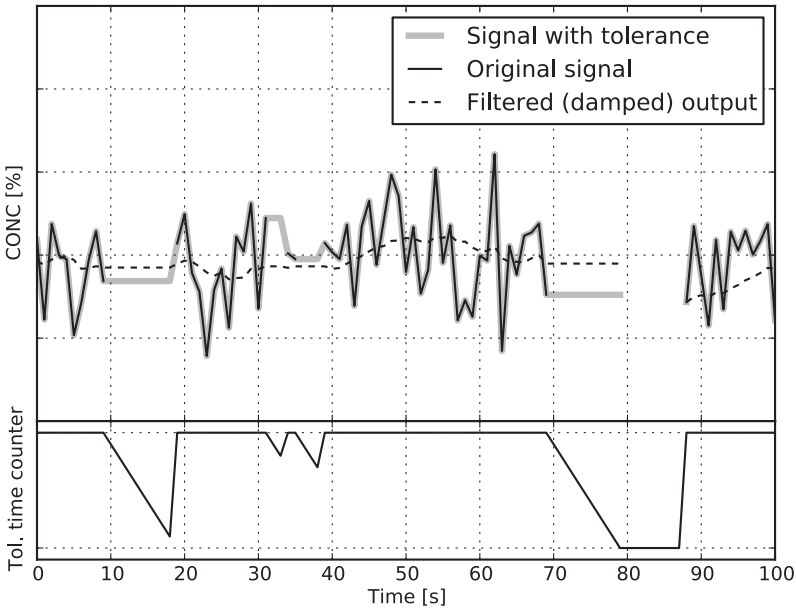


Figure 19 Effect of tolerance time on output

5.7 Field sample

A field sample is a measurement taken from the process that has the calculated average of 10 consequent measurements. A field sample is usually taken when a snapshot of the process condition is needed.

The result of the field sample is displayed on the screen, with date, time and measurement results. The results can be used to calculate corrections against a laboratory or other reference if needed: For example, if the raw concentration (the measurement value without field correction) indicates a value of 10.0, and laboratory reference indicates a value of 9.0, the required field offset would be -1.0 to make the refractometer reading to match the laboratory.

Field sample results are stored in volatile memory. If the refractometer is powered off, the results are lost.

More information

- Taking a field sample with Indigo520 (page 50)
- Taking a field sample with Insight (page 67)

6. Start-up

6.1 Start-up

The PR53 unit is configured at the factory and ready to be used. The concentration model has been set up according to the order. If the concentration model needs to be changed, it can be done using the service port and Insight software.

More information

- Uploading concentration curves (page 66)

6.1.1 Starting up stand-alone refractometer

1. Connect the refractometer to the receiving system either with the analog output channel or Modbus RTU.

   The refractometer is now ready to measure and transmit measurement signals.
2. Check the LED - green light indicates that the power is on.
3. If Modbus RTU is used, change the RS-485 communication parameters and the Modbus unit ID as needed by using the Insight software and a USB adapter.
4. After the wiring is made, check that the green LED blinks when the master system polls the values.

   This indicates that the refractometer has successfully received a request and responded to a Modbus request made to its unit ID.

More information

- Refractometer connections (page 20)
- Configuring Modbus communication settings with Insight (page 75)

6.1.2 Starting up refractometer with Indigo520

1. Connect the refractometer to the Indigo520 transmitter using the interconnecting cable. Make sure the 8th character of the configuration code on the Indigo520 type label is "L".
2. Connect the wires from the refractometer to Indigo520 probe port 1 or 2 according to chapter Refractometer connections.

   Indigo520 transmitter provides the power supply for the refractometer and initializes the communication with the sensor automatically.

3. After the refractometer has been detected, configure the numerical and graphical display views and analog output channels using the Indigo520 display or the web user interface.

   See Indigo500 User Guide (M212287EN) for details.



If you have the optional prism wash system installed, you need to perform a prism wash test. See PR53 Prism Wash System User Guide (M212808EN).

More information

- Refractometer connections (page 20)

6.1.3 Starting up refractometer with HART

The HART feature is enabled automatically and cannot be disabled. Refer to refractometer connection instructions and wiring diagram for setting up the hardware. Refer to your HART host's user documentation to establish the communication.

The PR53 FDI package can be found in the FieldComm Group package repository.

More information

- Refractometer connections (page 20)

7. Using refractometer with Vaisala Indigo520

7.1 Vaisala Indigo520 transmitter

The Indigo520 transmitter is an optional accessory to PR53 refractometers and other Indigo-compatible Vaisala devices. One or two refractometers can be connected to the same Indigo520 transmitter. By default, Indigo520 identifies the devices as "probe 1" and "probe 2" and the serial number, when connected to the corresponding port in the wiring header.

With Vaisala Indigo520 Transmitter, you can:

- View the refractometer status
- Adjust concentration measurement
- Perform RI calibration
- Configure the analog output channel
- Configure analog output signal damping
- Configure refractometer prism washes.

For the full user guide, see Indigo500 User Guide (M212287EN).

7.2 Connecting refractometer to Indigo520



WARNING! If you have a refractometer for potentially explosive environments, follow the installation site safety precautions and read the Safety Guide fully before installing. The Safety Guide is delivered with the product or it can be found in docs.vaisala.com.

Before connecting the wires or cables, make sure that the transmitter is powered off.

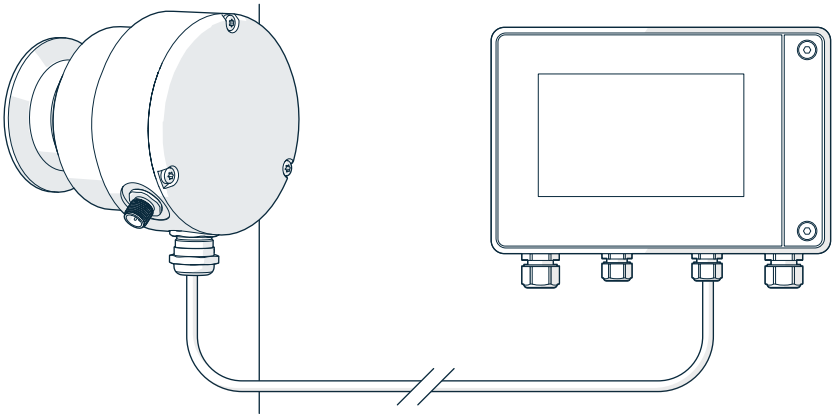


Figure 20 Connecting refractometer to Indigo520

1. Open the 2 hex screws on the cover of the transmitter using a 4-mm Allen key.
2. Open the transmitter cover.
3. Connect the wires inside the refractometer.

   For more information on connecting the refractometer, see model-specific installation guide.
4. Connect the wires inside the transmitter, see Indigo500 User Guide (M212287EN).

7.3 General settings

In general settings, you can give a custom name to the refractometer, such as a tag number, position, or other identification. This helps to distinguish the refractometers. The custom name is stored in the refractometer memory, and is displayed on the Indigo520, Insight software and other interfaces as the device identification, as well as in device logs.

You can edit the general settings of the refractometer in **Menu > <your refractometer> > General**.

In **General**, you can give a custom name to the refractometer.

7.4 Diagnostics menu

You can view various diagnostic and measurement values in the **Diagnostics** menu. From Indigo520 software version 1.16.2 onwards, you can find the **Diagnostics** menu from **Menu > <your refractometer> > Diagnostics**. In older software versions the **Diagnostics** view is the fourth **Home** view.

In **Diagnostics**, you can perform the following actions:

- Take a **Field sample**.
  - Field sample is a function to record a point in the measurement data. To avoid unnecessary noise, the field sample is an average of 10 seconds of the measurement data.
  - Field sample is a sample of the calculated average of 10 consequent measurements.
  - When triggered simultaneously with a laboratory sample collection, the field sample point can be used for calibration against a laboratory reference.
  - The samples are shown in a window so that they can be recorded for later use.

  Recording samples needs to be done manually, by taking a note or a photo.

- Start a **Prism wash**.
  - Activate a configured prism wash.
  - View any configured prism washes and drainings.
  - See diagnostics of the previous prism wash.

7.4.1 Viewing refractometer status

The refractometer status is shown in **Diagnostics**. The status **Normal operation** is shown when there are no active errors.

7.5 Concentration measurement

Adjustment of the raw concentration value may be required to compensate for some process conditions or to fit the measurement to the laboratory results.

There are four presets that each have their own C and F parameters that can be stored in their memory slots.

7.5.1 Calculating field adjustment

To calculate field gain and field offset, you need to take samples from the process liquid.

1. Take samples from the process liquid and take a field sample.
2. Repeat as many times as needed.

   To calculate offset and gain you need at least two points. Take samples from process conditions with a wide span in the measurement range.
3. Calculate field gain and field offset from the data points.
4. Go to **Menu > Concentration curves**.
5. Select the concentration curve and **Modify adjustment**.

6. Modify the values to **Offset** and **Gain**.

> If there is already a previous field calibration, before calculating the offset and gain values for a new field calibration, reset the values as follows:
> - **Offset**: 0
> - **Gain**: 1

More information

- Taking a field sample with Indigo520 (page 50)

7.5.2 Changing concentration curves with Indigo520

The PR53 refractometer is able to hold up to 4 concentration curves in its memory. By default, the unit is delivered with one concentration curve preconfigured at the factory as ordered. Additional concentration curves can be added using the Insight software and a USB adapter. Multiple concentration curves preconfigured at the factory are available as a tailored order.

Do not alter the concentration curve parameters, except if you are changing to another process medium. If you are unsure what to do, contact helpdesk@vaisala.com.

A concentration curve is specific to the given process medium, for example, sucrose or sodium hydroxide. The set of parameters is given by Vaisala. Do not alter the concentration curve parameters. If you are changing from one process medium to another, do it using Insight.

1. You can select the concentration curve in **Menu > Concentration curves**.
2. You can change the C parameters in **Menu > Concentration curves > View parameters > Modify parameters**.

   Changing from one concentration curve to another changes the way concentration is calculated from monitored liquids. The refractometer will restart to apply the change.

> If any concentration limit warnings have been set, they may be triggered by the change.

More information

- Field adjustment parameters (page 35)

7.5.3 Taking a field sample with Indigo520

To take a field sample, browse to the Diagnostics view and select **Field sample**.

More information

- Field sample (page 43)

7.6 RI calibration

In order to perform RI calibration, you need:

- Indigo520 transmitter or Vaisala Insight software
- Sample holder
- Cleaning solution
- Tissues
- Nominal reference RI liquids, see below
- Protective clothing
- Environment with a good ventilation

Nominal reference RI liquids

RI calibration is performed using a set of nominal reference RI liquids that cover the entire measurement range of the prism. The selection of nominal reference RI liquids varies depending on the type of prism in use, as different types of prisms cover a specific RI measurement range.

- A = RI 1.320–1.530 nD Sapphire prism
- B = RI 1.360–1.570 nD Sapphire prism

The prism type can be identified from the configuration code located on the side of the refractometer.

For refractometer models PR53AC, PR53AP, PR53GC, PR53GP, and PR53SD, refer to the 7th digit of the configuration code.

For refractometer models PR53M and PR53W, refer to the 6th digit of the configuration code.

CAUTION! Each liquid has their own safety instructions with them. Read the instructions carefully before you start RI calibration.

7.6.1 Preparing RI calibration

Before you begin RI calibration, you must perform preparatory actions.

1. Remove the refractometer from the process and place it on a table, prism pointing upwards.
2. Clean the prism and the sample holder with ethanol cleaning solution. Make sure by looking closely that the prism is clean.
3. Mount the sample holder on the prism.
4. Prepare the necessary refractive index reference liquids and de-ionized water (sample liquids) and place them near the refractometer.

5. Let the refractometer and sample liquid temperature settle to room temperature, +20 ... +30 °C (+68 ... +86 °F). Calibration must be done within this temperature range.

> The cooling of the refractometer may take several hours.

7.6.2 Performing RI calibration with Indigo520

1. Go to **Menu** and select the refractometer.
2. Select **RI calibration > Calibrate**.

> RI calibration can be done using either the touch screen or web interface. When calibration is being performed on one user interface, the other cannot be used at the same time.

3. Read the instructions on the screen and select **OK**.

> From this point onwards, the process is semi-automated and you will guided through the process on the screen.

4. Add a calibration point by pressing **+** and selecting the reference RI you want to calibrate against.
   - When calibrating, the refractometer waits for the temperature measurement to stabilize. This may take up to 4 minutes.
   - After nominal RI is selected, the refractometer calculates the correct reference RI at the measured temperature.

> Do not hold the refractometer or sample liquid container in your hand or near external heat sources during calibration. Changes in the refractometer or sample liquid temperature may decrease the measurement quality of the point or cause the calibration of the point to fail.

5. Once temperature measurement has stabilized, the UI will request you to apply sample liquid onto the sample holder and place the light cover on top.

   The calibration process will happen automatically from this point on with the following steps:
   a. Detecting sample
   b. Waiting for the sample to stabilize
   c. Calibrating

6. Once the calibration process is ready, results are displayed in the results screen.

   You can later view the results of a calibrated point by selecting a calibration point tile from the calibration view.

   You can now choose the following:
   - **Close**: Closes the summary screen and returns to calibration view
   - **Recalibrate point**: Calibrates the point again
   - **Delete point**: Removes the calibrated point.
7. Repeat the process for other available points as needed.
8. Finalize calibration by selecting **Complete calibration**. This will replace old calibration data with the new data.

   You can also do the following:
   - **Optical image**: View refractometer status, diagnostic values and both optical and slope image.
   - **Cancel calibration**: Quit the calibration process. Old calibration data is not replaced.

The result screen shows the difference between reference value and measured value, some diagnostic values, and the status of a single calibration point.

7.7 Configuring analog outputs with Indigo520

To configure analog outputs, see Indigo500 User Guide (M212287EN).

7.8 Configuring measurement damping with Indigo520

You can apply measurement damping to diminish the influence of process noise. Damping is applied to the concentration value, and therefore the output signal, of the selected refractometer.

You can select the type of measurement damping in **Menu > <your refractometer> > Damping**.

You can edit the following:

- **Damping time**
- **Tolerance time**
- **Slew rate**

More information

- Measurement damping (page 39)

8. Using refractometer with Vaisala Indigo80

8.1 Vaisala Indigo80 handheld indicator

Vaisala Indigo80 Handheld Indicator is a portable diagnostics tool that accommodates either one or two compatible Vaisala devices, such as refractometers. The indicator can display measurement data and diagnostic information on the spot, configure the measurement device and perform data logging.

With the indicator, you can:

- See real-time measurements and device and status information
- Configure refractometer features and settings such as concentration curves, signal damping, and analog output
- Log measurement data, including integer type diagnostics parameters (for example, ambient light)
- Adjust the temperature and analog output of the refractometer.

For more information on using the indicator, for example, editing the measurement views and performing data logging, see Indigo80 User Guide (M212722EN).

More information

- Indigo80 handheld indicator (page 28)

8.1.1 Device compatibility

For information on the refractometer firmware versions tested for compatibility with the Indigo80 handheld indicator, see Firmware version compatibility of Indigo80-compatible devices Technical Note (M212901EN).

8.1.2 Indigo80 keypad

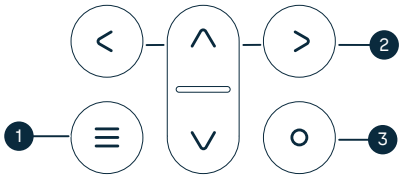


Figure 21 Indigo80 keypad

1 Power on/off and main menu button
2 Arrow buttons for navigating menus and scrolling views
3 Select button for selecting items in the user interface

8.1.3 Indigo80 main menu

Pressing the ☰ button while navigating the Indigo80 menus and views opens the main menu.

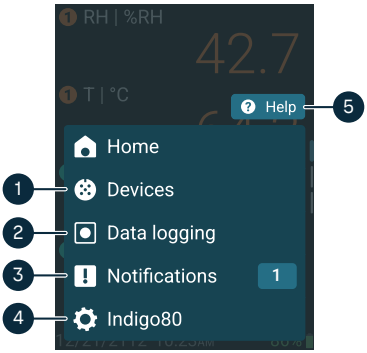


Figure 22 Indigo80 main menu

1 **Devices** menu contains, for example, options related to sensor purge, calibration, and environment settings (depending on the connected device).
2 **Data logging** menu for setting logging interval and duration, and browsing data files.
3 **Notifications** menu displays notifications related to Indigo80 and the connected devices.
4 **Indigo80** menu for changing the settings of Indigo80 (for example, date, time, and language) and viewing device information.
5 **Help** menu contains tours showing the key features of Indigo80, as well as instructions for sending devices to Vaisala for calibration and maintenance.

8.2 Connecting to Indigo80

WARNING! If you have a refractometer for potentially explosive environments, follow the installation site safety precautions and read the Safety Guide fully before installing. The Safety Guide is delivered with the product or it can be found in docs.vaisala.com.

- Connection cable (M12-M12, Vaisala item code 272075SP)

CAUTION! Use only cables provided by Vaisala to connect devices to the refractometer. Attempting to connect incompatible devices or cables can damage the equipment.

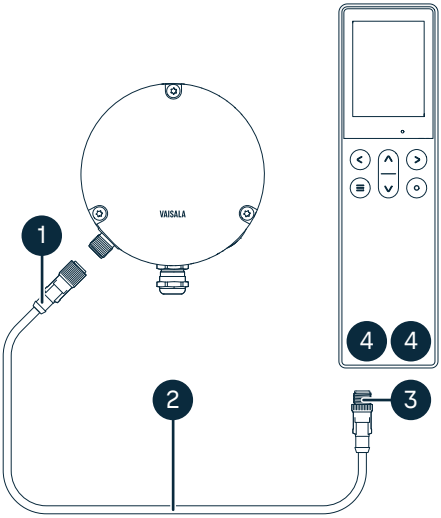


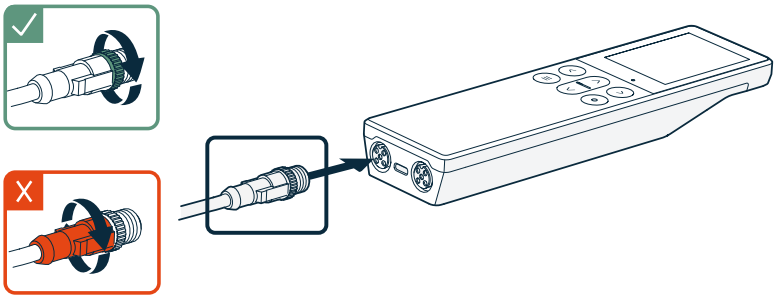
Figure 23 Connecting refractometer to Indigo80

1 M12-5F cable connector
2 M12-M12 connection cable
3 M12-5M cable connector
4 M12-5F ports on the bottom of Indigo80 for connecting compatible Vaisala devices. Ports are labeled ❶ and ❷.

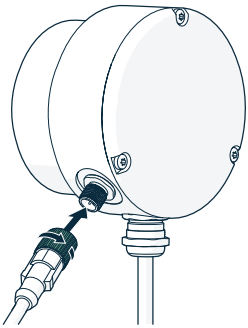
1. If the indicator is powered and no devices are connected to it, the text **Please connect a measurement device** will be shown on the display.

2. Insert the connection cable in one of the ports on the bottom of the indicator.

   - **Note the orientation of the cable connector when inserting it**
   - **Hold the connector in place while turning its locking ring clockwise – never twist the connector body!**



3. Connect the refractometer to the M12-5F end of the connection cable.



When the indicator recognizes the connected refractometer, it shows a notification on the display. A device connected to the leftmost port in the indicator is labeled ❶ on the indicator's display, while the device in the rightmost port is labeled ❷.

More information

- Indigo80 handheld indicator (page 28)

8.3 Calibrating or adjusting refractometer

With Indigo80, it is possible to perform

- Guided calibration of temperature

- Manual adjustment of temperature
- Manual adjustment of analog outputs.

8.3.1 Example of manually adjusting analog output

Connect a multimeter to the analog output wiring (connect in series to measure the current output, see Refractometer connections (page 20)).

To test and adjust the current output level of the analog output with the Indigo80 indicator:

1. Open the indicator main menu by pressing ☰.
2. Select **Devices > Calibrate / Adjust > Analog output 1**.
3. Enable the test mode from **Test mode on/off**.
4. Enter a low output level value in mA (for example, 5) in the **Test output level** field. The analog output starts to output current at this level.
5. Check the multimeter reading and enter the measured value in the **Measured value, low point** field.
6. Enter a high output level value in mA (for example, 19) in the **Test output level** field.
7. Check the multimeter reading and enter the measured value in the **Measured value, high point** field.
8. Select **Activate adjustment** to save the correction to the output level. The new adjustment is taken into use immediately.

   The adjustment can be reset to default values with **Restore default settings**.
9. Record the gain and offset values for later use: you can enter the **Analog output gain** and **Analog output offset** directly to achieve the same adjustment later.
10. Disable the test mode from **Test mode on/off**.

More information

- Connecting to Indigo80 (page 55)

8.4 Settings

In **Settings**, you can:

- Configure measurement damping
- See and change the active concentration curve
- Configure HART or analog output
- Define the device tag
- Restore the refractometer's factory default settings
- Modify parameters for concentration curves.

To access PR53 settings with the Indigo80 indicator,

1. Open the indicator main menu by pressing ☰.

2. Select **Devices**. If you have more than one device connected to the indicator, make a further selection between the devices.
3. Select **Settings**.

More information

- Measurement damping (page 39)
- Changing concentration curves with Indigo80 (page 59)
- Modifying concentration curves (page 59)
- Connecting to Indigo80 (page 55)

8.5 Changing concentration curves with Indigo80

The PR53 refractometer is able to hold up to 4 concentration curves in its memory. By default, the unit is delivered with one concentration curve preconfigured at the factory as ordered. Additional concentration curves can be added using the Insight software and a USB adapter. Multiple concentration curves preconfigured at the factory are available as a tailored order.

Do not alter the concentration curve parameters, except if you are changing to another process medium. If you are unsure what to do, contact helpdesk@vaisala.com.

A concentration curve is specific to the given process medium, for example, sucrose or sodium hydroxide. The set of parameters is given by Vaisala. Do not alter the concentration curve parameters. If you are changing from one process medium to another, do it using Insight.

To change one concentration curve to another with the Indigo80 indicator:

1. Open the indicator main menu by pressing ☰.
2. Select **Devices**. If you have more than one device connected to the indicator, make a further selection between the devices.
3. Select **Settings > Active concentration curve > Select curve**.
4. Select the curve and **Confirm**.

   Changing from one concentration curve to another changes the way concentration is calculated from monitored liquids. The refractometer will restart to apply the change.

   If any concentration limit warnings have been set, they may be triggered by the change.

8.5.1 Modifying concentration curves

Do not alter the concentration curve parameters, except if you are changing to another process medium. If you are unsure what to do, contact helpdesk@vaisala.com.

A concentration curve is specific to the given process medium, for example, sucrose or sodium hydroxide. The set of parameters is given by Vaisala. Do not alter the concentration curve parameters. If you are changing from one process medium to another, do it using Insight.

1. Open the indicator main menu by pressing ☰.
2. Select **Devices**. If you have more than one device connected to the indicator, make a further selection between the devices.
3. Select **Settings** and the concentration curve you want to modify.

   You can edit the concentration curve's **Name**, **Chemical coefficients**, **Field offset** and **Field gain**.
   This menu also contains the selections for disabling the concentration curve warnings that are shown if the measured concentration or temperature is out of range.

> The identifier of the concentration curve will be the **Name**, if given. If no name is given, the **Description** will be used as the identifier.

More information

- Connecting to Indigo80 (page 55)
- Uploading concentration curves (page 66)
- Disabling concentration curve warnings (page 37)

8.6 Diagnostics

In **Diagnostics**, you have access to the following:

- The status of the refractometer
- The **Optical image**
- The internal values of the refractometer
- Analog output information
- Taking a **Field sample**

To access **Diagnostics** with the Indigo80 indicator,

1. Open the indicator main menu by pressing ☰.
2. Select **Devices**. If you have more than one device connected to the indicator, make a further selection between the devices.
3. Select **Diagnostics**.

More information

- Field sample (page 43)
- Analyzing optical image (page 176)
- Connecting to Indigo80 (page 55)

9. Using refractometer with Vaisala Insight software

9.1 Insight PC software

With Vaisala Insight PC software, you can:

- Configure the analog output channel
- Configure signal damping
- Adjust concentration curves
- Calibrate the RI measurement
- Reset factory RI adjustment parameters

Advanced mode features:

- Adjusting the RI measurement
- Creating blank image
- Overwriting factory RI adjustment parameters

Insight is the only tool to adjust the RI and analog output channel of the refractometer.

9.2 Connecting to Insight software

WARNING! If you have a refractometer for potentially explosive environments, follow the installation site safety precautions and read the Safety Guide fully before installing. The Safety Guide is delivered with the product or it can be found in docs.vaisala.com.

When connecting several devices at the same time, note that your computer may not be able to supply enough power through its USB ports. Use an externally powered USB hub that can supply >2 W for each port.

Insight can be coupled with 6 devices. The refractometer can be powered through USB, but an external power source can also be used.

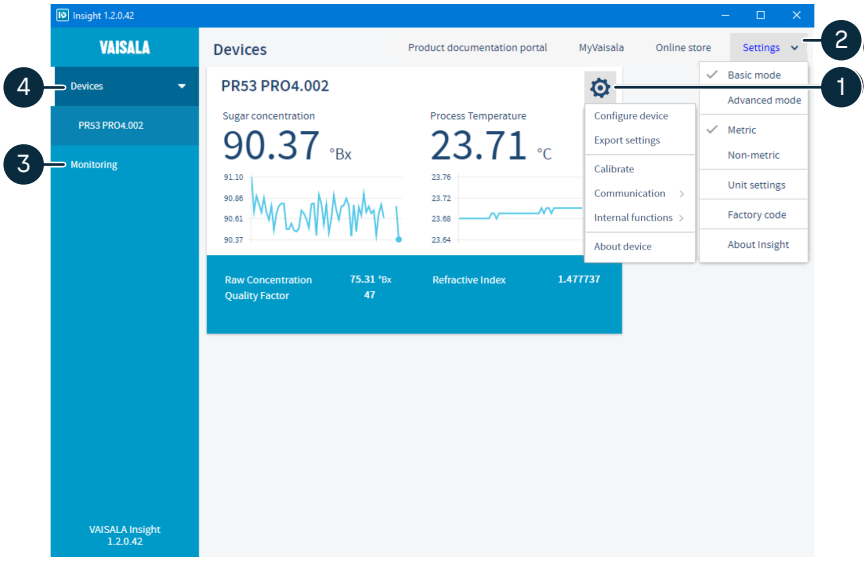
Insight is meant for configuring a standalone refractometer. If you have Indigo520 connected to the refractometer, you can configure the refractometer by connecting Insight to Indigo520, or alternatively, by disconnecting the Indigo520 before connecting the refractometer to Insight.



Figure 24 Connecting refractometer to Insight

1. Open the Insight software on your computer.
2. Connect the USB cable to a free USB port on the PC.

9.3 Insight main view



1 Select ⚙ to access the device-specific menu.
   - **Configure device**: environmental compensation settings, analog output 1 and 2 settings, filtering factor and general settings.
   - **Export settings**: creates a text file export of the device settings.
   - **Calibrate**: options for calibrating and adjusting RI and T output, testing and adjusting current (analog) output levels, and restoring factory adjustments.
   - **Communication**: contains a quick access selection for restarting the device.
   - **Factory default settings**: restores the device back to default settings, clears any user adjustments and restores the latest factory calibration.
   - **About device**: general device information such as serial number and software version.
2 Select **Settings** to switch between the **Basic mode** and **Advanced mode** user modes, change the units of parameters (metric/non-metric), enter a factory code to access restricted functionality, or view information about the Insight software.
3 **Monitoring** provides options for monitoring and recording selected parameters, and exporting the monitoring data as a CSV (comma-separated values) file.
4 Device information menu with the following tabs:
   - **Measurements**: measurement graph view with parameter drop-down selection.
   - **Calibration information**: read-only information about the latest stored calibration.
   - **Diagnostics**: troubleshooting and administrative information about the device status, log file download.

9.3.1 Insight software user modes

You can switch between the **Basic mode** and **Advanced mode** user modes in the **Settings** menu.

Depending on the connected device, switching to **Advanced mode** may provide access to additional configuration options. Use these options only as described in the product documentation or as instructed by Vaisala support.

9.3.2 Insight Diagnostics view

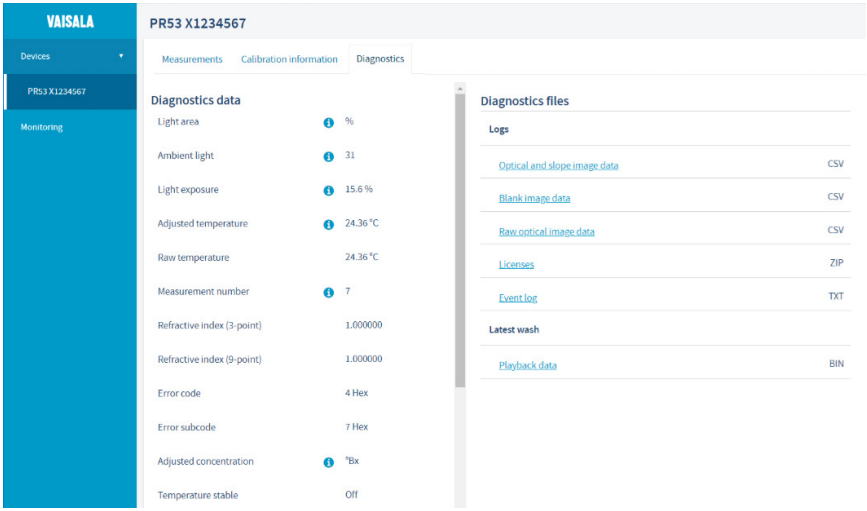


Figure 25 PR53 Insight Diagnostics view example

The **Diagnostics** tab contains information about the device status. In addition to viewing real-time diagnostics data about the device status, you can also review license information and download various log files, including a timestamped event log.

Diagnostics event log overview

The following event types are logged in the event log that you can download from the Diagnostics view:

- Error
- Device startup
- Host connected
- Blank image created
- RI adjustment performed
- Factory settings restored
- Parameters changed
- Event log cleared

One event log can contain a maximum of 2000 events. The actual number of events depends on the event type.

9.4 Concentration measurement

Adjustment of the raw concentration value may be required to compensate for some process conditions or to fit the measurement to the laboratory results.

There are four presets that each have their own C and F parameters that can be stored in their memory slots.

9.4.1 Calculating field adjustment

To calculate field gain and field offset, you need to take samples from the process liquid.

1. Take samples from the process liquid and take a field sample.
2. Repeat many enough times.

   To calculate offset and gain you need at least two points. Take samples from process conditions with a wide span in the measurement range.
3. Calculate field gain and field offset from the data points.
4. Go to **> Configure device**.
5. Select the concentration curve you want to modify.
6. Scroll to the end of the screen to modify the **Field gain** and **Field offset**.

> If there is already a previous field calibration, before calculating the offset and gain values for a new field calibration, reset the values as follows:
> - **Field offset**: 0
> - **Field gain**: 1

More information

- Taking a field sample with Insight (page 67)

9.4.2 Changing concentration curves with Insight

The PR53 refractometer is able to hold up to 4 concentration curves in its memory. By default, the unit is delivered with one concentration curve preconfigured at the factory as ordered. Additional concentration curves can be added using the Insight software and a USB adapter. Multiple concentration curves preconfigured at the factory are available as a tailored order.

Do not alter the concentration curve parameters, except if you are changing to another process medium. If you are unsure what to do, contact helpdesk@vaisala.com.

A concentration curve is specific to the given process medium, for example, sucrose or sodium hydroxide. The set of parameters is given by Vaisala. Do not alter the concentration curve parameters. If you are changing from one process medium to another, do it using Insight.

1. You can select the concentration curve in **> Configure device > Active concentration curve > Select curve**.
2. You can change the C parameters in **> Configure device > Concentration curve 1/2/3/4**.

   Changing from one concentration curve to another changes the way concentration is calculated from monitored liquids. The refractometer will restart to apply the change.

   If any concentration limit warnings have been set, they may be triggered by the change.

9.4.3 Uploading concentration curves

Upload concentration curves if you need to restore original concentration curves, add new previously not configured concentration curves, or take into use updated concentration curves.

1. Log into MyVaisala.com and go to **LM Calibration tools > Concentration models POLARIS PR53**. If you do not have access to the tools, contact your local distributor for the curve data strings.
2. Use the search function to find the correct concentration curve.
3. Select the concentration curve from the list to view its details.
4. Select **Copy to clipboard** to copy the curve data string.

   The curve data string is copied to your clipboard.
5. In Insight, go to **> Configure device > Concentration curve upload**.
6. Select a target concentration curve from the **Target curve** drop down menu. You can either overwrite one of the existing concentration curves or select **Add a new curve**. You can add a maximum of 4 concentration curves.
7. Paste curve data string into the **Curve data string** field.
8. Accept the change by selecting **Save**.

   It takes 10–15s to save the changes. The refractometer may restart.

   If you are replacing an active concentration curve, the new curve is automatically taken into use. See Changing concentration curves with Insight (page 65) for activating concentration curves.

9.4.4 Disabling concentration curve warnings with Insight

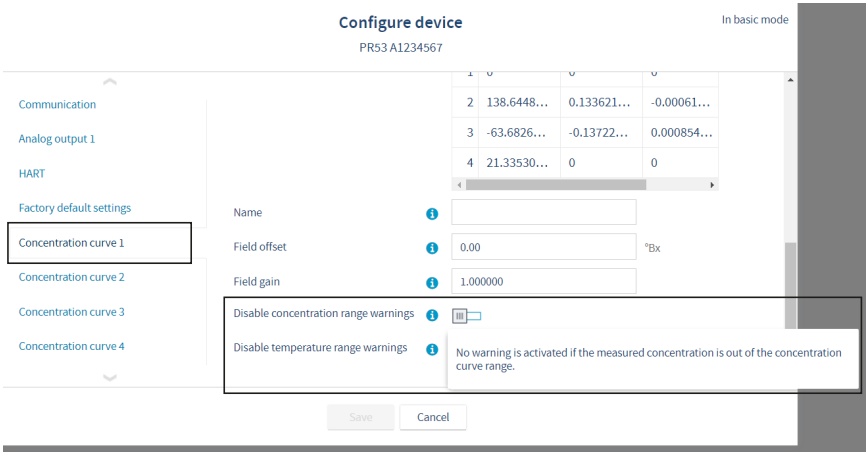


Figure 26 Selections for disabling curve warnings for Concentration curve 1

To disable concentration curve range warnings in Insight:

1. Select the concentration curve (1–4) from which you want to disable warnings:

   > Configure device > Concentration curve 1/2/3/4
2. Activate the selections for disabling the temperature range or the concentration range warning as needed.
3. Select **Save** to take the configuration into use.
4. Configure the warning settings of the other concentration curves as needed.

More information

- Disabling concentration curve warnings (page 37)

9.4.5 Taking a field sample with Insight

To take a field sample, select the refractometer > **Diagnostics > Take field sample > Refresh**.

More information

- Field sample (page 43)

9.5 RI calibration

In order to perform RI calibration, you need:

- Indigo520 transmitter or Vaisala Insight software
- Sample holder
- Cleaning solution
- Tissues
- Nominal reference RI liquids, see below
- Protective clothing
- Environment with a good ventilation

Nominal reference RI liquids

RI calibration is performed using a set of nominal reference RI liquids that cover the entire measurement range of the prism. The selection of nominal reference RI liquids varies depending on the type of prism in use, as different types of prisms cover a specific RI measurement range.

- A = RI 1.320–1.530 nD Sapphire prism
- B = RI 1.360–1.570 nD Sapphire prism

The prism type can be identified from the configuration code located on the side of the refractometer.

For refractometer models PR53AC, PR53AP, PR53GC, PR53GP, and PR53SD, refer to the 7th digit of the configuration code.

For refractometer models PR53M and PR53W, refer to the 6th digit of the configuration code.



CAUTION! Each liquid has their own safety instructions with them. Read the instructions carefully before you start RI calibration.

9.5.1 Preparing RI calibration

Before you begin RI calibration, you must perform preparatory actions.

1. Remove the refractometer from the process and place it on a table, prism pointing upwards.
2. Clean the prism and the sample holder with ethanol cleaning solution. Make sure by looking closely that the prism is clean.
3. Mount the sample holder on the prism.
4. Prepare the necessary refractive index reference liquids and de-ionized water (sample liquids) and place them near the refractometer.

5. Let the refractometer and sample liquid temperature settle to room temperature, +20 ... +30 °C (+68 ... +86 °F). Calibration must be done within this temperature range.

> The cooling of the refractometer may take several hours.

9.5.2 Performing RI calibration with Insight

1. Select the refractometer.
2. Select > **Calibrate**.
3. If you want to enter Calibration mode, select **Yes**.

> When in calibration mode, concentration calculation is paused and analog output 1 returns to error output level.

4. Select the **RI calibration** menu.
5. Apply sample liquid onto the sample holder and place the light cover on top.

> Do not hold the refractometer or sample liquid container in your hand or near external heat sources during calibration. Changes in the refractometer or sample liquid temperature may decrease the quality of the measurement point or cause it to fail.

6. From the available points, starting with Measure, point 1, press **Measure, point 1**.

   Calibration of a point may take a few minutes. The calibration progress can be seen at the top half of the screen.
   Before calibration, the refractometer waits for the measurement to stabilize and then proceeds to calibrate.
7. Select the used reference sample liquid for the available points, starting with **Nominal RI, point 1**.

   After nominal RI is selected, the refractometer calculates the correct reference RI at the measured temperature. It is not recommended to modify the reference RI value.
8. View the calibration results below in the result block.
9. Repeat the process for other available points as needed.

The result block shows the difference between reference value and measured value, some diagnostic values, and the status of a single calibration point.

Status of the available points, starting with **Status, point 1**, tells if the calibration was within specified accuracy limits.

If you need to recalibrate one or more of the calibration points,
1. Select **None** for Nominal RI.
2. Press **Measure point** for the selected point.
3. Reselect the wanted Nominal RI for the selected point.

9.5.3 Completing RI calibration

1. Once all necessary points have been calibrated, press **Store calibration** at the bottom of the register list. Pressing this button completes the calibration and stores current calibration results in the refractometer memory.

   You can only access the most recent calibration result. Older results are not stored.

9.6 RI adjustment

Each refractometer has their own unique RI adjustment curve that has been calculated at the Vaisala factory. These are the A parameters.

Only trained personnel should perform RI adjustment as a service procedure. Adjusting how the refractive index is calculated changes the way concentration is measured. If adjustment is done wrong, the refractometer can start measuring concentration incorrectly.

In order to perform RI calculation adjustment, you need to calibrate at least five calibration points that all have a different Nominal RI. You can do this in the **RI calibration** menu. Vaisala recommends that you perform RI adjustment based on a recent calibration.

1. Perform RI calibration in the **RI calibration** menu. Alternatively, retrieve calibration data from a previously stored calibration by selecting **Retrieve stored calibration**.
2. Verify from the retrieved calibration date that the RI calibration data is available and recent.
3. Select **Start adjustment**.

   Refractometer calculates new RI calculation parameters. New parameters and maximum difference are shown on the top half of the screen.
   Maximum difference is the greatest refractive index difference value calculated from the available calibration points when using new RI calculation parameters.
4. If you are satisfied with the new RI calculation parameters and maximum difference result, select **Yes**.

   The new calculation parameters are applied immediately. The refractometer reboots after the new parameters are applied.

9.6.1 Overwriting factory adjustment

Overwrite factory adjustment after optical components have been serviced.

1. Select **Overwrite factory adjustment**.

   If this is not done and the refractometer factory settings are restored, the refractometer may fail to calculate concentration accurately.

9.7 Temperature adjustment

The reference value needs to be known.

Temperature adjustment does not affect concentration calculations.

1. Go to ⚙ **> Calibrate device**.
2. Insert your device in the reference environment for the first calibration point.
3. Wait for the measurement to stabilize fully. The graph shows readings of the last 60 minutes.
4. When the measurement has stabilized, select the **Reference value, point 1** text box and enter the temperature of calibration point 1. Select **Enter** or click outside the field when done.
5. Check that the measured value for point 1 is automatically inserted.
6. Check the difference between each reference and measured value. Very large differences may be due to insufficient stabilization time or unsuitable calibration setup.

   If you want to adjust the device, select **Activate adjustment** and verify the result from the message that appears at the top of the screen..
   To exit without taking the adjustment in use, select **Close**.
7. After calibrating your device, update the information in the **Calibration information** tab.

More information

- RI adjustment (page 39)

9.7.1 Adjusting temperature using previously measured value

If the device allows the field for measured value to be edited and you have a list of previously collected calibration readings (for example, from a third party laboratory calibration), you can adjust the device without having to generate the calibration conditions and wait for stabilization.

1. Select the **Reference value, point 1** field and enter the temperature of calibration point 1. Press **Enter** or click outside the field when done.

2. Replace the automatically inserted measured value for point 1 with your previously measured value.
3. Repeat the procedure for all desired calibration points.
4. Select **Activate adjustment** and verify the result from the message that appears at the top of the screen.

9.8 Blank image

Blank image is a reference image that has been taken when there is no sample on the prism. It is used for normalizing the optical image for image detection and diagnostics.

Blank image is used when the chosen detection algorithm is IDS algorithm. The edge detection of this algorithm is based on the analysis of the normalized optical image. The changes caused by the sample and prism erosion are more easily detected in a normalized image. See the "no sample" image in Analyzing optical image (page 176). When there is no sample on the prism, this is the desired optical image.

There are three possible statuses for blank image:

- **OK**: The blank image is usable.
- **Checksum error**: No valid image available. Create a new blank image or restore factory image by pressing **Restore factory image**.
- **Not applicable**: Appears only if VD algorithm is used as detection algorithm.

More information

- Creating blank image (page 72)

9.8.1 Creating blank image



This is a maintenance operation only.

The procedure should only be done if the prism has been replaced, for example.

To create a blank image,

1. Remove the refractometer from the process line.
2. Clean the prism with ethanol cleaning solution.
3. Protect the prism from outside light.
4. Select **Create image**.

More information

- Blank image (page 72)

9.9 Configuring analog output

The PR53 process refractometer has one built-in 4–20 mA output.

For the electrical properties of the analog output, see Refractometer connections (page 20).

To configure the analog output, go to **> Configure device > Analog output 1**.

To adjust the analog output:

- **Output low end** 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 Bx or 0 °F).
- **Output high end** sets the range, which is the value given when the signal is 20 mA.
- **Error output level** sets an analog default output value that the instrument returns to in certain malfunction situations. The factory setting for default output is 3.4 mA. For a list of malfunctions that are affected, see Error statuses (page 84).
  - NAMUR NE 43 uses the 3.8–20.5 mA signal range for measurement information. With PR53 process refractometers, you can configure ≤3.6 mA to indicate diagnostic failures. With that information, it is easier to detect a failure condition on a refractometer, for example, it clearly tells you whether you have an empty pipe or a failed instrument.
- **No liquid error output** and **No liquid error output level** allow you to set a secondary mA output value for empty pipe (message **No liquid detected**) to differentiate it from the other messages that cause the measurement to revert to default mA. By default the secondary mA output is disabled.

More information

- Refractometer connections (page 20)
- Adjusting output level for analog output 1 (page 73)
- Error statuses (page 84)

9.9.1 Adjusting output level for analog output 1

In test mode, you can test the current output level of the analog output with a multimeter, and adjust the output level (2-point adjustment) if necessary.

Always switch **Test mode** off after testing to return the analog outputs to normal operating mode. The analog output does not output measurement data when analog outputs are in test mode.

To test and adjust the current output level of the analog output:

1. Connect a multimeter to the analog output wiring (connect in series to measure the current output).
2. Go to **> Calibrate > Yes**.

3. Enable the **Test mode** (switch to **ON** position).

> Selecting **Disabled** turns off the selected output.

4. Enter a low output value in mA (for example, **5**) in the **Test output level** field. The analog output starts to output current at this level.
5. Check the multimeter reading and enter the measured value (for example, **4.95**) in the **Measured value, low point** field.
6. Enter a high mA value (for example, **19**) in the **Test output level** field, check the multimeter reading, and enter the value of the multimeter reading to the **Measured value, high point** field if it differs from the test output value.
7. Select **Activate adjustment** to save the correction to the output level.
8. To verify that the current level of the output is now accurate, enter a new value (for example, **12**) in the **Test output level** field and check that the multimeter reading matches the test output value you entered.
9. Record the gain and offset values for later use: you can enter the gain and offset directly to achieve the same adjustment later.
10. Disable the **Test mode** (switch to **OFF** position) and select **Close** to exit the calibration mode.
11. Replace the original analog output wiring.

9.9.2 Configuring measurement damping with Insight

You can apply measurement damping to diminish the influence of process noise. Damping is applied to the concentration value, and therefore the output signal, of the selected refractometer.

You can select the type of measurement damping in **> Configure device > Damping > Damping type**

You can edit the following:

- **Damping time**
- **Tolerance time**
- **Slew rate**

More information

- Measurement damping (page 39)

9.10 Configuring Modbus communication settings with Insight

You can configure the following Modbus communication settings with the Insight PC software:

- Device address
- Communication bit rate
- Parity, data bits, and stop bits
- Response delay

To configure the Modbus communication settings with Insight:

1. Connect to Insight and select **> Configure device > Communication**.
2. Enter the communication values as needed: see the instructions in the Insight interface for allowed ranges and additional information.
3. Select **Save** to store the settings.

More information

- System wiring (page 22)
- Modbus RTU (page 29)
- Starting up stand-alone refractometer (page 45)
- Modbus registers (page 164)

9.11 Configuring HART settings

You can confgure HART in Insight through **> Configure device > HART**.

- **Polling address**: HART short polling address in which PR53 can be found when polling a HART bus in multidrop mode. It must be unique between devices connected to the same HART bus.
- **Configuration change counter**: The configuration change counter is incremented once for every change to the device configuration.
- **Write protection**: Device configuration can be protected by enabling write protection. This disables configuration change using HART.
- **Multidrop mode**: Disables automatic update of the 4-20 mA analog output channels and sets a fixed value of 4 mA. This is required if multiple HART devices are connected to a single HART bus.

If multidrop mode is activated, the PR53 analog output channel no longer follows the concentration measurement value.

9.12 Restoring factory settings

The **Restore default settings** function restores the refractometer to the latest saved settings and parameters. Restoring factory settings does not restore the concentration curves.

1. Select **Factory default settings > Restore default settings > Yes**.

More information

- Uploading concentration curves (page 66)

10. Preventive maintenance

10.1 Preventive maintenance

WARNING! If you have a refractometer for potentially explosive environments, read the Safety Guide fully before continuing servicing the refractometer. The Safety Guide is delivered with the product or it can be found in docs.vaisala.com.

PR53 process refractometers do not have wearing parts or periodically changeable parts. Depending on the process conditions, PR53 process refractometers may never need to be serviced.

There a few things that should be monitored:

Table 6 Preventive maintenance

Part	Action
Prism	Make sure that the prism is clean by monitoring the following: • Optical image diagnostics. See Analyzing optical image (page 176). • Change in the Quality Factor value. Change in the value usually indicates that the prism is dirty. See Vaisala Polaris Process Refractometer PR53 Prism Wash System User Guide and Data logging in Indigo500 User Guide (M212287EN).
Prism gasket	Visually check that the prism gasket is intact. This is especially important with the hygienic devices' wetted parts.
Refractometer's internal humidity level	Relative humidity indicates if any liquid has leaked inside the refractometer or if the internal drying capsule needs replacement. Typically the internal relative humidity should be < 50 %RH.
PR53AC and PR53AP flow cell	The wash nozzle gasket must be changed to a new one if the wash nozzle is removed, for maintenance purposes, for example. The old gasket can break and pieces can fall into the process liquid. The new gasket needs to be lubricated. Use lubricant that is suitable for food industry applications.

10.1.1 PR53M maintenance safety

WARNING! Do not open the hex socket screws on the refractometer cover. The pressurized process liquid will burst out and could result in death or serious injury.

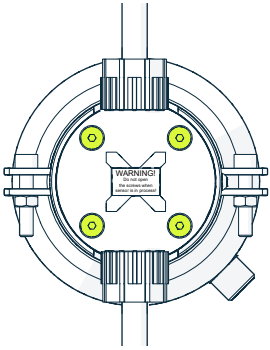


Figure 27 Hex socket screws on PR53M flow cell end plate bolts (NPT fitting)

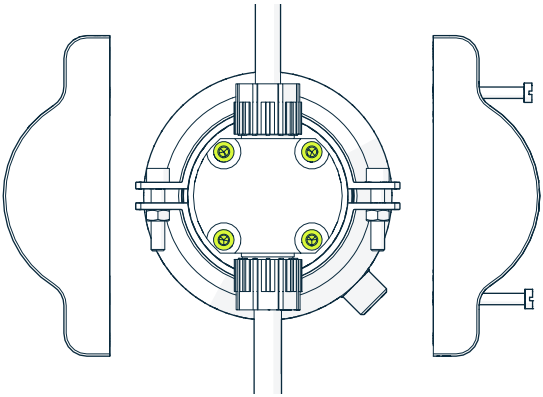


Figure 28 Hex socket screws on PR53M flow cell end plate bolts (integrated fittings)

10.2 Cleaning refractometer and prism

Cleaning the prism

In most applications the prism stays clean due to its self-cleaning effect.

In case of a coating problem, the preferred solution is to try to increase the flow velocity, for example, by installing a pipe portion with smaller diameter. If increasing the velocity does not provide a solution, consider installing a wash nozzle and a wash system. See PR53 Prism Wash System User Guide (M212808EN).

If the prism needs mechanical cleaning:

- Clean the prism with a soft cloth or with a glass fiber brush, if the dirt is resilient.
- Use water or if needed, a suitable solvent.
- Dry the prism gently using a lint-free cloth, such as a microfiber cloth.

Do not rub the prism using sand paper, rubbing compound, wire brush, and similar.

Pay special attention to cleaning the prism when performing RI calibration.

Cleaning the refractometer

CAUTION! Electrostatic discharge (ESD) can cause damage to electronic circuits. Avoid touching exposed component contacts or connectors.

Clean the refractometer by using a suitable solvent and a moist cloth.

11. Troubleshooting

11.1 Troubleshooting messages

Table 7 Hardware troubleshooting

Problem	Severity level	Cause	Corrective action
Message **Internal humidity too high.**	Error	The relative humidity measured at the refractometer's processor card exceeds 60 %RH. The reason may be moisture leaking in through the prism seal or the cover being open.	Make sure that the prism seal is intact and the cover is closed. If necessary, replace the prism seal.
Message **Internal temperature too high.**	Error	The temperature on the sensor processor card exceeds +65 °C (+150 °F). To read this temperature, • in Indigo520, go to **Menu > <your refractometer> > Diagnostics**. • in Insight, go to **<your refractometer> > Diagnostics** .	Make sure you are using the device in the right temperature. See the ambient and process temperature in the model-specific specifications.
Indigo520: No devices connected / Disconnected Insight: No connected devices in the start screen	n/a	The cables are not properly connected. The refractometer is connected to both Indigo520 and Insight.	Make sure that cables are properly connected at both ends. If the refractometer is connected to both Indigo520 and Insight, it prioritizes Indigo520 and is not visible to Insight. If you are able to open the refractometer cover, make sure that the green LED is on. This means that the refractometer is powered.
Relays not working	n/a	Relays may be in test mode. Make sure using Indigo520 that the test mode is inactive in **Menu > Inputs and outputs > Relays > Test mode**. For testing the wash function, see PR53 Prism Wash System User Guide (M212808EN).	

Problem	Severity level	Cause	Corrective action
Analog output signal is not working as expected	n/a	Check wiring, see the model-specific installation guide. If the analog output signal does not correspond to the concentration display, check output signal configuration, see **Diagnostics**. For possible correction, configure the analog output. • Indigo520: See Indigo500 User Guide (M212287EN). • Insight: See Configuring analog output (page 73). A low analog output signal can also be caused by high resistance in the external current loop, see Refractometer connections (page 20). A noisy signal can be damped, see • Indigo520: Configuring measurement damping with Indigo520 (page 53) • Insight: Configuring measurement damping with Insight (page 74)	

Table 8 Measurement troubleshooting

Problem	Severity level	Cause	Corrective action
Message **No optical image.**	Critical	To see the optical image, you need to view the Diagnostics menu in Indigo520 or Insight. There are several possible causes: 1. The prism is heavily coated. Perform prism wash if available, see PR53 Prism Wash System User Guide (M212808EN). If the prism wash is not available, remove the refractometer from process line and clean the prism manually. 2. There is moisture condensation in the refractometer head. 3. The refractometer head temperature is too high. 4. The light source is faulty. When the refractometer is removed from the process, a yellow flashing light can be seen through the prism. The light is only visible at an oblique angle. Also check the LED value in the **Diagnostics** view; 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 on the optical element. 6. The CCD card in the refractometer is faulty.	

Problem	Severity level	Cause	Corrective action
Message **Blank image corrupted.**	Critical	Blank image is missing or corrupted.	Create a new blank image. See Blank image (page 72). Contact helpdesk@vaisala.com.
Message **External light level too high.**	Error	The measurement is not possible because too much outside light reaches the camera.	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.
Message **Prism coating detected.**	Error	The optical surface of the prism is coated by the process medium or impurities in the process medium.	Perform prism wash if available, see PR53 Prism Wash System User Guide (M212808EN). If prism wash is not available, remove the refractometer from process line and clean prism manually. If the problem is recurrent, consider improving the flow conditions, see model-specific installation guide. If prism wash is available, adjust the wash parameters, see PR53 Prism Wash System User Guide (M212808EN).
Message **Temperature measurement error.**	Error	A temperature element is faulty.	Contact your distributor or helpdesk@vaisala.com, the temperature element may need to be replaced. Note that a difference to some other process temperature measurement is not a fault. PR53 measures the true temperature of the prism surface.
Message **Invalid calculation parameters.**	Error	The A parameters are incorrect.	Perform RI adjustment or contact helpdesk@vaisala.com.

Problem	Severity level	Cause	Corrective action
Message **C measurement out of concentration curve range.**	Warning	Concentration measurement is outside of the range defined in the concentration curve. If the measurement concentration is other than the valid range for the used curve, the measurement result may be unreliable.	1. Make sure that the measurement is correct. If yes, consider if the used concentration curve is suitable for the process. Contact your sales representative or helpdesk@vaisala.com. 2. If you know that the measurement does not correspond to the assumed concentration value, the range of the measurement may be outside of the valid range defined by the concentration curve. Contact helpdesk@vaisala.com.
Message **T measurement out of concentration curve range.**	Warning	Temperature measurement is outside of the range defined in the concentration curve. If the measurement temperature is other than the valid range for the used curve, the measurement result may be unreliable.	1. Make sure that the measurement is correct. If yes, consider if the used concentration curve is suitable for the process. Contact your sales representative or helpdesk@vaisala.com.
Message **External light level high.**	Warning	Some light from the outside reaches the sensor and may disturb the measurement.	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.
Message **Image quality low.**	Warning	The most likely cause for this message is scaling on the prism. There still is an optical image available, but the measurement quality may not be optimal.	Clean the prism.
Message **No liquid detected.**	Warning	The operation of the equipment is OK but there is no process liquid on the prism.	

Problem	Severity level	Cause	Corrective action
Message **Calibration mode active.**	Warning	The refractometer can be set to calibration mode in the context of RI calibration check. When calibration mode is active, the refractometer will not calculate the concentration.	Make sure that the calibration mode is off in all used user interfaces.
Unexpected concentration drift	n/a	For drift upward, suspect prism coating, see PR53 Prism Wash System User Guide (M212808EN). Otherwise make sure calibration is correct, see RI calibration (page 51), as well as RI adjustment, see RI adjustment (page 70). The latter can only be done with Insight. A good way to observe the possible concentration drift is to check the measurement log from Indigo520, if available. In addition to RI and concentration, this log includes the QF value, the changes of which can indicate prism coating. See Indigo500 User Guide (M212287EN).	

11.2 Error statuses

Certain malfunctions cause the mA measurement to return to the error output level, see Configuring analog output (page 73). For more information, see the following table.

Invalid calculation parameters.: RI adjustment parameters are invalid. Perform RI adjustment or contact helpdesk@vaisala.com.

Blank image corrupted.: Blank image for IDS image detection algorithm is corrupted. Create blank image or contact helpdesk@vaisala.com.

There are 4 error state messages, in rising severity order:

1. Info
2. Warning
3. Error
4. Critical

The 32-bit error code register is divided into two types of sections:

- Status bits (image and temperature)
- Error bits (environmental, calculation, and system).

In status sections, bits of that section form a value that represents the status of that measurement. For example, if the four bits in the image section are 0x0110 (= 6 in decimal representation), image measurement status is **External light level too high.**

In error bits sections, each bit represents an error or status, which are independent from each other. This means that there can be multiple errors active simultaneously. For example, if the four bits in the calculation section are 0x0110, **Temperature out of concentration curve range.** and **Invalid calculation parameters.** are active.

Table 9 Error statuses

Status	Severity	LED	mA error state	mA secondary error state	Modbus error code field	Modbus error code bit	Comment
Powered on	Normal	Green	-	-	-	-	The device is powered on. No communication to RS-485 port with device Modbus ID detected.
RS-485 response	Normal	Green, blink	-	-	-	-	The device received communication to the RS-485 port, either from a Modbus RTU master, or Indigo520 transmitter.
Image quality low.	Warning	Yellow	-	-	Image	1	The slope of the optical image is not clear, possible reasons: the prism is coated, excessive thermal noise, outside light.
External light level high.	Warning	Yellow	-	-	Image	2	External light is disturbing the measurement.
Prism coating detected.	Error	Red	x	-	Image	3	Prism is coated and requires washing or cleaning.

Status	Severity	LED	mA error state	mA secondary error state	Modbus error code field	Modbus error code bit	Comment
No liquid detected.	Warning	Yellow	x	x	Image	4	No liquid detected because of empty pipe, for example. No sample available for measurement.
No optical image.	Error	Red	x	-	Image	5	Critical error, optical image can not be extracted, contact help desk.
External light level too high.	Error	Red	x	-	Image	6	External light is disturbing the measurement excessively.
Temperature measurement error.	Error	Red	x	-	Temperature	1	Temperature measurement can not be made, possible temperature sensor failure.
Concentration out of concentration curve range.	Warning	Yellow	-	-	Calculation	1	Concentration is outside the valid range for the used concentration curve. Reliability of the measurement can not be guaranteed, outputs are still active.

Status	Severity	LED	mA error state	mA secondary error state	Modbus error code field	Modbus error code bit	Comment
Temperature out of concentration curve range.	Warning	Yellow	-	-	Calculation	2	Temperature is outside the valid range for the used concentration curve. Reliability of the measurement can not be guaranteed, outputs are still active.
Invalid calculation parameters.	Error	-	x	-	Calculation	4	C-parameters are not correctly set.
Calibration mode active.	Normal	-	x	-	Calculation	8	Calibration mode is activated.
Internal temperature too high.	Error	Red	x	-	Environmental	1	The temperature at the electronics compartment exceeds 65 °C (149 °F)
Internal humidity too high.	Error	Red	x	-	Environmental	2	The humidity at the electronics compartment exceeds 60 %RH
Blank image corrupted.	Error	Red	x	-	System	2	System failure, contact technical support.

11.3 Measurement status details

There are different measurement statuses that you can view in the **Diagnostics** tab of the Insight software.

- C measurement status
- T measurement status
- Field sample status

Table 10 Measurement status details

Message	C measurement status	T measurement status	Field sample status
None	No errors detected.	No errors detected.	No errors detected.
Unavailable (S)	Concentration measurement is unavailable because no liquid is detected on the prism or the device is in calibration mode.	-	No field sample has been taken.
Unreliable (R)	Refractometer is measuring temperature outside concentration curve measurement range. Temperature compensation might not work properly.	-	A warning in image detection has occurred during taking the field sample.
Under range (U)	Refractometer is measuring a value outside concentration curve measurement range.	Refractometer is measuring a value outside concentration curve measurement range.	-
Over range (O)	Refractometer is measuring a value outside concentration curve measurement range.	Refractometer is measuring a value outside concentration curve measurement range.	-
Locked (L)	Concentration value is locked during prism wash.	Temperature value is locked during prism wash.	-
Failure (F)	Optical image is not available. Refractometer needs maintenance, contact helpdesk@vaisala.com.	Temperature sensor has failed. Refractometer needs maintenance, contact helpdesk@vaisala.com.	Optical image is not available or temperature sensor has failed during taking the field sample.
Not ready (W)	-	-	Field sample is being measured and the results are not yet available.

11.4 Concentration laboratory calibration

Wait until normal, stable process conditions occur. Extract a sample and perform field calibration. If the required field adjustment is excessive and the diagnostic status is normal operation, the RI measurement may be the cause. It can be checked by RI calibration check procedure.

- Indigo520: Calculating field adjustment (page 49), Performing RI calibration with Indigo520 (page 52)
- Insight: Calculating field adjustment (page 65), Performing RI calibration with Insight (page 69).

11.5 RI calibration failure

It is recommended to recalibrate any failed points at least once more. Something external may have caused the calibration failure.

- Temperature related failures:
  - There is a difference between the sample temperature and the refractometer temperature.
  - Measured temperature is out of the specified +20 ... +30 °C (+68 ... +86 °F) calibration range.
  - The temperature may not be sufficiently stable and is changing. This appears as a long waiting time for stabilization in the RI calibration process.

If the calibration failure is caused by temperature, both refractometer and sample liquid temperature should be allowed to stabilize to be in the calibration range. Retry calibration after a little while.

- Reference liquid related failures:
  - There is coating on the prism.
    Clean the prism and the sample holder, and then recalibrate.
  - There are impurities in the sample liquid.
    Clean the prism and the sample holder. Replace the sample liquid and then recalibrate.
  - Reference liquid has expired.
    Check the expiration date and use another reference liquid if needed. Notice that the liquids may expire quicker if the containers are left open for extended periods of time.

More information

- Analyzing optical image (page 176)

12. Technical data

12.1 Compatibility

The PR53 refractometer is mechanically compatible with most PR-23 and PR-43 refractometers. The communication and electronic system has to be updated with the refractometer change.

12.2 PR53 common specifications

If you have a refractometer for potentially explosive environments, the product specifications can be found in the Safety Guide. The Safety Guide is delivered with the product or it can be found in docs.vaisala.com.

Table 11 PR53 series measurement performance

Property	Description/Value
Accuracy specified with respect to calibration reference, including non-linearity, hysteresis at +20 °C.	
Refractive index	
Measurement range	1.32–1.53 nD (Corresponds to 0–100 °Bx)
Accuracy	±0.00014 nD (0.1 °Bx)
Repeatability *(Confidence level k=2, including random noise, at Ta = +20 °C, from raw signal, no filtering)*	±0.0000033 nD
Resolution	±0.000001 nD
Response time T_{63} with default damping	10 s *(With standard low-pass filtering)*
Measurement cycle	1 / s
Long-term stability	Max. 0.1 % full scale / a
Temperature	
Accuracy at 20 °C (68 °F)	±0.3 °C (0.54 °F)
Sensor class	F0.15 IEC 60751
Temperature coefficient	±0.002 °C / C

Table 12 PR53 series operating environment

Property	Specification
Operating environment	Indoor, Outdoor
Use in wet location	Yes
Pollution degree	2

For PR53SD measurement performance, see PR53SD specifications (page 107).

For PR53S measurement performance, see PR53S specifications (page 111).

Table 13 PR53 series inputs and outputs

Property	Specification
Supply	
Operating voltage	24 V DC nominal (9–30 V DC)
Power consumption	Less than 1 W
Protection class	3, PELV
Overvoltage category	I
Outputs	
Output parameters	RI, temperature, concentration, quality factor
Analog outputs	
mA	Sourcing, isolated, NAMUR NE 43, configurable
mA range	3.2–20.5 mA
Maximum load	600 Ω
Accuracy of analog outputs at +20 °C	±0.1 % of full scale (±0.0002 RI)
Supported protocol	HART 7
Digital outputs	
Digital output	RS-485, non-isolated
Maximum cable run	300 m (approx. 1000 ft) (digital)
Supported protocol	Modbus RTU
Connectors	
External connectors	1 × M12 M 4 pins, A-coded (*For USB2 adapter and Insight software, see vaisala.com/insight.*) 1 × M16×1.5 cable gland, Cable D 5–10 mm / Adapter for conduit entry M16×1.5 / NPT ½"

12.3 PR53AC specifications

Table 14 PR53AC operating environment

Property	Specification
Process parameters	
Process temperature	–40 ... +150 °C (–40 ... +302 °F) [1]
Design temperature	+180 °C (356 °F) [2]
Design pressure	40 bar [3]
Operating environment	
Storage temperature	–40 ... +65 °C (–40 ... +149 °F)
Operating temperature	–40 ... +60 °C (–40 ... +140 °F)
Maximum operating altitude	2000 m (approx. 6500 ft)
Operating humidity	0–100 %RH
Storage humidity	0–100 %RH, non-condensing
UL 50E/NEMA rating	Type 4X: Dust-tight. Protected from corrosion and hose-directed water.
IP rating	IP66: Dust-tight. Protected from powerful water jets from any direction. IP67: Dust-tight. Protected from the effects of temporary immersion in water under standardized conditions of pressure and time.

1) –40 ... +130 °C (-40 ... 266 °F) EPDM gasket, -40... +150 °C (–40 ... +302 °F) PTFE gasket.
2) Maximum momentary temperature peak.
3) Maximum at +20 °C (68 °F), operating pressure to the clamp rating pressure.

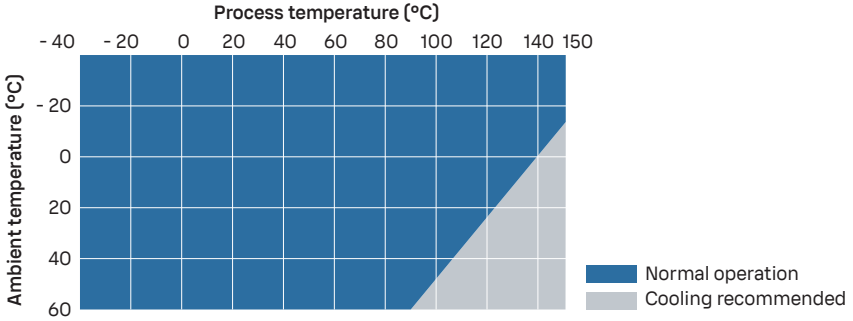


Figure 29 PR53AC process temperature, options Sanitary 2.5″ and Type N (indicative)

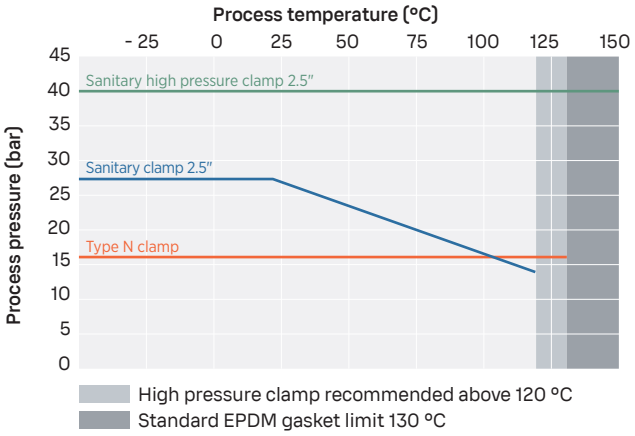


Figure 30 PR53AC process pressure

Table 15 PR53AC compliance

Property	Specification
Electromagnetic compatibility (EMC)	EN 61326-1, industrial environment
Safety	IEC/EN/UL 61010-1
Pressure	CRN all territories, ASME BPVC Sec VIII Div. 1 Ed. 2021
Material compliance	FDA 21 CFR 177.150, 177.2600, 177.1550 EC 1935/2004 EC 2023/2006, GMP EU 10/2011
Compliance marks	CE, China RoHS, RCM, UKCA
Vibration and shock	Tested according to IEC 60068-2
Listing marks	MET listed (US and Canada)

Table 16 PR53AC sanitary compliance

Property	Specification
Hygienic design	3-A 46-04 EHEDG

Property	Specification
Compliance marks	3-A, EHEDG (for EHEDG compliant installation, use 2.5″ / 4″ sanitary gasket)
Biocompatibility	USP Class VI <88>, 70 °C
ADI free (Animal Derived Ingredients)	Yes

Table 17 PR53AC mechanical specifications

Property	Specification
Wetted parts	
Sensor head	EN 1.4435 BN2 (AISI 316L) [1]
Surface roughness	Ra 0.8 µm Ra 0.38 µm electropolished [1]
Prism	Sapphire monocrystalline, 99.996 % Al_2O_3 [2]
Prism gasket	Modified PTFE [3]
Sanitary 2.5″ gasket	EPDM [2]
Type N gasket	EPDM [2]
Welding ferrule	EN 1.4435 (AISI 316L) [1] [4] ASME BPE-2019 (DIN 32676-C)
Non-wetted parts	
Housing	EN 1.4404 (AISI 316L)
Screws TX20, torque 2.0 Nm	EN 1.4404 (AISI 316L)
Cable gland	EN 1.4305 (AISI 303) HUMMEL 1.693.1600.50
Blanking plug	EN 1.4305 (AISI 303) AGRO 8717.96.08.70
Thread adpter	EN 1.4404 (AISI 316L) Vaisala, DRW257718, M16×1.5 / NPT ½ in
M12 connector	Gland, EN 1.4305 (AISI 303) Contacts, CuZn with Ni/Au plating Phoenix Contact, 1405233, M12/4(M), A, 4×0.34 mm^2, TPE, 0.5 m Carrier, PA 6.6
Sanitary 2.5″ clamp	EN 1.4301 (AISI 304) [2]

Property	Specification
Type N Clamp	EN 1.4301 (AISI 304) [2]
Cable	2×2×0.5 mm² (AWG 21), PUR jacket, gray 10 m multistrand, with ferrules Flame-retardant acc. to IEC 60332-1-2, FT1, VW1
Weight	2.7 kg (5.95 lb)

1) *EN 10204 / 3.1 certificate included.*
2) *Manufacturer's declaration included.*
3) *ADI free, FDA 21 C.F.R 177.1550, 3A Sanitary Standard, USP Class VI <88>, 70 °C.*
4) *3-A certificate, EHEDG certificate.*

12.4 PR53AP specifications

Table 18 PR53AP operating environment

Property	Specification
Process parameters	
Process temperature	–40 ... +150 °C (–40 ... +302 °F) [1]
Design temperature	+180 °C (356 °F) [2]
Design pressure	40 bar [3]
Operating environment	
Storage temperature	–40 ... +65 °C (–40 ... +149 °F)
Operating temperature	–40 ... +60 °C (–40 ... +140 °F)
Maximum operating altitude	2000 m (approx. 6500 ft)
Operating humidity	0–100 %RH
Storage humidity	0–100 %RH, non-condensing
UL 50E/NEMA rating	Type 4X: Dust-tight. Protected from corrosion and hose-directed water.
IP rating	IP66: Dust-tight. Protected from powerful water jets from any direction. IP67: Dust-tight. Protected from the effects of temporary immersion in water under standardized conditions of pressure and time.

1) *–40 ... +130 °C (–40 ... 266 °F) EPDM gasket, –40... +150 °C (–40 ... +302 °F) PTFE gasket*
2) *Maximum momentary temperature peak.*
3) *Maximum at +20 °C (68 °F), operating pressure to the clamp rating pressure.*

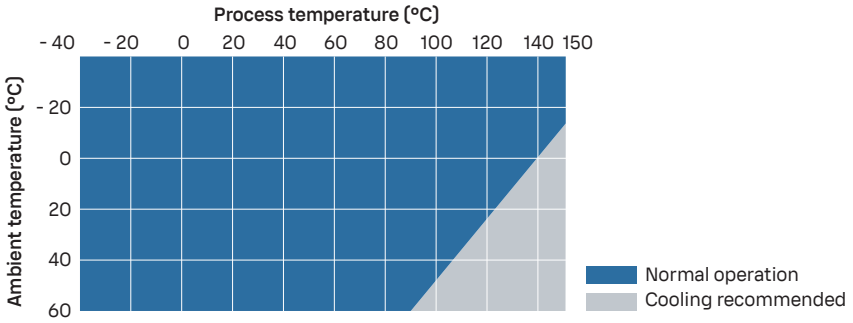


Figure 31 PR53AP, depth 170 mm process temperature (indicative)

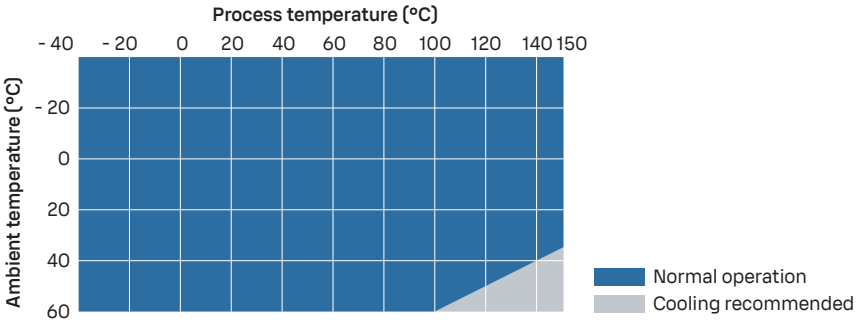


Figure 32 PR53AP, depth 42 mm and 66 mm process temperature (indicative)

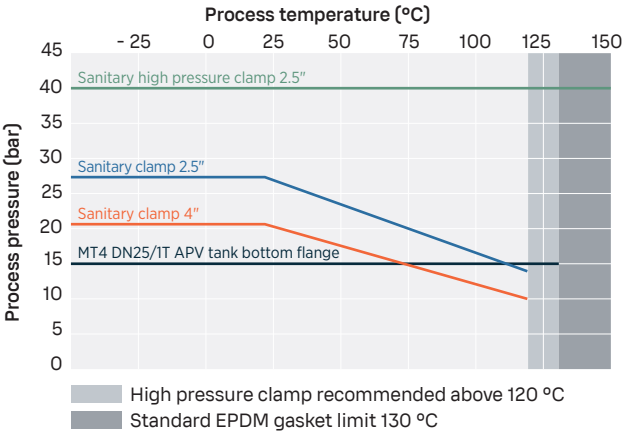


Figure 33 PR53AP process pressure

Table 19 PR53AP compliance

Property	Specification
Electromagnetic compatibility (EMC)	EN 61326-1, industrial environment
Safety	IEC/EN/UL 61010-1
Pressure	CRN all territories, ASME BPVC Sec VIII Div. 1 Ed. 2021
Material compliance	FDA 21 CFR 177.150, 177.2600, 177.1550 EC 1935/2004 EC 2023/2006, GMP EU 10/2011
Compliance marks	CE, China RoHS, RCM, UKCA
Vibration and shock	Tested according to IEC 60068-2
Listing marks	MET listed (US and Canada)

Table 20 PR53AP sanitary compliance

Property	Specification
Hygienic design	3-A 46-04 EHEDG [1)]
Compliance marks	3-A, EHEDG [2)]

Property	Specification
Biocompatibility	USP Class VI <88>, 70 °C
ADI free (Animal Derived Ingredients)	Yes

1) *Excluding tank bottom flange.*
2) *For EHEDG compliant installation, use 2.5″ / 4″ sanitary gasket.*

Table 21 PR53AP mechanical specifications

Property	Specification
Wetted parts	
Sensor head	EN 1.4435 BN2 (AISI 316L) [1]
Wash nozzle	EN 1.4404 (AISI316L) [1] EPDM gasket [2]
Surface roughness	Ra 0.8 µm
Prism	Sapphire monocrystalline, 99.996 % Al_2O_3 [2]
Prism gasket	Modified PTFE [3]
Sanitary gasket 2.5″ / 4″	EPDM [2]
Tank bottom gasket MT4 DN25/1T for tank bottom flange	EPDM [2]
Tank bottom flange	AISI316L [1]
Welding ferrule	EN 1.4435 (AISI 316L) [1] [4]
Non-wetted parts	
Housing	EN 1.4404 (AISI 316L)
Screws, TX20, torque 2.0 Nm	EN 1.4404 (AISI 316L)
Cable gland	EN 1.4305 (AISI 303) HUMMEL 1.693.1600.50
Blanking plug	EN 1.4305 (AISI 303) AGRO 8717.96.08.70
Thread adapter	EN 1.4404 (AISI 316L) Vaisala, DRW257718, M16×1.5 / NPT ½ in

Property	Specification
M12 connector	Gland, EN 1.4305 (AISI 303) Contacts, CuZn with Ni/Au plating Phoenix Contact, 1405233, M12/4(M), A, 4×0.34 mm^2, TPE, 0.5 m Carrier, PA 6.6
Sanitary clamp 2.5″ / 4″	EN 1.4301 (AISI 304) [2]
Cable	2×2×0.5 mm^2 (AWG 21), PUR jacket, black 10 m multistrand, with ferrules Flame-retardant acc. to IEC 60332-1-2, FT1, VW1
Weight	3.6–4.2 kg (7.94–9.26 lb)

1) *Material certificate included.*
2) *Manufacturer's declaration included.*
3) *ADI free, FDA 21 C.F.R 177.1550, 3A Sanitary Standard, USP Class VI <88>, 70 °C.*
4) *3-A certificate, EHEDG certificate.*

12.5 PR53GC specifications

Table 22 PR53GC operating environment

Property	Specification
Process parameters	
Process temperature	–40 ... +150 °C (–40 ... +302 °F)
Design temperature	+180 °C (356 °F) [1]
Operating environment	
Storage temperature	–40 ... +65 °C (–40 ... +149 °F)
Operating temperature	–40 ... +60 °C (–40 ... +140 °F)
Maximum operating altitude	2000 m (approx. 6500 ft)
Operating humidity	0–100 %RH
Storage humidity	0–100 %RH, non-condensing
UL 50E/NEMA rating	Type 4X: Dust-tight. Protected from corrosion and hose-directed water.

Property	Specification
IP rating	IP66: Dust-tight. Protected from powerful water jets from any direction. IP67: Dust-tight. Protected from the effects of temporary immersion in water under standardized conditions of pressure and time.

1) Maximum momentary temperature peak.

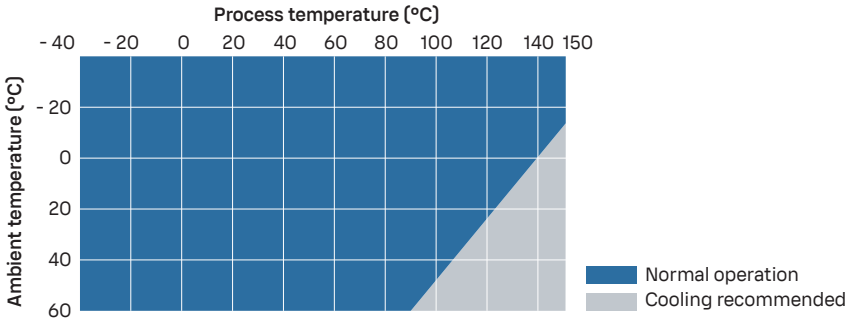


Figure 34 PR53GC process temperature (indicative)

Table 23 PR53GC compliance

Property	Specification
Electromagnetic compatibility (EMC)	EN 61326-1, industrial environment
Safety	IEC/EN/UL 61010-1
Pressure	CRN all territories, ASME BPVC Sec VIII Div. 1 Ed. 2021
Compliance marks	CE, China RoHS, RCM, UKCA
Vibration and shock	Tested according to IEC 60068-2

Table 24 PR53GC mechanical specifications

Property	Specification
Wetted parts	

Property	Specification
Sensor head	EN 1.4404 (AISI 316L) EN 2.4660 (Alloy 20) EN 2.4819 (Alloy C276) 1)
Surface roughness	Ra 0.8 µm
Prism	Sapphire monocrystalline, 99.996 % Al_2O_3 2)
Prism gasket	Modified PTFE 2)
L coupling gasket	PTFE 2)
Welding ferrule	EN 1.4404 (AISI 316L) EN 2.4660 (Alloy 20) EN 2.4819 (Alloy C276) 2)
Non-wetted parts	
Housing	EN 1.4404 (AISI 316L)
Screws, TX20, torque 2.0 Nm	EN 1.4404 (AISI 316L)
Cable gland	EN 1.4305 (AISI 303) HUMMEL 1.693.1600.50
Blanking plug	EN 1.4305 (AISI 303) AGRO 8717.96.08.70
Thread adapter	EN 1.4404 (AISI 316L) Vaisala, DRW257718, M16×1.5 / NPT ½ in
M12 connector	Gland, EN 1.4305 (AISI 303) Contacts, CuZn with Ni/Au plating Phoenix Contact, 1405233, M12/4(M), A, 4×0.34 mm^2, TPE, 0.5 m Carrier, PA 6.6
L coupling clamp (60.3 mm)	EN 1.4301 (AISI 304) 2)
Cable	2×2×0.5 mm^2 (AWG 21), PUR jacket, gray 10 m multistrand, with ferrules Flame-retardant acc. to IEC 60332-1-2, FT1, VW1
Weight	2.7 kg (5.95 lb)

1) Material certificate included.
2) Manufacturer's declaration included.

12.6 PR53GP specifications

Table 25 PR53GP operating environment

Property	Specification
Process parameters	
Process temperature	−40 ... +150 °C (−40 ... +302 °F)
Design temperature	+180 °C (+356 °F) [1]
Design pressure	40 bar [2]
Operating environment	
Storage temperature	−40 ... +65 °C (−40 ... +149 °F)
Operating temperature	−40 ... +60 °C (−40 ... +140 °F)
Maximum operating altitude	2000 m (approx. 6500 ft)
Operating humidity	0–100 %RH
Storage humidity	0–100 %RH, non-condensing
UL 50E/NEMA rating	Type 4X: Dust-tight. Protected from corrosion and hose-directed water.
IP rating	IP66: Dust-tight. Protected from powerful water jets from any direction. IP67: Dust-tight. Protected from the effects of temporary immersion in water under standardized conditions of pressure and time.

1) *Maximum momentary temperature peak.*
2) *Maximum at +20 °C, operating pressure to the process connection rating pressure.*

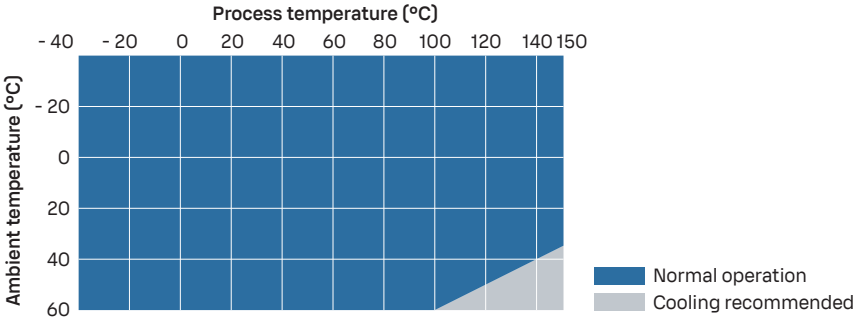


Figure 35 PR53GP process temperature (indicative)

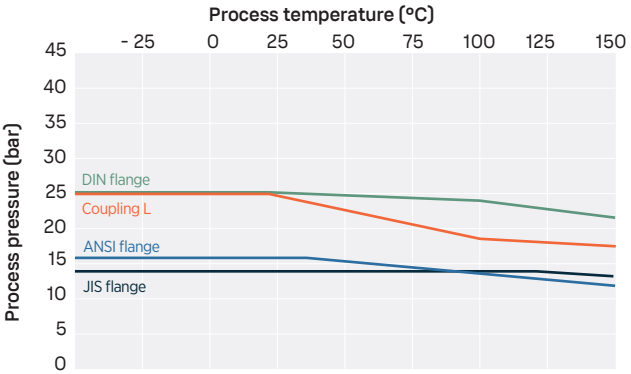


Figure 36 PR53GP process pressure

Table 26 PR53GP compliance

Property	Specification
Electromagnetic compatibility (EMC)	EN 61326-1, industrial environment
Safety	IEC/EN/UL 61010-1
Pressure	CRN all territories, ASME BPVC Sec VIII Div. 1 Ed. 2021
Compliance marks	CE, China RoHS, RCM, UKCA
Vibration and shock	Tested according to IEC 60068-2

Table 27 PR53GP mechanical specifications

Property	Specification
Wetted parts	
Sensor head	EN 1.4404 (AISI 316L) [1]
Surface roughness	Ra 0.8 µm
Prism	Sapphire monocrystalline, 99.996 % Al_2O_3 [2]
Prism gasket	Modified PTFE [2]
L coupling gasket	PTFE [2]
L coupling welding ferrule	EN 1.4404 (AISI 316L)[1]
Wash nozzle parts	EN 1.4404 (AISI 316L) [1]

Property	Specification
Non-wetted parts	
Housing	EN 1.4404 (AISI 316L)
Screws TX20, torque 2.0 Nm	EN 1.4404 (AISI 316L)
Cable gland	EN 1.4305 (AISI 303) HUMMEL 1.693.1600.50
Blanking plug	EN 1.4305 (AISI 303) AGRO 8717.96.08.70
Thread adapter	EN 1.4404 (AISI 316L) Vaisala, DRW257718, M16×1.5 / NPT ½ in
M12 connector	Gland, EN 1.4305 (AISI 303) Contacts, CuZn with Ni/Au plating Phoenix Contact, 1405233, M12/4(M), A, 4×0.34 mm^2, TPE, 0.5 m Carrier, PA 6.6
Flange	EN 1.4404 (AISI 316L) Dimensioning and tolerances as per ASME B16.5, DIN 2543, JIS B2220
L coupling clamp, 88.9 mm	EN 1.4301 (AISI 304)
Cable	2×2×0.5 mm^2 (21 AWG) PUR jacket, gray 10 m multistrand, with ferrules Flame-retardant acc. to IEC 60332-1-2, FT1, VW1
Weight	PR53GP 2″ flange 7.2 kg (15.87 lb) - 7.7 kg (16.98 lb) PR53GP 3″ flange 10.5 kg (23.15 lb) - 11.7 kg (25.79 lb) PR53 L coupling 5.1 kg (11.24 lb)

1) *Material certificate included.*
2) *Manufacturer's declaration included.*

12.7 PR53M specifications

Table 28 PR53M operating environment

Property	Specification
Process parameters	

Property	Specification
Process temperature	–10 … +130 °C (+14 … +266 °F)
Pressure	10 bar at 20 °C, 4.5 bar at 130 °C (145 psi at 68 °F, 652 psi at 266 °F)
Operating environment	
Storage temperature	–40 … +65 °C (–40 … +149 °F)
Operating temperature	–40 … +60 °C (–40 … +140 °F)
Maximum operating altitude	2000 m (approx. 6500 ft)
Operating humidity	0–100 %RH
Storage humidity	0–100 %RH, non-condensing
UL 50E/NEMA rating	Type 4X: Dust-tight. Protected from corrosion and hose-directed water.
IP rating	IP66: Dust-tight. Protected from powerful water jets from any direction. IP67: Dust-tight. Protected from the effects of temporary immersion in water under standardized conditions of pressure and time.

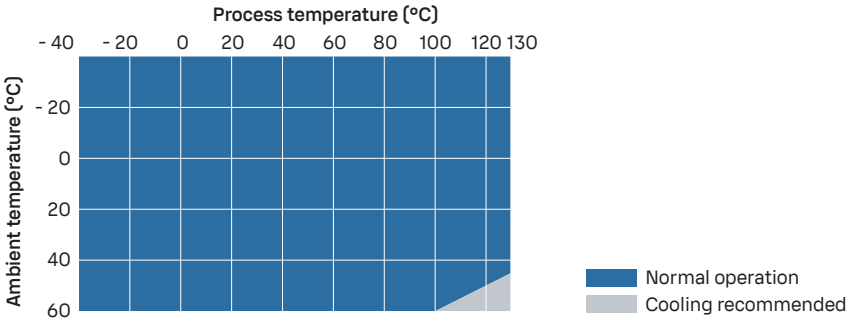


Figure 37 PR53M process temperature (indicative)

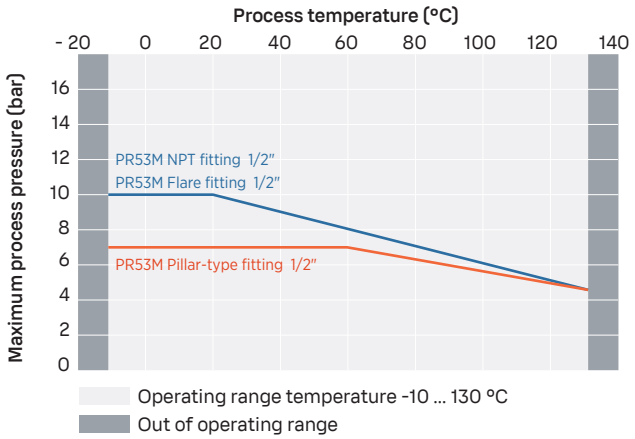


Figure 38 PR53M process pressure

Table 29 PR53M compliance

Property	Specification
Electromagnetic compatibility (EMC)	EN 61326-1, industrial environment
Safety	IEC/EN/UL 61010-1
Compliance marks	CE, China RoHS, RCM, UKCA
Vibration and shock	Tested according to IEC 60068-2

Table 30 PR53M mechanical specifications

Property	Specification
Wetted parts	
Prism and sapphire plate	Sapphire monocrystalline, 99.996 % Al_2O_3 [1)]
Flow cell	Ultra pure PTFE [1)]
Prism gasket	Modified PTFE [1)]
Process gasket	Kalrez W240UP [1)]
Non-wetted parts	
Housing	Stainless steel (AISI 316)
Coating	Cerakote, white (PR53M with integrated fittings)

Property	Specification
Screws TX20, torque 2.0 Nm	EN 1.4404 (AISI 316L)
Cable	2×2×0.5 mm^2 (AWG 21), PUR jacket, gray 10 m multistrand, with ferrules Flame-retardant acc. to IEC 60332-1-2, FT1, VW1

1) *Manufacturer's declaration included.*

12.8 PR53SD specifications

Table 31 PR53SD measurement performance

Property	Description/Value
Refractive index	
Measurement range	1.32–1.53 nD (0–90 % total solids), normal-range prism 1.36–1.57 nD (20–100 % total solids), high-range prism
Accuracy	±0.00014 nD (0.1 °Bx) [1]
Repeatability	±0.00002 nD [2]
Resolution	±0.000001 nD
Response time T_{63} with default damping	10 s [3]
Measurement cycle	1 / s
Long-term stability	Max. 0.1 % full scale / a
Temperature	
Accuracy at 20 °C (68 °F)	±0.3 °C (0.54 °F) [1]
Sensor class	F0.15 IEC 60751
Temperature coefficient	±0.002 °C / C

1) *Accuracy specified with respect to calibration reference, including non-linearity, hysteresis at +20 °C.*
2) *Repeatability, confidence level k=2, including random noise, at Ta = +20 °C, with standard low-pass filtering.*
3) *At standard low-pass filtering.*

Table 32 PR53SD operating environment

Property	Specification
Process parameters	
Process temperature	–40 ... +170 °C (–40 ... +338 °F)
Design temperature	+180 °C (+356 °F) [1)]
Design pressure / maximum operating pressure	35 bar (507.6 psi)
Maximum retraction pressure	35 bar (507.6 psi)
Operating environment	
Storage temperature	–40 ... +65 °C (–40 ... +149 °F)
Operating temperature	–40 ... +60 °C (–40 ... +140 °F)
Maximum operating altitude	2000 m (approx. 6500 ft)
Operating humidity	0–100 %RH
Storage humidity	0–100 %RH, non-condensing
UL 50E/NEMA rating	Type 4X: Dust-tight. Protected from corrosion and hose-directed water.
IP rating	IP66: Dust-tight. Protected from powerful water jets from any direction. IP67: Dust-tight. Protected from the effects of temporary immersion in water under standardized conditions of pressure and time.

1) Maximum momentary temperature peak.

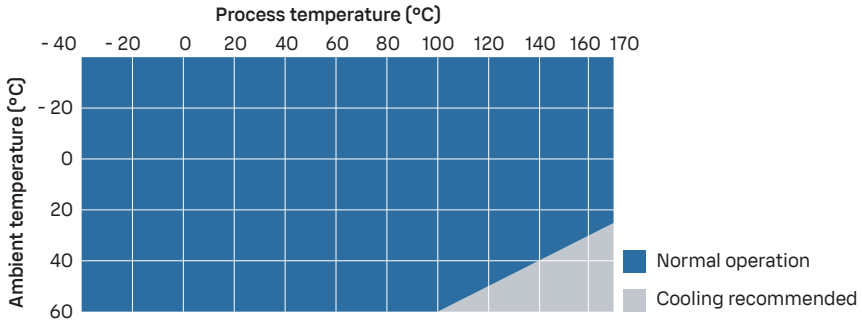


Figure 39 PR53SD process temperature (indicative)

Table 33 PR53SD compliance

Property	Specification
Electromagnetic compatibility (EMC)	EN 61326-1, industrial environment
Safety	IEC/EN/UL 61010-1
Pressure	CRN all territories, ASME BPVC Sec VIII Div. 1 Ed. 2021
Compliance marks	CE, China RoHS, RCM, UKCA
Vibration and shock	Tested according to IEC 60068-2

Table 34 PR53SD mechanical specifications

Property	Specification
Wetted parts	
Sensor head	EN 1.4462 [1)]
Prism	Sapphire monocrystalline, 99.996 % Al_2O_3 [2)]
Process gasket	Co-Cr-Ni Alloy (AMS 5876) lined PTFE [2)]
Prism gasket	Modified PTFE [2)]
SD flange	EN 1.4462 [1)]
Wash nozzle	EN 1.4462 [2)]
Non-wetted parts	
Housing	EN 1.4404
Screws, TX20 torque 2.0 Nm	EN 1.4404 (AISI 316L)
Stud bolts, M12 torque 75 Nm, M10 torque 40 Nm	EN 1.4435 (AISI 316L), grade 8.8
Flanges (3 pcs)	EN 1.4462 (AISI 2205) ASME B16.5, DIN 2543
Cable	2×2×0.5 mm^2 (AWG 21), PUR jacket, grey 10 m multistrand, with ferrules Flame-retardant acc. to IEC 60332-1-2, FT1, VW1
Weight	Retractor and wash connection 15 kg (33.07 lb) Refractometer 5.4 kg (11.9 lb)

1) *EN 10204 / 3.1 certificate included.*
2) *Manufacturer's declaration included.*

12.9 PR53W specifications

Table 35 PR53W operating environment

Property	Specification
Process parameters	
Process temperature	–10 ... +130 °C (+14 ... +266 °F)
Operating pressure	10 bar (145 psi)
Operating environment	
Storage temperature	–40 ... +65 °C (–40 ... +149 °F)
Operating temperature	–40 ... +60 °C (–40 ... +140 °F)
Maximum operating altitude	2000 m (approx. 6500 ft)
Operating humidity	0–100 %RH
Storage humidity	0–100 %RH, non-condensing
UL 50E/NEMA rating	Type 4X: Dust-tight. Protected from corrosion and hose-directed water.
IP rating	IP66: Dust-tight. Protected from powerful water jets from any direction. IP67: Dust-tight. Protected from the effects of temporary immersion in water under standardized conditions of pressure and time.

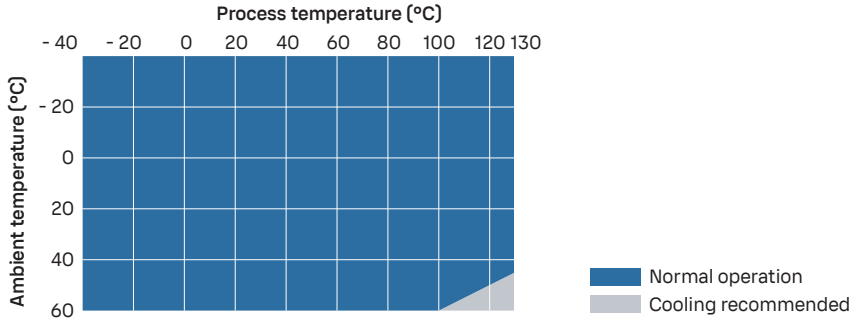


Figure 40 PR53W process temperature (indicative)

Table 36 PR53W compliance

Property	Specification
Electromagnetic compatibility (EMC)	EN 61326-1, industrial environment
Safety	IEC/EN/UL 61010-1
Compliance marks	CE, China RoHS, RCM, UKCA
Vibration and shock	Tested according to IEC 60068-2

Table 37 PR53W mechanical specifications

Property	Specification
Wetted parts	
Prism and sapphire plate	Sapphire monocrystalline, 99.996 % Al_2O_3 [1)]
Valve body lining	ETFE [1)]
Prism gasket	Modified PTFE [1)]
Valve body gasket	PTFE [1)]
Process gasket	Kalrez W240UP [1)]
Valve body M10 stud	EN 1.4404 (AISI 316L) [1)]
Non-wetted parts	
Valve body	Cast iron [1)]
Housing	EN 1.4404 (AISI 316L)
Screws TX20, torque 2.0 Nm	EN 1.4404 (AISI 316L)
Cable	2×2×0.5 mm^2 (AWG 21), PUR jacket, gray 10 m multistrand, with ferrules Flame-retardant acc. to IEC 60332-1-2, FT1, VW1

1) *Manufacturer's declaration included*

12.10 PR53S specifications

Table 38 PR53S measurement performance

Property	Description/Value
Accuracy specified with respect to calibration reference, including non-linearity, hysteresis at +20 °C (+68 °F).	

Property	Description/Value
Refractive index	
Measurement range	1.32–1.53 nD (Corresponds to 0–100 °Bx)
Accuracy	±0.0002 nD (0.1 °Bx)
Repeatability *(Confidence level k=2, including random noise, at Ta = +20 °C (+68 °F), with standard low-pass filtering)*	±0.0000033 nD
Resolution	±0.000001 nD
Response time T_{63} with default damping	10 s *(With standard low-pass filtering)*
Measurement cycle	1 / s
Long-term stability	Max. 0.1 % full scale / a
Temperature	
Accuracy at +20 °C (+68 °F)	±0.3 °C (0.54 °F)
Sensor class	F0.15 IEC 60751
Temperature coefficient	±0.002 °C / C

Table 39 PR53S operating environment

Property	Specification
Process parameters	
Process temperature	–20 ... +85 °C (-4 ... +185 °F)
Pressure	10 bar at 20 °C, 4.5 bar at 130 °C (145 psi at 68 °F, 652 psi at 266 °F)
Operating environment	
Storage temperature	–40 ... +65 °C (–40 ... +149 °F)
Operating temperature	–20 ... +45 °C (–4 ... +113 °F)
Maximum operating altitude	2000 m (approx. 6500 ft)
Operating humidity	0–100 %RH
Storage humidity	0–100 %RH, non-condensing

Property	Specification
IP rating	IP66: Dust-tight. Protected from powerful water jets from any direction. IP67: Dust-tight. Protected from the effects of temporary immersion in water under standardized conditions of pressure and time.

Table 40 PR53S compliance

Property	Specification
Electromagnetic compatibility (EMC)	EN 61326-1, industrial environment [1] FCC part 15 B, Class B CAN ICES-3(B)/NMB-3(B)
Compliance marks	CE, China RoHS, KC
Vibration and shock	Tested according to IEC 60068-2

1) *Analog output may deviate up to ±0.25 % from full scale in industrial environments at 700-1000 MHz.*

Table 41 PR53S inputs and outputs

Property	Specification
Supply	
Operating voltage	24 V DC nominal (9–30 V DC)
Power consumption	Less than 1 W
Protection class	3, PELV
Overvoltage category	I
Outputs	
Output parameters	Refractive index, temperature, concentration, quality factor
Analog outputs	
mA	Sourcing, isolated, NAMUR NE 43, configurable
mA range	3.8–20.5 mA
Maximum load	600 Ω
Accuracy of analog outputs at +20 °C	±0.1 % of full scale (±0.0002 RI)

Property	Specification
Supported protocol	HART 7
Output parameters	Concentration
Digital outputs	
Digital output	RS-485, non-isolated
Maximum cable run	300 m (approx. 1000 ft) (digital)
Supported protocol	Modbus RTU
Connectors	
External connectors	1 × M12 8-pin A-coded male With an adapter 1 × M12 4-pin A-coded male *An adapter cable is needed to connect to USB2 and Indigo80. USB2 adapter is used with Insight software, see vaisala.com/insight.*

Table 42 PR53S mechanical specifications

Property	Specification
Wetted parts	
Prism and sapphire plate	Sapphire monocrystalline, 99.996 % Al_2O_3 [1)]
Flow cell	Ultra pure PTFE [1)]
Prism gasket	Modified PTFE [1)]
Process gasket 20.2 × 3 mm (0.8 × 0.1 in)	Kalrez W240UP [1)]
Non-wetted parts	
Housing	PVDF
Connector	Stainless steel
Cable	PEX or FEP

1) Manufacturer's declaration included.

Table 43 PR53S mounting accessories

Item	Item code
1/4″ flare fitting nut	PR-9130
3/8″ flare fitting nut	PR-9131
1/2″ flare fitting nut	PR-9132

Item	Item code
3/4" flare fitting nut	PR-9133
Pillar nut and sleeve	n/a
Refractometer support	PR-12107

Table 44 PR53S accessories

Item	Item code
USB adapter for Vaisala Insight PC software (see www.vaisala.com/insight)	USB2
M12 4-to-8-pin adapter cable	CBL211714
5 m (16.5 ft) cable M12, open-ended	278421
10 m (33 ft) cable M12, open-ended	285771
Flow cell body with flare fitting, 1/4 inch	F2-025-TM
Flow cell body with flare fitting, 3/8 inch	F2-038-TM
Flow cell body with flare fitting, 1/2 inch	F2-050-TM
Flow cell body with flare fitting, 3/4 inch	F2-075-TM
Flow cell body with flare fitting, 1 inch	F2-100-TM
Flow cell body with pillar fitting, 1/4 inch	P2-025-TM
Flow cell body with pillar fitting, 3/8 inch	P2-038-TM
Flow cell body with pillar fitting, 1/2 inch	P2-050-TM
Flow cell body with pillar fitting, 3/4 inch	P2-075-TM
Flow cell body with pillar fitting, 1 inch	P2-100-TM

12.11 Spare parts and accessories

Table 45 Interconnecting cable specifications

Property	Specification
Maximum cable run	300 m (approx. 1000 ft)
Type	Shielded, multistrand
Dimensions	OD 5–10 mm (0.20–0.39 in), 0.2–2.5 mm^2 (AWG 24–14), stripping length 10–12 mm (0.39–0.47 in)
Circuit breaker (between Indigo520 and power source)	1 A (slow)

Table 46 Spare parts

Description	Item code
2.5″ EPDM gasket	278220SP
Desiccant capsules (6 pcs)	238440SP
H72 prism and sealing	278253SP
H73 prism and sealing	278254SP
Isolation valve	275267SP
Non-return valve	278021SP
PR53SD steam wash nozzle	DRW258211SP
Prism gasket	DRW252500SP
Shut-off steam valve	277082SP
Steam hose	ASM215065SP
Strainer	265983SP
Temperature sensor long	278286SP
Temperature sensor short	278287SP

Table 47 Accessories

Accessory	Item Code
USB adapter for service port, for Insight service software (see www.vaisala.com/insight)	USB2
Instrument cable, 2×2×0.5 mm^2 (AWG 21), PUR jacket, grey, open ends, 10 m, Flame-retardant acc. to IEC 60332-1-2, FT1, VW1	CBL211266-10M
Instrument cable, 2×2×0.5 mm^2 (AWG 21), PUR jacket, grey, open ends, 30 m, Flame-retardant acc. to IEC 60332-1-2, FT1, VW1	CBL211266-30M
Instrument cable, 2×2×0.5 mm^2 (AWG 21), PUR jacket, grey, open ends, 50 m, Flame-retardant acc. to IEC 60332-1-2, FT1, VW1	CBL211266-50M
Cooling Cover	ASM214675SP
Verification kit (5 pcs): 1.33, 1.37, 1.42, 1.47, 1.52	280380SP
Calibration kit (14 pcs): 1.32, 1.33, 1.35, 1.36, 1.37, 1.38, 1.40, 1.42, 1.45, 1.47, 1.50, 1.52, 1.53, 1.57	278292SP
High-range special kit (8 pcs): 1.42, 1.47, 1.53, 1.57, 1.60, 1.62, 1.67, 1.72	278293SP

Accessory	Item Code
Sampler holder and cover	278295SP

For PR53S accessories, see PR53S specifications (page 111).

12.12 Recycling instructions

These recycling instructions guide you on the end-of-life treatment of this Vaisala product. As waste regulations and infrastructure vary in each country, these instructions only indicate the different components to be separated and common ways to handle them. Always follow local requirements when disposing of the product. Vaisala encourages to use the best available recycling practices to minimize related environmental impacts.

Vaisala is committed to meeting the requirements of the EU Waste Electrical and Electronic Equipment (WEEE) Directive. This directive aims to minimize the impact of electrical and electronic goods on the environment, by increasing reuse and recycling, and reducing the amount of WEEE going to landfill. This symbol indicates that the product should be collected separately from other waste streams and treated appropriately.

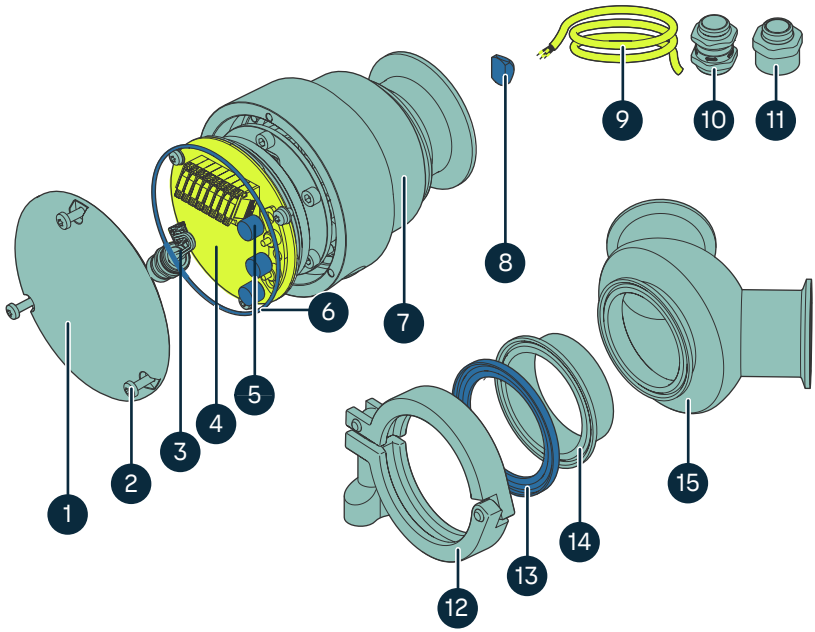


Figure 41 Materials for recycling PR53 and flow cells

Table 48 Materials for recycling PR53 and flow cells

	Part	Material	Recycling
1	Cover	Stainless steel	Metal waste
2	Screws and washers	Stainless steel	Metal waste
3	M12 connector	Various	Metal waste
4	Electronics	Various	Electrical and electronic waste
5	Drying capsules	Various	Other
6	O-rings	FPM	Other
7	Enclosure	Stainless steel	Metal waste
8	Prism	Sapphire	Other
9	Cables	Various	Electrical and electronic waste
10	Cable gland	Various	Metal waste
11	Conduit hub	Various	Metal waste
12	Clamps	Stainless steel	Metal waste
13	Gaskets	Various	Other
14	Ferrule	Stainless steel	Metal waste
15	Flow cells	Stainless steel	Metal waste

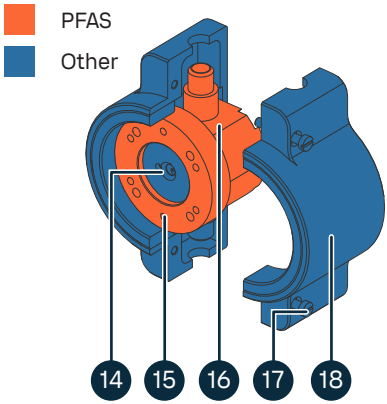


Figure 42 Materials for recycling PR53M

Table 49 Materials for recycling PR53M

	Part	Material	Recycling
14	PR53M sapphire plate	Sapphire	Other
15	PR53M head ring	PVDF	PFAS
16	PR53M flow cell	PTFE	PFAS
17	PR53M screws	PEEK	Other
18	PR53M light cover	PP-C	Other

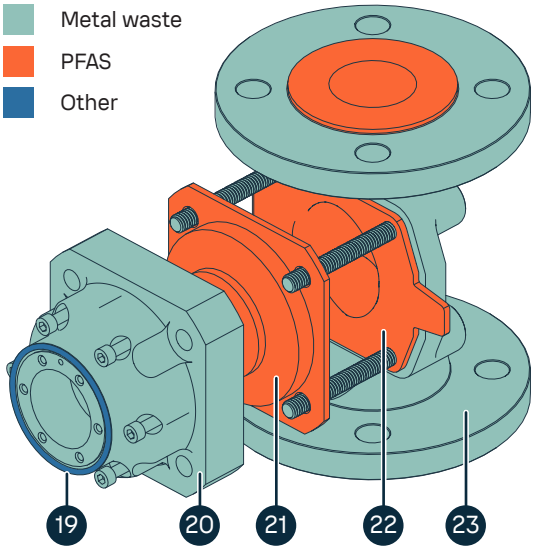


Figure 43 Materials for recycling PR53W

Table 50 Materials for recycling PR53W

	Part	Material	Recycling
19	O-rings	FPM	PFAS
20	PR53W body	Stainless steel	Metal waste
21	PR53 lining	PTFE	PFAS
22	Saunders lining	ETFE	PFAS
23	Saunders body	SG iron	Metal waste

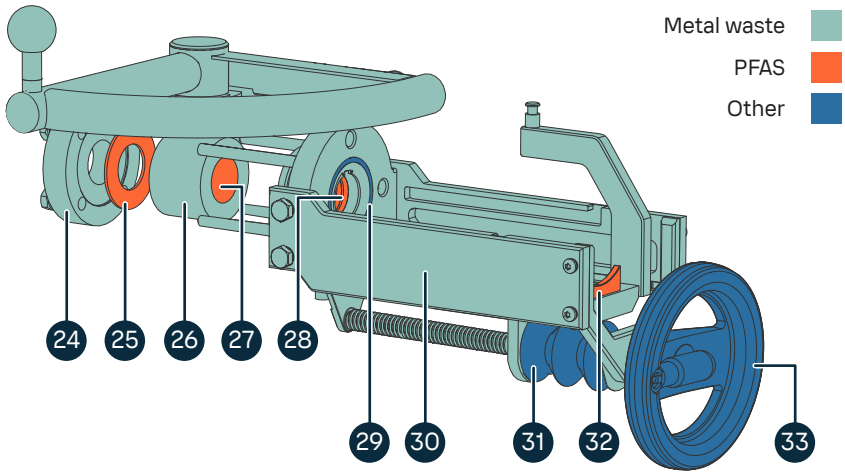


Figure 44 Materials for recycling PR53 SDI5

Table 51 Materials for recycling PR53 SDI5

	Part	Material	Recycling
24	Welding flange	Stainless steel	Metal waste
25	Spacer (retro fit only)	PTFE	PFAS
26	Isolation valve and handle	Stainless steel	Metal waste
27	Lining	PTFE	PFAS
28	Lining	PTFE	PFAS
29	O-rings	EPDM	Other
30	Retractor	Stainless steel	Metal waste
31	Rubber bellow	EPDM	Other
32	Support	PTFE	PFAS
33	Hand wheel	PP (polypropylene)	Other

13. Spare part instructions

13.1 Replacing 2.5" EPDM gasket

Follow these instructions to replace the 2.5″ EPDM gasket in PR53 refractometers and flow cells.

- Gasket 2.5″ EPDM (Vaisala item 278220SP)
- Wrenches of different sizes

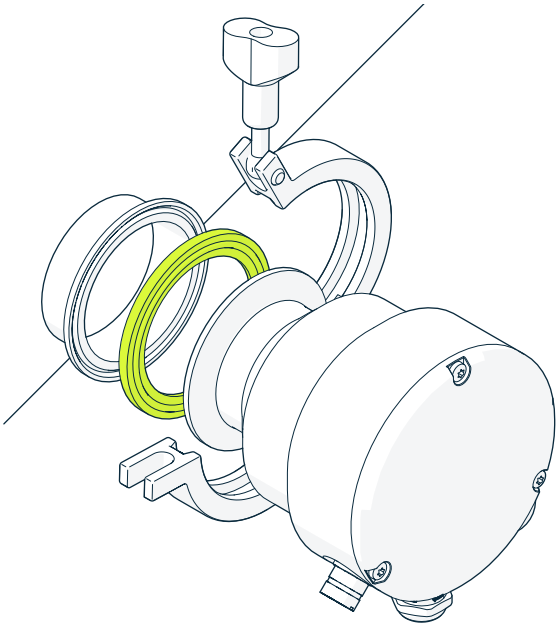


Figure 45 Installing 2.5″ EPDM gasket to PR53AC refractometer

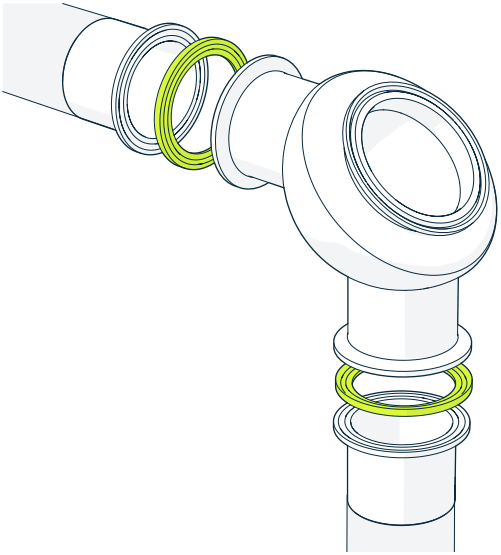
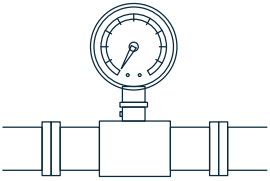


Figure 46 Installing 2.5″ EPDM gasket to flow cells

1. Familiarize yourself with the safety instructions of the installation site.
2. Make sure the process line is depressurized and empty.



3. Open the clamp or clamps holding the refractometer or flow cell in place.
4. Replace the gasket.

> **CAUTION!** The old gasket can be hard to remove. To avoid damaging the sealing surface, do not use sharp tools for removing or installing the gaskets.

5. Reinstall the refractometer with clamps.
6. Keep the material certificates delivered with the spare part for later use.
7. Recycle removed parts according to the recycling instructions in PR53 Series User Guide (M212898EN).

13.2 Replacing non-return valve for PR53GP

Follow these instructions to replace the non-return valve in PR53GP refractometer.

- Non-return valve (Vaisala item 278021SP)
- 9/16 in wrench
- PTFE-tape

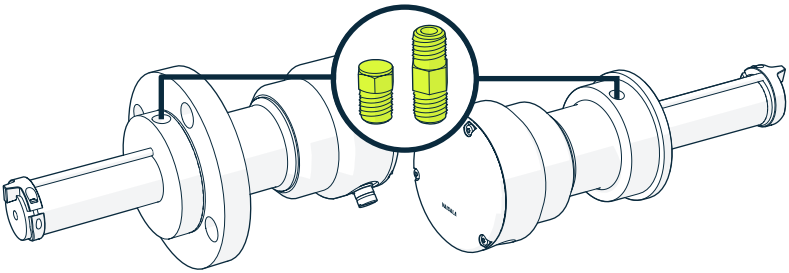
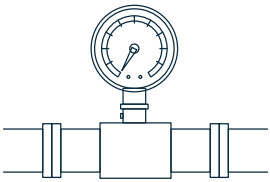


Figure 47 Installing non-return valve to PR53GP wash connection.

1. Familiarize yourself with the safety instructions of the installation site.
2. Make sure the process line is depressurized and empty.



3. Remove the old non-return valve.
4. Clean the threads with a brush to remove any remaining PTFE-tape.
5. Add 2-3 rounds of PTFE-tape to the threads of the new non-return valve.

6. Install the non-return valve. Make sure you install it according to the flow direction. Tighten using a 9/16 in wrench.

CAUTION! Be careful not to over-tighten.

7. Make sure there is no leaking after restarting the process. Tighten connection if needed.
8. Keep the material certificates delivered with the spare part for later use.
9. Recycle removed parts according to the recycling instructions in PR53 Series User Guide (M212898EN).

13.3 Replacing isolation valve for PR53SD Safe-Drive system

Follow these instructions to replace the isolation valve for PR53SD Safe-Drive system.



Wear protective eyewear, gloves, safety helmet, and safety shoes during installation and maintenance work.

WARNING! Follow local and state legislation and regulations on occupational safety.

WARNING! If you have a wash system in place or are planning to install a wash system, make sure to familiarize yourself with safety regulations related to hot steam and water. For more details, see the related wash system user guide.

WARNING! Process refractometers may be installed in processes that have hot, cold, caustic, or otherwise hazardous liquids. When installing or removing the refractometer from the process, use personal protective equipment (PPE) adequate for the process medium and according to the requirements of the installation site.

- Isolation valve (Vaisala item 275267SP)
- 16-mm wrench
- 27-mm wrench

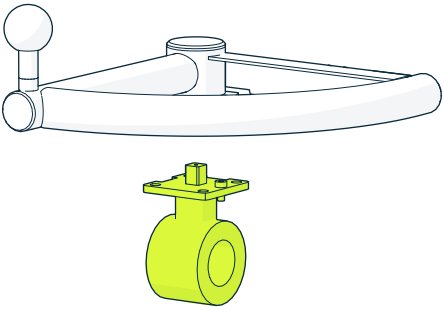
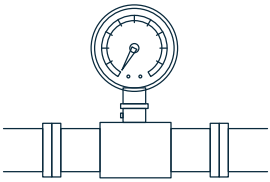


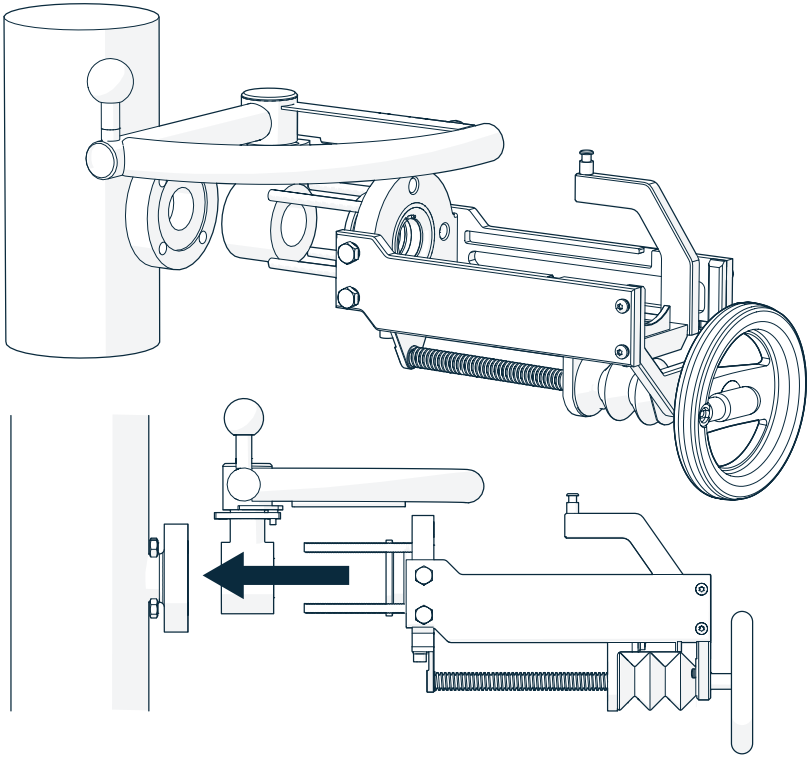
Figure 48 PR53SD isolation valve spare part

1. Familiarize yourself with the safety instructions of the installation site.
2. Make sure the process line is depressurized and empty.



3. Remove the refractometer from the process. See PR53SD and SDI5 Installation Guide (M212953EN).
4. Remove the protection caps from the bolts. Keep them for later use.
5. Remove the retractor and old isolation valve. Loosen the bolts using a 16-mm wrench.
6. Remove the valve handle with a 27-mm wrench and keep it for later use.
7. Install the handle into the new isolation valve. Tighten to 75 Nm using a 27-mm wrench.

8. Install the new isolation valve with the retractor. Align the isolation valve and retractor with the welded connection. Make sure the isolation valve is closed as shown in the figure. Two persons are required for the installation. It is recommended that the valve handle is pointing upward.



CAUTION! If you are using the retrofit mounting kit, make sure the flange adapters and spacer stay in place when installing the new isolation valve.

9. Cross-tighten the bolts to 27 Nm using a 16-mm wrench. Hold the equipment level while tightening.

CAUTION! Be careful not to over-tighten. Using the ball valve will become difficult if the connections are too tight.

10. Install protection caps over the nuts. This prevents incorrect usage when the refractometer is retracted.
11. Make sure all connections are properly tightened.
12. Install the refractometer. See PR53SD and SDI5 Installation Guide (M212953EN).
13. Recycle removed parts according to the recycling instructions.

More information

- Recycling instructions (page 117)

13.4 Replacing PR53 desiccant capsules

Follow these instructions to replace the PR53 desiccant capsules.

- Desiccant capsules (6 pcs)(Vaisala item 238440SP)
- TX20 Torx key
- TX10 Torx key

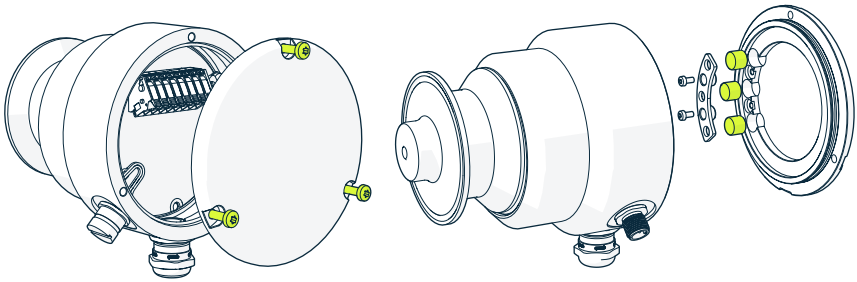


Figure 49 Replacing PR53 desiccant capsules

1. Familiarize yourself with the safety instructions of the installation site.
2. Loosen the screws on the refractometer cover with a TX20 Torx key. Be careful not to drop the bolts. Keep the bolts for later use.
3. Loosen the screws on the desiccant capsule holder using a TX10 Torx key.
4. Remove 3 old desiccant capsules.
5. Install 3 new desiccant capsules.
6. Reinstall the desiccant capsule holder. Tighten the screws to 0.7 Nm with a TX10 Torx key.
7. Reinstall the refractometer cover. Tighten the screws to 2 Nm using a TX20 Torx key. Be careful not to overtighten. The screws may break.

8. Recycle removed parts according to the recycling instructions in PR53 Series User Guide (M212898EN).

13.5 Replacing SWS100 steam hose

Follow these instructions to replace the steam hose in the steam wash system (SWS100).

WARNING! If you have a wash system in place or are planning to install a wash system, make sure to familiarize yourself with safety regulations related to hot steam and water. For more details, see the related wash system user guide.

WARNING! Process refractometers may be installed in processes that have hot, cold, caustic, or otherwise hazardous liquids. When installing or removing the refractometer from the process, use personal protective equipment (PPE) adequate for the process medium and according to the requirements of the installation site.

- Steam hose (Vaisala item ASM215065SP)
- 9/16 in wrench
- PTFE-tape

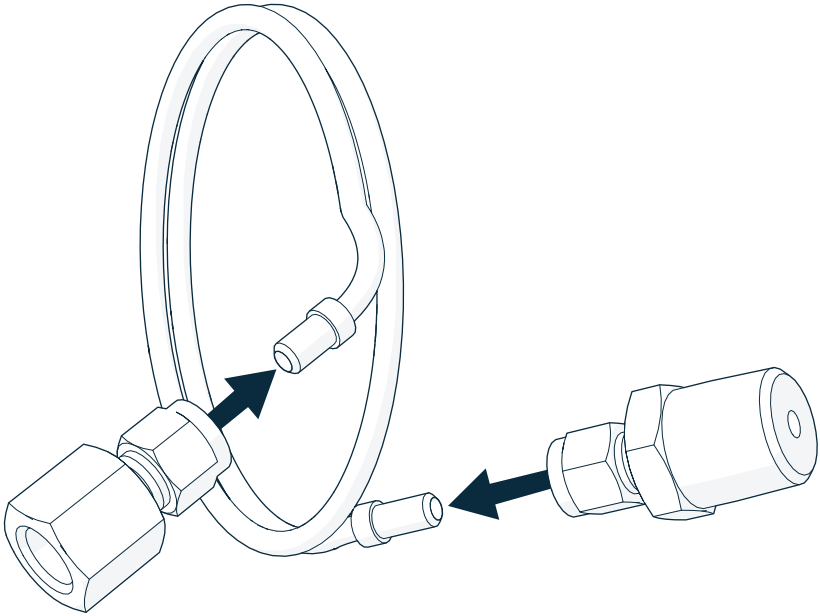
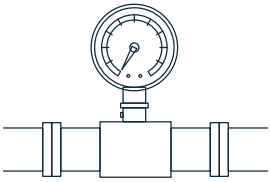


Figure 50 SWS100 steam hose

1. Familiarize yourself with the safety instructions of the installation site.
2. Make sure the process line is depressurized and empty.



3. Remove the old steam hose between SWS100 and the steam valve.
4. Clean the threads with a brush to remove any remaining PTFE-tape.
5. Add 2-3 rounds of PTFE-tape to the threads of the new steam hose.

6. Install the new steam hose. Tighten using a 9/16 in wrench.

> **CAUTION!** Be careful not to over-tighten.

7. Recycle removed parts according to the recycling instructions in PR53 Prism Wash System User Guide (M212808EN).

13.6 Replacing PR53SD shut-off steam valve

Follow these instructions to replace the ball valve used as a shut-off steam valve in PR53SD wash systems.

> **WARNING!** If you have a wash system in place or are planning to install a wash system, make sure to familiarize yourself with safety regulations related to hot steam and water. For more details, see the related wash system user guide.

> **WARNING!** Process refractometers may be installed in processes that have hot, cold, caustic, or otherwise hazardous liquids. When installing or removing the refractometer from the process, use personal protective equipment (PPE) adequate for the process medium and according to the requirements of the installation site.

- Shut-off steam valve (Vaisala item 277082SP)
- 9/16 in wrench
- PTFE-tape

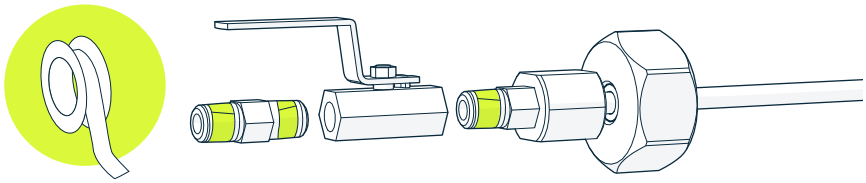
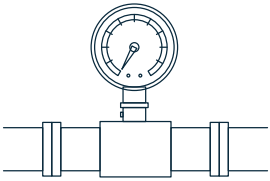


Figure 51 Shut-off steam valve for PR53SD wash system

1. Familiarize yourself with the safety instructions of the installation site.

2. Make sure the process line is depressurized and empty.



3. Remove the old shut-off steam valve using a 9/16 in wrench.
4. Clean the threads with a brush to remove any remaining PTFE-tape.
5. Add 2-3 rounds of PTFE-tape to the threads of the new valve.
6. Install the new valve. Tighten using 9/16 in wrench.

CAUTION! Be careful not to over-tighten.

7. Make sure all connections are properly tightened.
8. Recycle removed parts according to the recycling instructions in PR53 Prism Wash System User Guide (M212808EN).

13.7 Replacing SWS100 strainer

Follow these instructions to replace the strainer for SWS100 steam wash system.

- Strainer (Vaisala item 276373SP)
- 1 ¼ in wrench
- PTFE-tape
- Brush

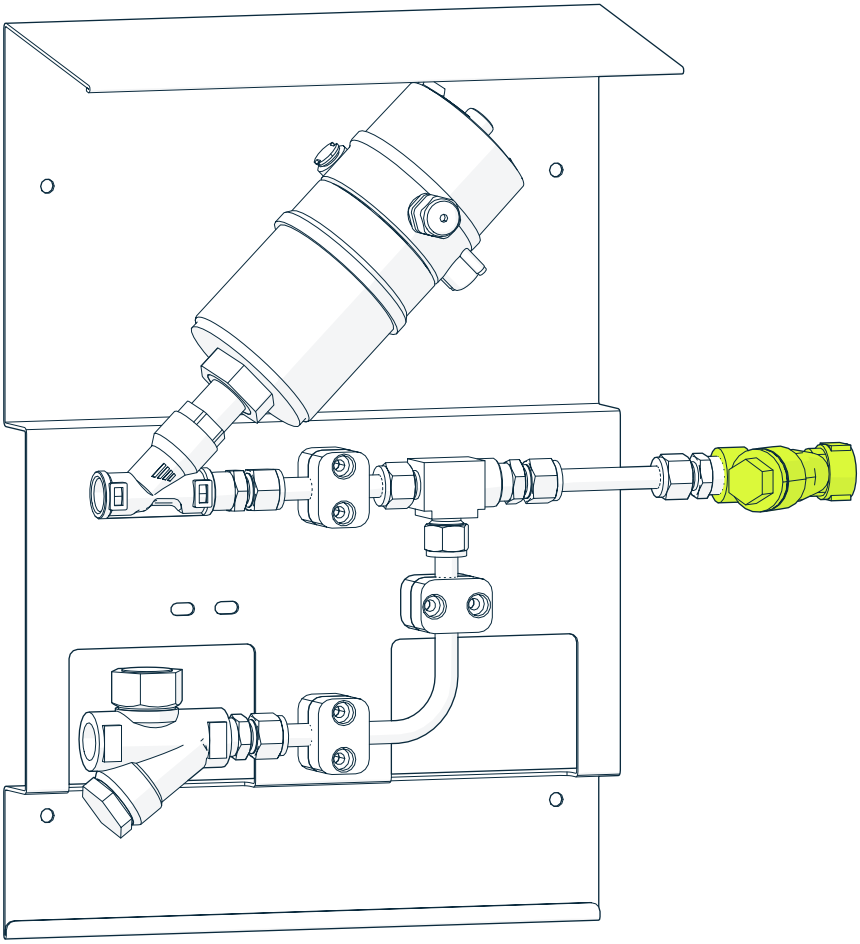
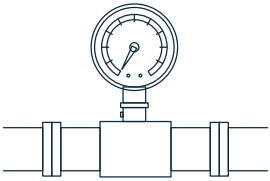


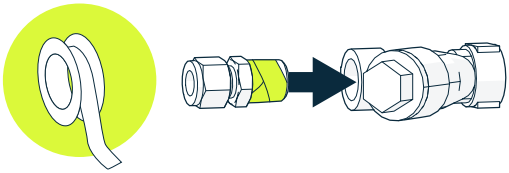
Figure 52 SWS100 strainer spare part

1. Familiarize yourself with the safety instructions of the installation site.

2. Make sure the process line is depressurized and empty.



3. Remove the old strainer. Loosen it using a 1 ¼ in wrench.
4. Clean the threads with a brush to remove any remaining PTFE-tape.
5. Add 2-3 rounds of PTFE-tape to the threads of the new strainer.



6. Install the new strainer. Tighten using a 1 ¼ in wrench.

> **CAUTION!** Be careful not to over-tighten.

7. Recycle removed parts according to the recycling instructions in PR53 Prism Wash System User Guide (M212808EN).

13.8 SDI5 wash nozzle removal and insertion overview

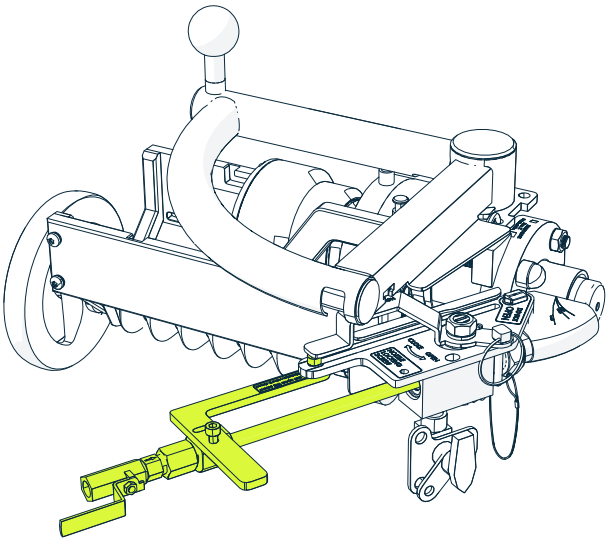


Figure 53 SDI5 wash nozzle retracted from wash connection

Follow these instructions to remove and insert the SDI5 wash nozzle.

- For instructions on removing the wash nozzle, see Removing SDI5 wash nozzle (page 138).
- For instructions on inserting the wash nozzle, see Inserting SDI5 wash nozzle (page 145).
- For instructions on attaching the wash nozzle assembly to the wash connection, see Installing wash connection (page 151).

Note the following warnings when extracting or inserting the wash nozzle.

WARNING! Depressurize and isolate the water/steam line to the wash nozzle before performing maintenance on the wash nozzle or its isolation valve assembly.

WARNING! The wash nozzle is sealed by radial shaft seals that may leak during operation of the wash nozzle. Use suitable personal protective equipment (PPE) and take other necessary safety precautions.

WARNING! Process refractometers may be installed in processes that have hot, cold, caustic, or otherwise hazardous liquids. When installing or removing the refractometer from the process, use personal protective equipment (PPE) adequate for the process medium and according to the requirements of the installation site.

WARNING! If you have a wash system in place or are planning to install a wash system, make sure to familiarize yourself with safety regulations related to hot steam and water. For more details, see the related wash system user guide.

WARNING! Surfaces on the equipment are hot. Use suitable personal protective equipment (PPE).

CAUTION! Operate the wash nozzle isolation valve with single hand only, do not apply greater force or use impact on the lever.

13.8.1 SDI5 wash nozzle assembly parts

The illustration below shows the parts of the wash nozzle assembly with the wash nozzle inserted. Items 8– 10 show how the ball valve for the wash hose connection is inserted: the ball valve is included as a separate part in the SDI5 wash nozzle assembly delivery package.

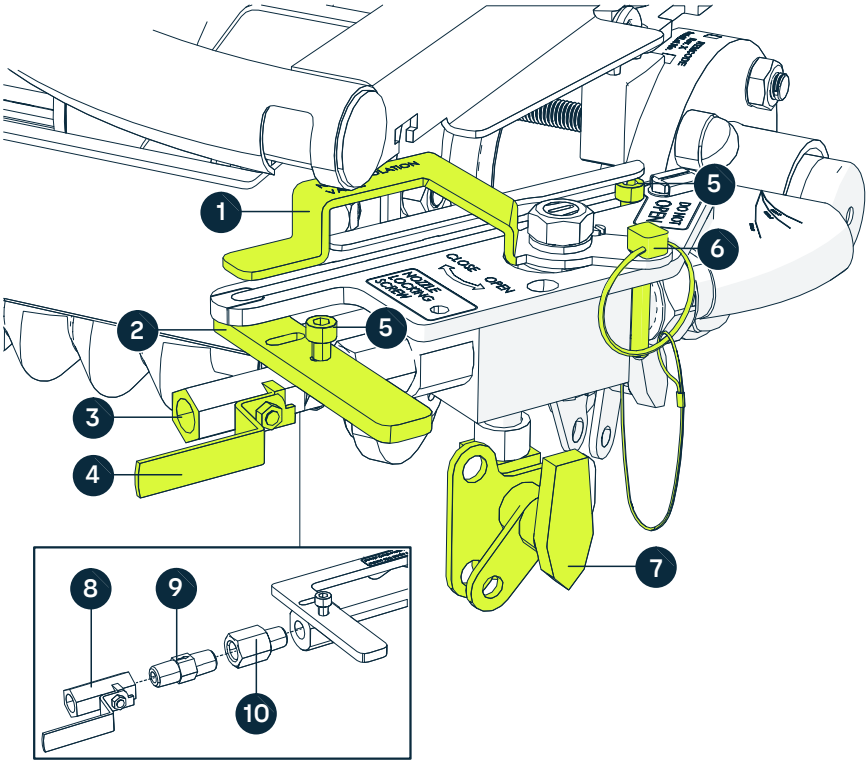


Figure 54 SDI5 wash nozzle parts

1 Wash isolation valve handle
2 Wash nozzle handle
3 Wash nozzle fitting
4 Shut-off steam/water valve
5 Nozzle locking screw (2 pcs). These screws prevent the wash nozzle from ejecting under pressure when the valve is open.
6 Wash isolation valve handle safety pin
7 Bleed valve
8 Ball valve for the wash hose connection (included as a separate part). Ball valve thread type: 1/4" NPT female.
9 Check valve (1/4" NPT male)
10 Thread adapter (NPT female - ISO male 1/4")

13.8.2 Removing SDI5 wash nozzle

Follow these instructions to remove the SDI5 wash nozzle assembly. For instructions on replacing the wash nozzle assembly after it has been removed, see Inserting SDI5 wash nozzle (page 145).

WARNING! Depressurize and isolate the water/steam line to the wash nozzle before performing maintenance on the wash nozzle or its isolation valve assembly.

WARNING! The wash nozzle is sealed by radial shaft seals that may leak during operation of the wash nozzle. Use suitable personal protective equipment (PPE) and take other necessary safety precautions.

WARNING! Process refractometers may be installed in processes that have hot, cold, caustic, or otherwise hazardous liquids. When installing or removing the refractometer from the process, use personal protective equipment (PPE) adequate for the process medium and according to the requirements of the installation site.

WARNING! If you have a wash system in place or are planning to install a wash system, make sure to familiarize yourself with safety regulations related to hot steam and water. For more details, see the related wash system user guide.

WARNING! Surfaces on the equipment are hot. Use suitable personal protective equipment (PPE).

CAUTION! Operate the wash nozzle isolation valve with single hand only, do not apply greater force or use impact on the lever.

- SDI5 steam or water wash nozzle assembly:
  - Steam wash nozzle, Vaisala item code PR-11023
  - Water wash nozzle, Vaisala item code PR-11024

Required tools (not included in delivery):

- 9/16 in wrench for wash system hose (if using Vaisala wash system hose)
- 5-mm Allen key for nozzle locking screws

The illustration below shows the parts of the wash nozzle assembly with the wash nozzle inserted. Items 8– 10 show how the ball valve for the wash hose connection is inserted: the ball valve is included as a separate part in the SDI5 wash nozzle assembly delivery package.

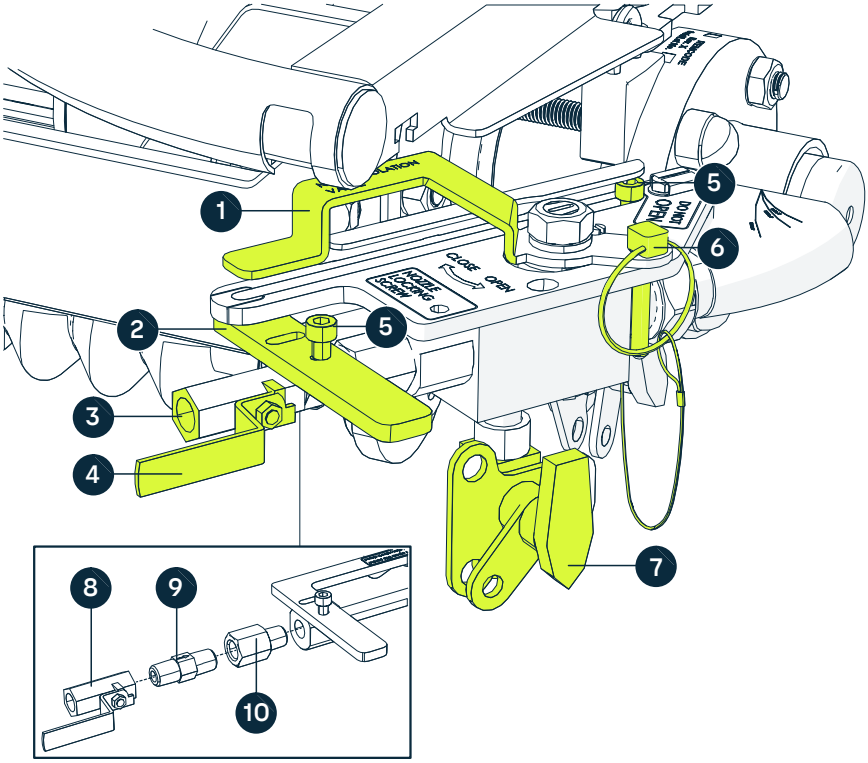
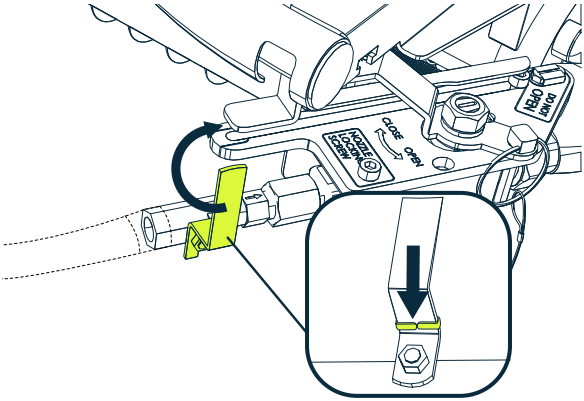


Figure 55 SDI5 wash nozzle parts

1 Wash isolation valve handle
2 Wash nozzle handle
3 Wash nozzle fitting
4 Shut-off steam/water valve
5 Nozzle locking screw (2 pcs). These screws prevent the wash nozzle from ejecting under pressure when the valve is open.
6 Wash isolation valve handle safety pin
7 Bleed valve
8 Ball valve for the wash hose connection (included as a separate part). Ball valve thread type: 1/4” NPT female.
9 Check valve (1/4” NPT male)
10 Thread adapter (NPT female - ISO male 1/4”)

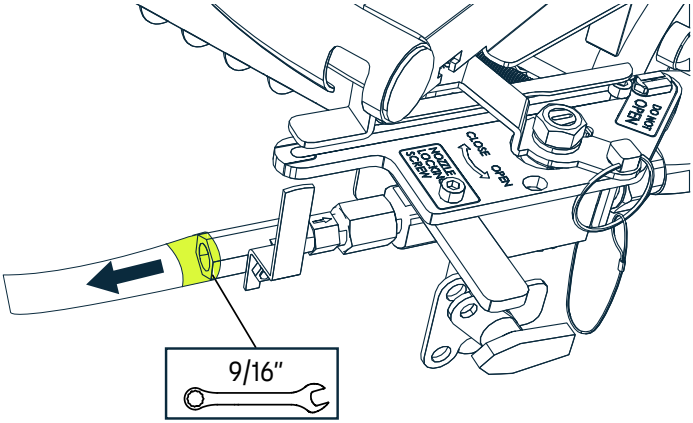
1. Familiarize yourself with the safety instructions of the installation site.
2. Close the shut-off valve to stop steam/water delivery to wash nozzle.



Ensure that the safety latch of the valve handle is closed (pushed down on the handle).

WARNING! Always shut the main water/steam valve before performing any work on the wash nozzle.

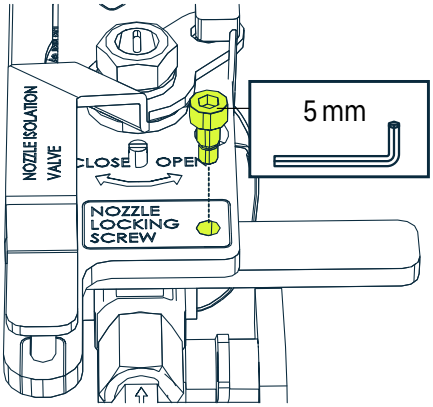
3. Disconnect the wash system hose. When using a Vaisala wash system hose, the connection is opened with a 9/16 in wrench.



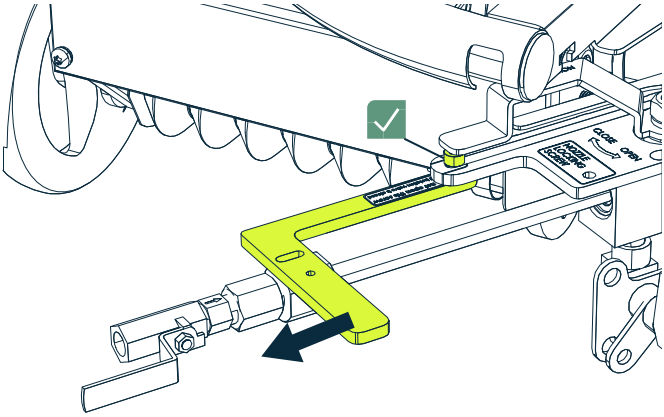
NOTE: This step is not necessary if you continue to use the same wash nozzle and wash system hose. You only need to disconnect the wash system hose if you are connecting a new wash nozzle to it.

WARNING! Process fluid may leak through the nozzle in case of worn check valve/shut-off valve.

4. Loosen the screw on the wash nozzle handle with a 5-mm Allen key to allow detaching the handle from the wash system frame. Detach the screw and store it in a secure location.



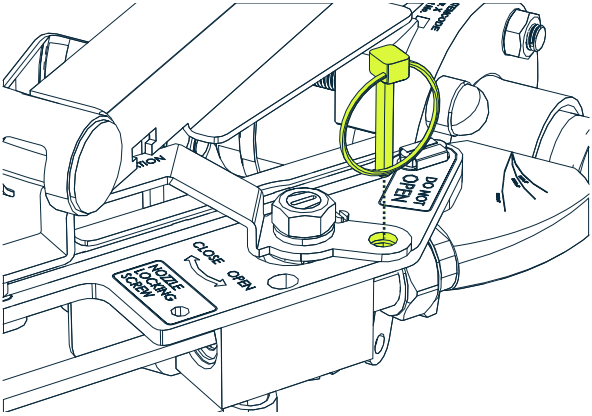
5. Pull the wash nozzle handle out until the screw stops in the slot on the frame.



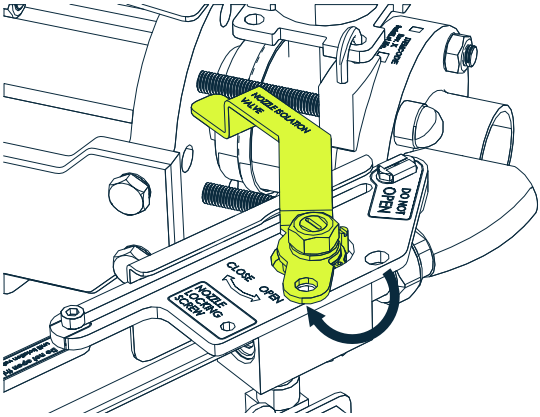
6. After pulling the nozzle out of the valve, check the valve for leaks.

> **WARNING!** If you notice leaks at any point in the installation, replace the valve seals in the next possible maintenance.

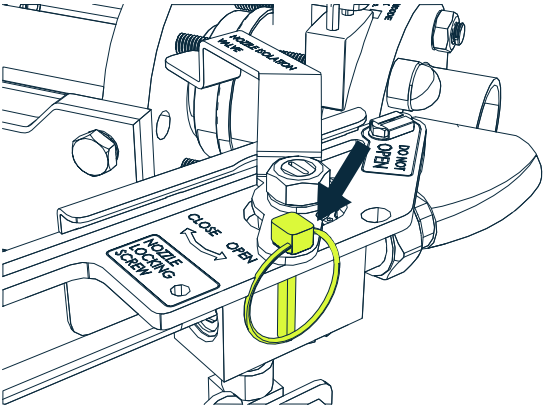
7. Pull out the safety pin from the isolation valve handle slot.



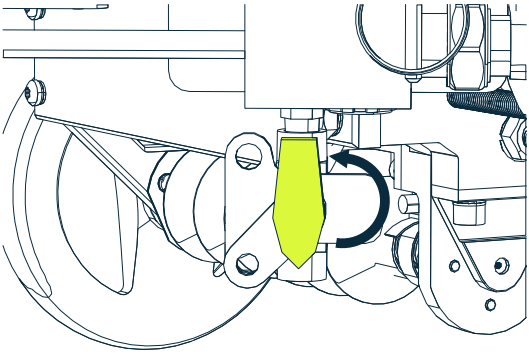
8. Turn the isolation valve handle into the closed position.



9. Lock the isolation valve handle in the closed position with the safety pin.

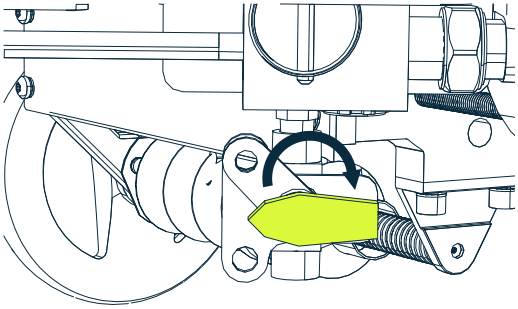


10. Open the wash nozzle assembly bleed valve to verify that the valve is isolated and there are no liquids in the wash nozzle assembly.

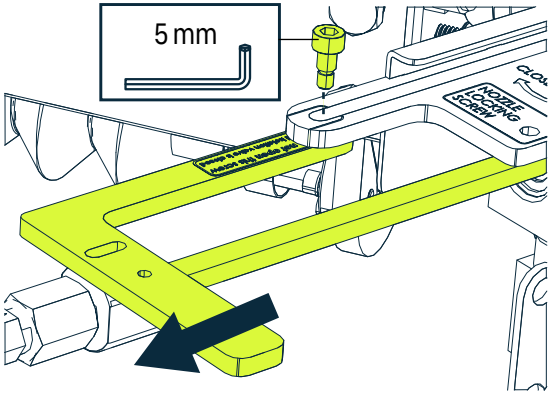


If there is liquid coming out of the bleed valve, check that the isolation valve is closed. If the isolation valve is closed and liquid continues to leak out of the bleed valve, push the wash nozzle back into the wash system. Do not remove the wash nozzle if liquid is leaking from the bleed valve.

11. If there is no liquid coming out of the bleed valve, close the bleed valve. Ensure that the bleed valve is in the closed position.



12. Open the screw on the wash nozzle frame and pull the wash nozzle out. Store the screw in a secure location after detaching it.



For instructions on replacing the wash nozzle assembly after it has been removed, see Inserting SDI5 wash nozzle (page 145).

13.8.3 Inserting SDI5 wash nozzle

Follow these instructions to insert the SDI5 wash nozzle assembly after it has been removed from the wash connection. For instructions on removing the wash nozzle assembly, see Removing SDI5 wash nozzle (page 138).

CAUTION! Operate the wash nozzle isolation valve with single hand only, do not apply greater force or use impact on the lever.

- SDI5 steam or water wash nozzle assembly:
  - Steam wash nozzle, Vaisala item code PR-11023
  - Water wash nozzle, Vaisala item code PR-11024

Required tools (not included in delivery):

- 9/16 in wrench for wash system hose (if using Vaisala wash system hose)
- 5-mm Allen key for nozzle locking screws

The illustration below shows the parts of the wash nozzle assembly with the wash nozzle pulled out. Items 8–10 show how the ball valve for the wash hose connection is inserted with the check valve and thread adapter. The ball valve is included as a separate part in the SDI5 wash nozzle assembly delivery package.

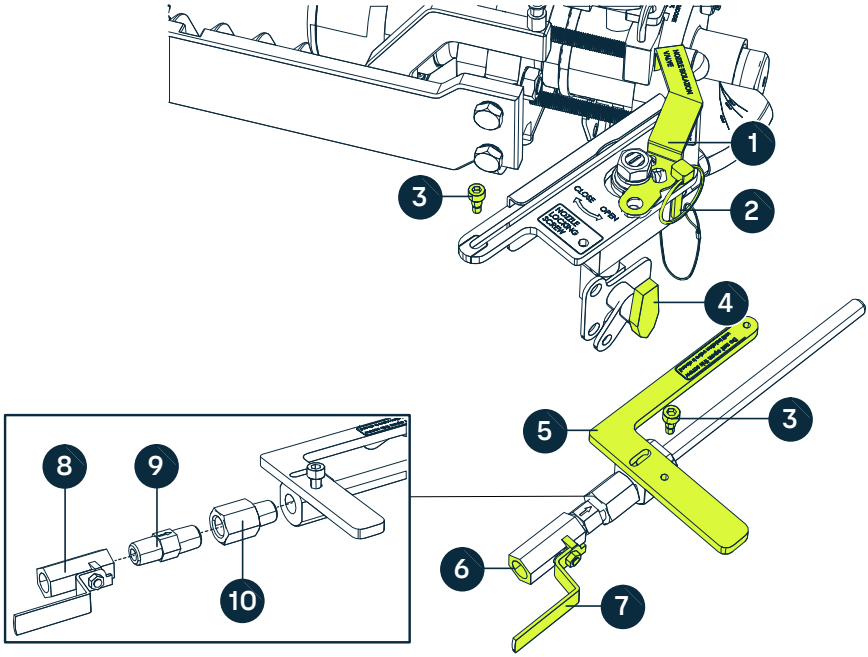
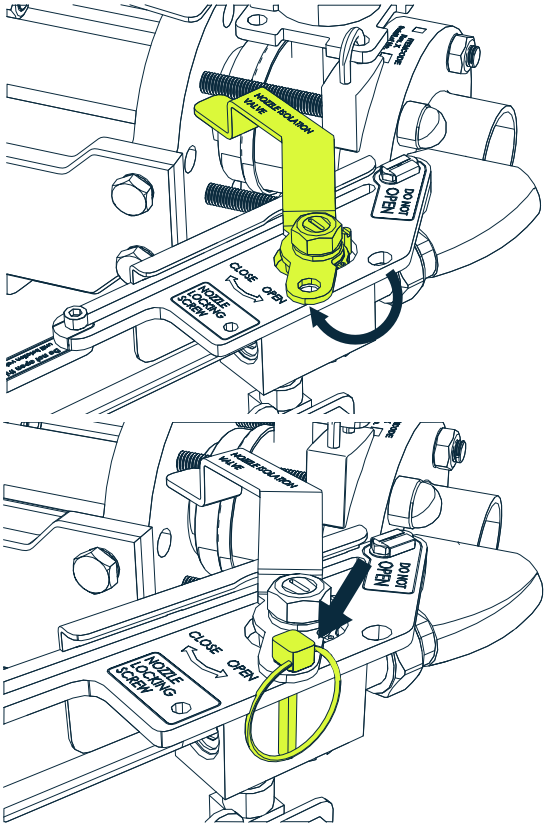


Figure 56 SDI5 wash nozzle parts overview with wash nozzle pulled out

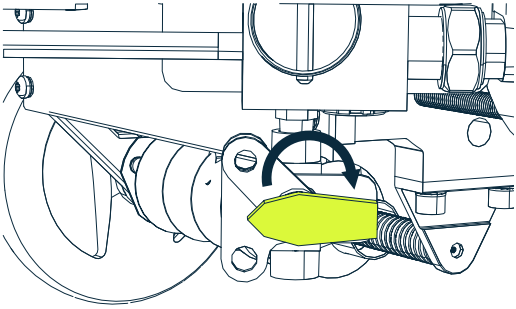
1 Wash isolation valve handle
2 Wash isolation valve handle safety pin
3 Nozzle locking screw (2 pcs). These screws prevent the wash nozzle from ejecting under pressure when the valve is open.
4 Bleed valve
5 Wash nozzle handle
6 Wash nozzle fitting
7 Shut-off steam/water valve
8 Ball valve for the wash hose connection (included as a separate part). Ball valve thread type: 1/4” NPT female.
9 Check valve (1/4” NPT male)
10 Thread adapter (NPT female - ISO male 1/4”)

1. Familiarize yourself with the safety instructions of the installation site.

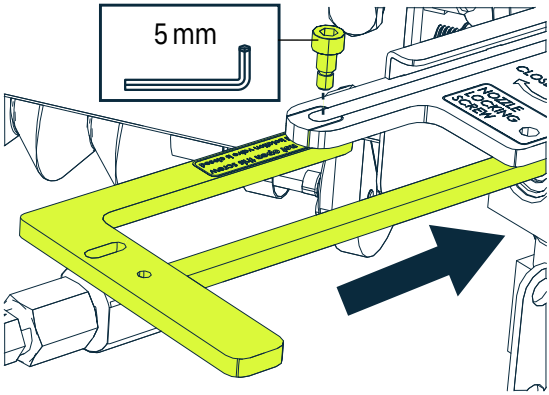
2. Ensure that the isolation valve handle is in the closed position and that the isolation valve handle safety pin is in its slot.



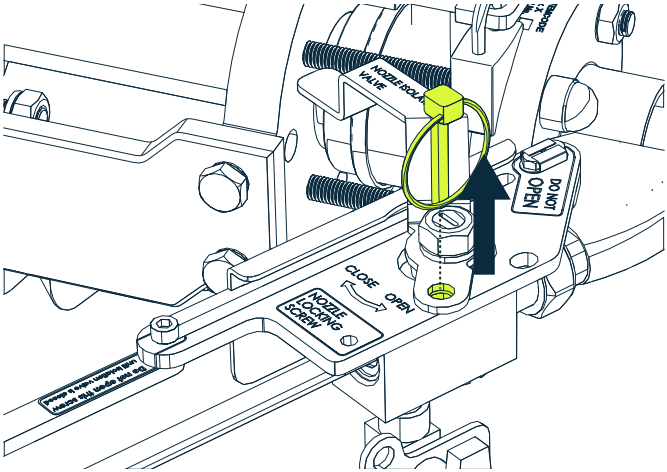
3. Ensure that the bleed valve is in the closed position.



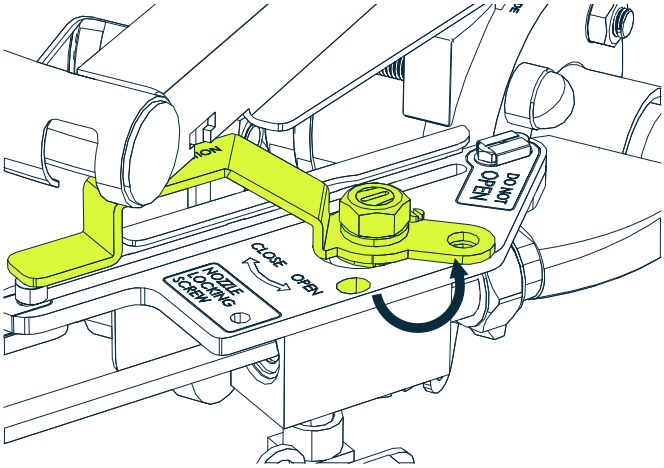
4. Insert the wash nozzle partially into the wash isolation valve so that the screw slot on the handle is aligned with the slot on the frame, and then attach the locking screw to the handle. Tighten to 5 Nm / tool tightness with a 5-mm Allen key.



5. Pull out the isolation valve handle safety pin.

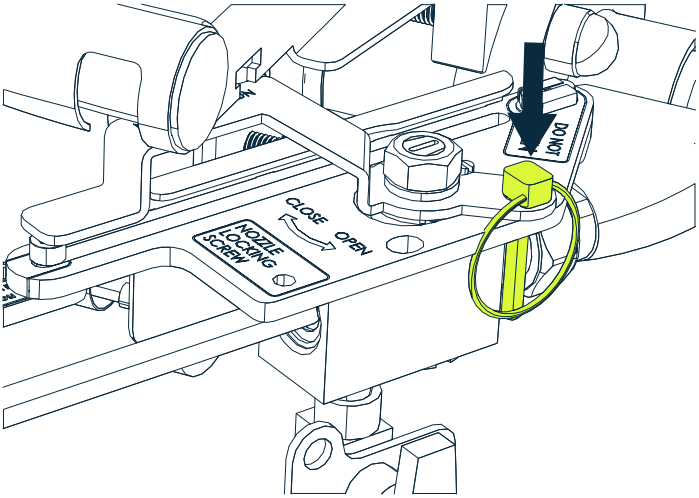


6. Carefully turn the isolation valve handle into the open position: monitor for any possible leaks while turning.

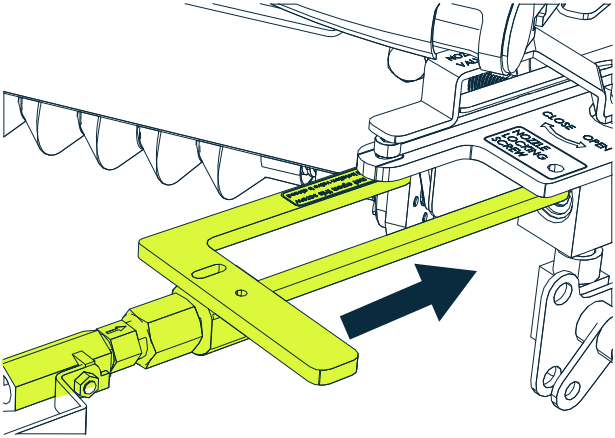


WARNING! If you notice leaking while turning the isolation valve handle open, close the handle and lock it in the closed position with the safety pin. Contact Vaisala support for instructions.

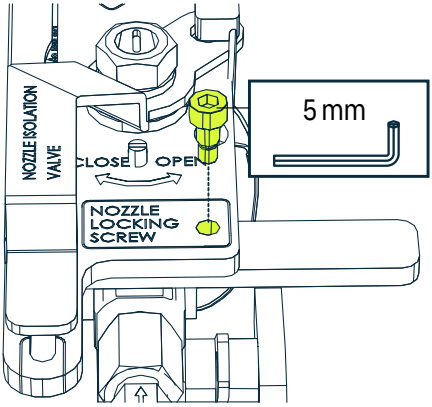
7. Lock the isolation valve handle in the open position with the safety pin.



8. Push the wash nozzle fully inside the isolation valve.

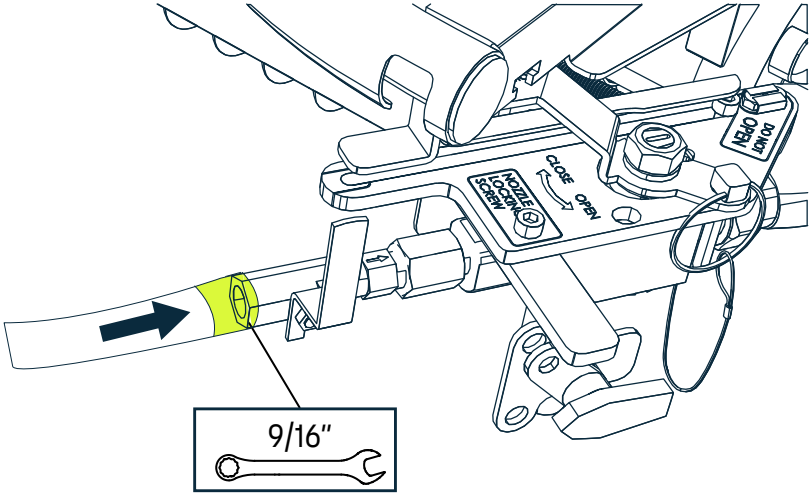


9. Close the nozzle locking screw. Tighten to 5 Nm / tool tightness with a 5-mm Allen key.

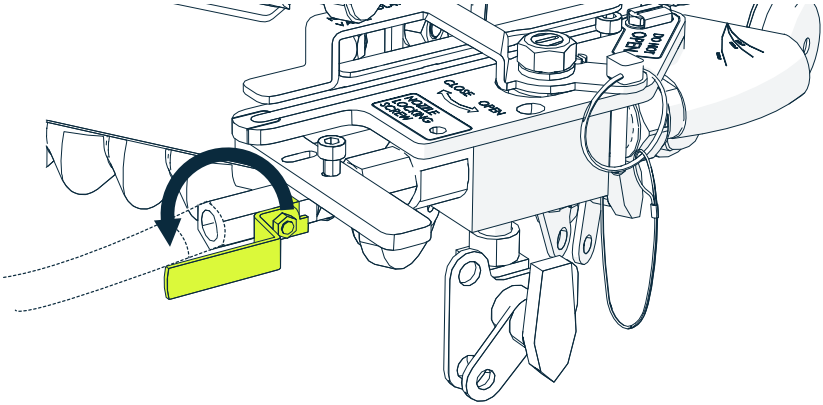


10. Add 2-3 rounds of PTFE tape to the threads of the new wash nozzle fitting,

11. Connect the hose to the wash nozzle fitting. When using the Vaisala fitting, tighten with a 9/16 in wrench.



12. Open the shut-off valve.



For instructions on removing the wash nozzle assembly, see Removing SDI5 wash nozzle (page 138).

13.9 Installing wash connection

Follow these instructions to install the SDI5 wash connection.

WARNING! Depressurize the process before performing maintenance on the wash nozzle or its isolation valve assembly.

WARNING! If you are not using a wash system, plug the wash connection.

CAUTION! Operate the wash nozzle isolation valve with single hand only, do not apply greater force or use impact on the lever.

Included in delivery:
- Bolts (2 pcs)
- Locking plate
- Isolation valve and nut
- Wash nozzle assembly
- Ball valve (thread type: 1/4 inch NPT female)

Required tools (not included in delivery):
- 5-mm Allen key
- 8-mm wrench
- 32-mm wrench
- 9/16 in wrench
- PTFE-tape
- Pliers

The illustration below shows the parts of the wash nozzle assembly with the wash nozzle inserted. Items 8– 10 show how the ball valve for the wash hose connection is inserted: the ball valve is included as a separate part in the SDI5 wash nozzle assembly delivery package.

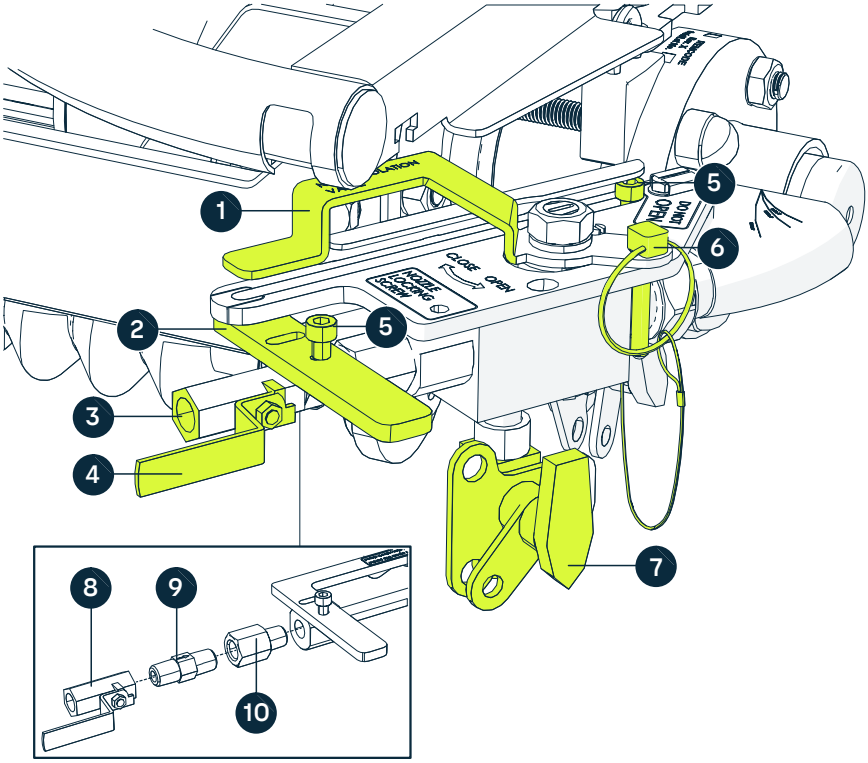
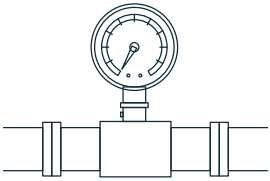


Figure 57 SDI5 wash nozzle parts

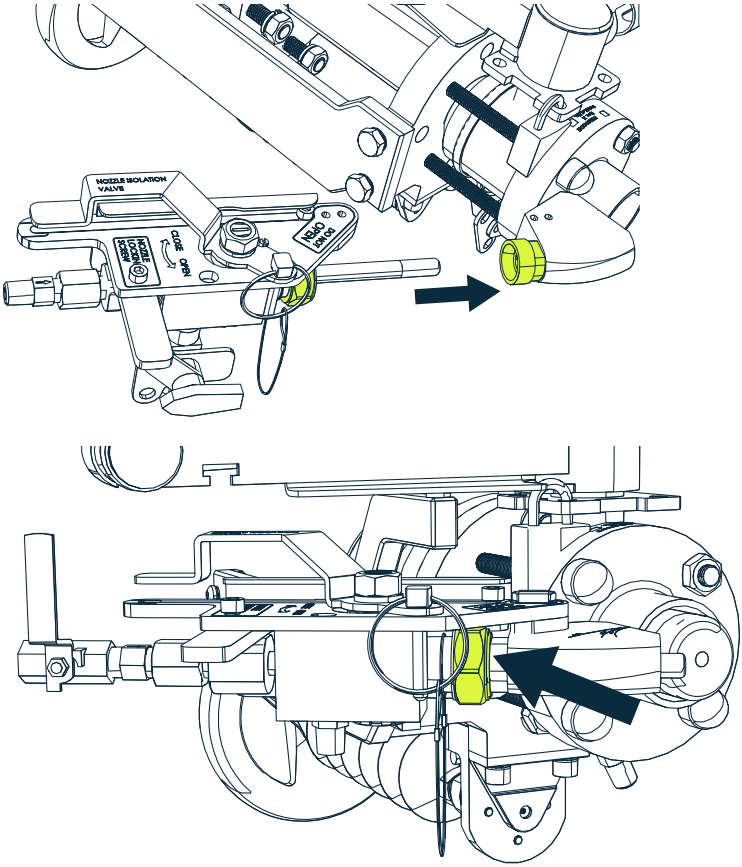
1 Wash isolation valve handle
2 Wash nozzle handle
3 Wash nozzle fitting
4 Shut-off steam/water valve
5 Nozzle locking screw (2 pcs). These screws prevent the wash nozzle from ejecting under pressure when the valve is open.
6 Wash isolation valve handle safety pin
7 Bleed valve
8 Ball valve for the wash hose connection (included as a separate part). Ball valve thread type: 1/4” NPT female.
9 Check valve (1/4” NPT male)
10 Thread adapter (NPT female - ISO male 1/4”)

1. Familiarize yourself with the safety instructions of the installation site.
2. Make sure the process line is depressurized and empty.



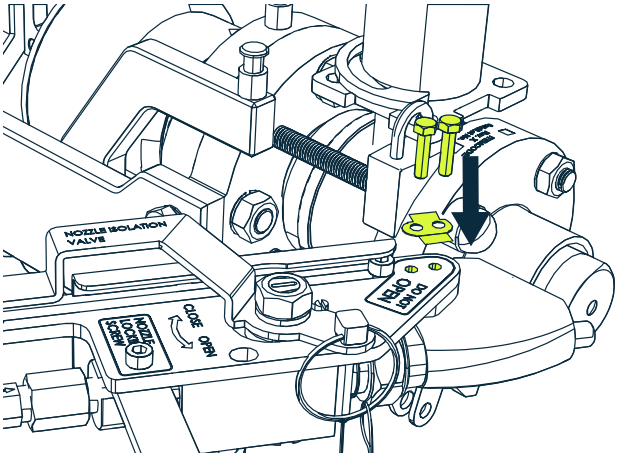
3. Ensure that the process shutoff valve is closed before working on the wash connection and the wash nozzle.

4. Connect the wash isolation valve assembly to the wash connection. Tighten the isolation valve nut to finger tightness.

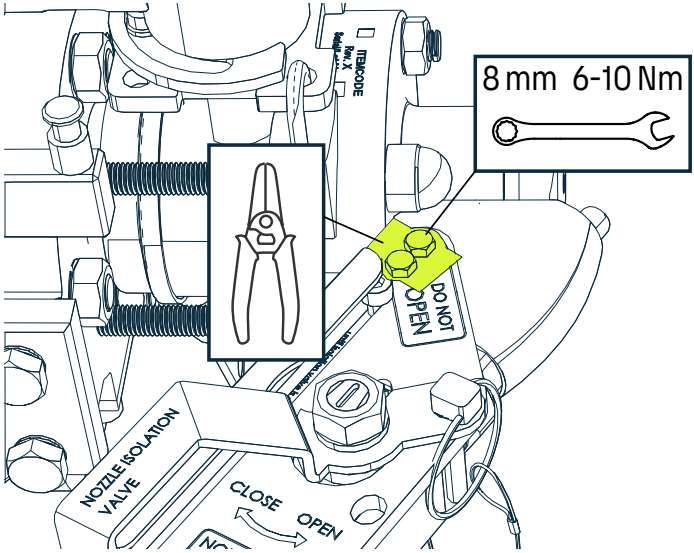


Make a visual check that the isolation valve assembly guide plate is parallel to the nozzle connection flat surface.

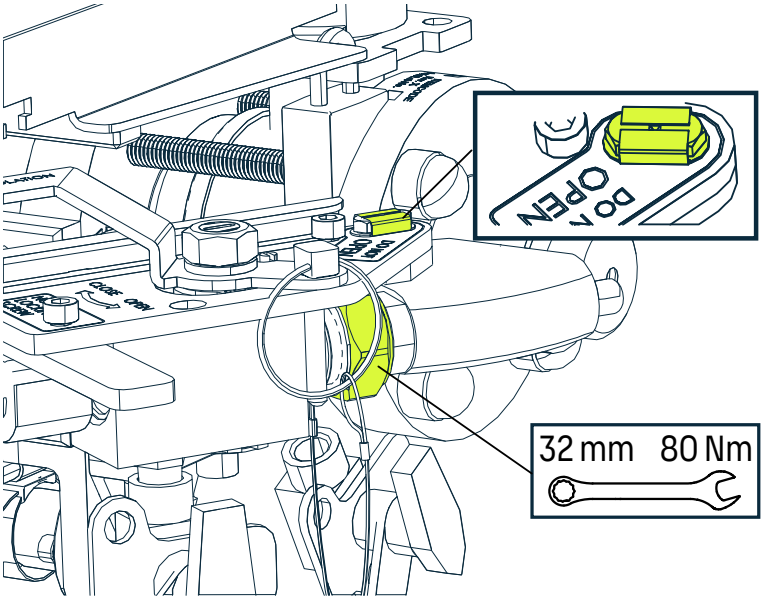
5. Attach the wash nozzle guide plate to the wash connection with 2 bolts. First place the bolt locking plate on top of the bolt holes, and then tighten the bolts to finger tightness.



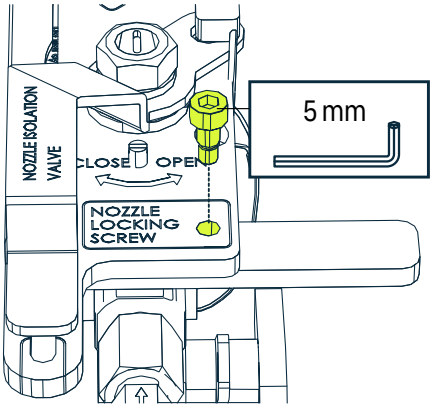
6. Fully tighten the 2 bolts that connect the wash nozzle handle rail to the wash connection. Tighten to 6–10 Nm using an 8-mm wrench or socket. After fully tightening the bolts, fold the locking plate over the bolts with pliers.



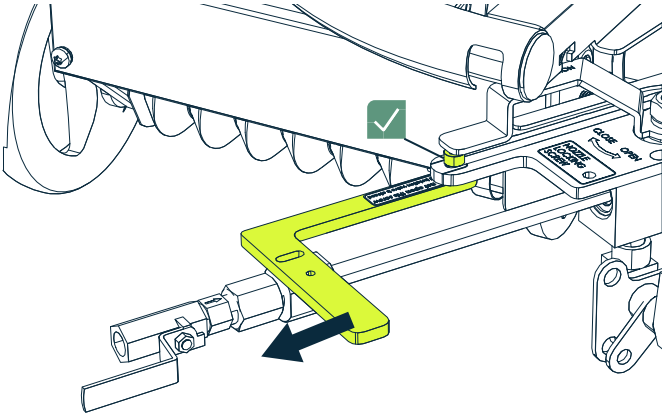
7. Fully tighten the isolation valve nut. Tighten to 80 Nm using a 32-mm (1.26-in) wrench.



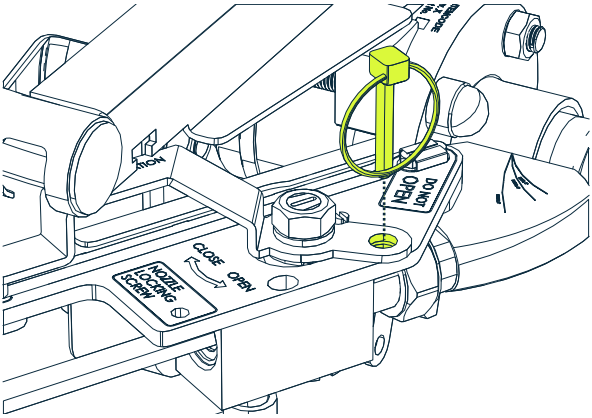
8. Check the operation of the nozzle retraction. Loosen the screw on the wash nozzle handle with a 5-mm Allen key to allow detaching the handle from the wash system frame. Detach the screw and store it in a secure location.



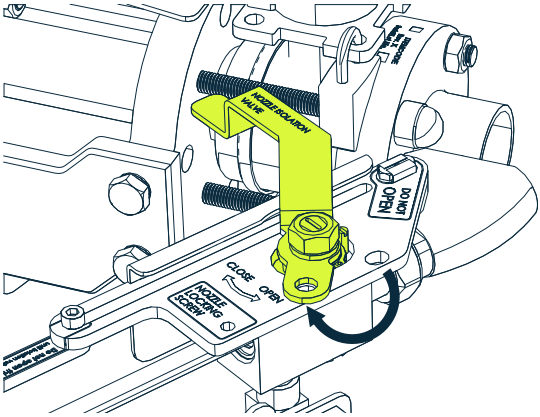
9. Pull the wash nozzle handle out until the screw stops in the slot on the frame.



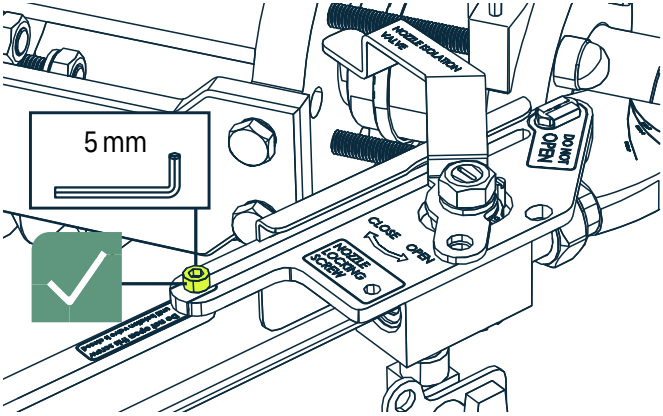
10. Pull out the safety pin from the isolation valve handle slot.



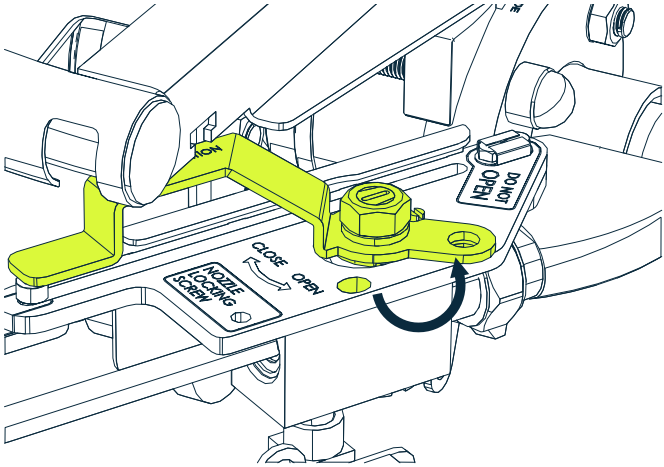
11. Turn the isolation valve handle into the closed position.



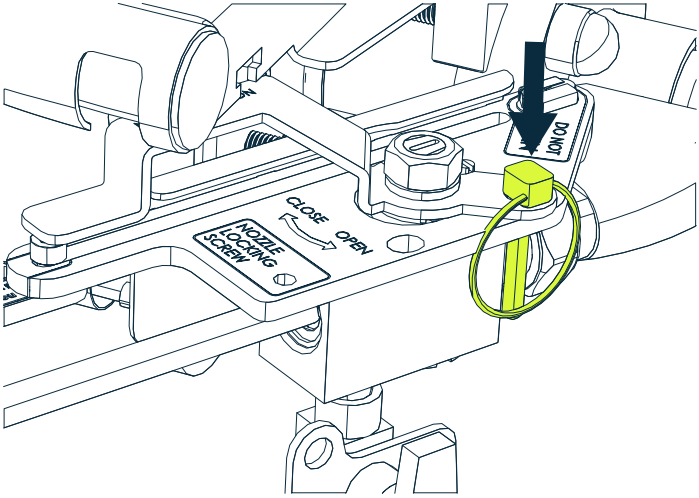
12. Check that the locking screw on the wash nozzle frame is fully closed (tightened to 5 Nm / tool tight).



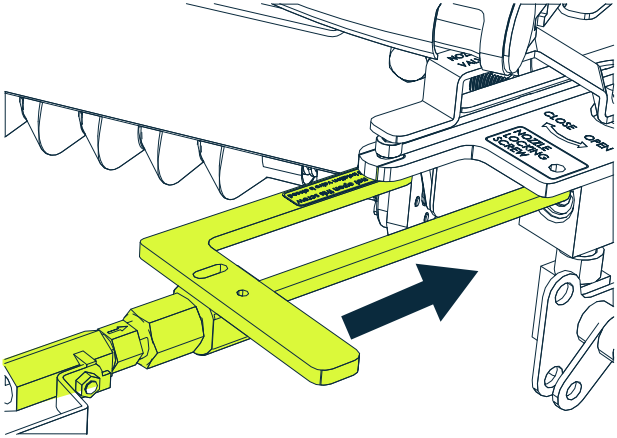
13. Turn the isolation valve handle back into the open position.



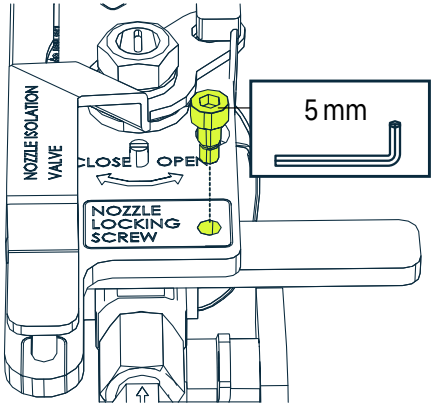
14. Lock the isolation valve handle in the open position with the safety pin.



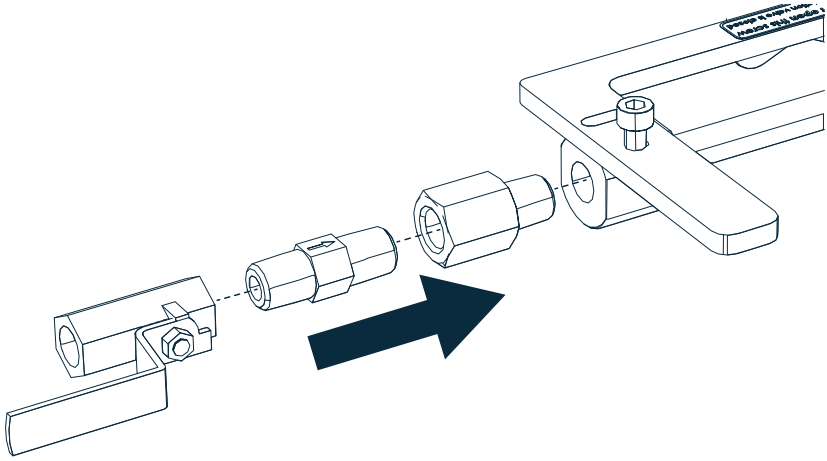
15. Push the wash nozzle fully inside the isolation valve.



16. Close the nozzle locking screw. Tighten to 5 Nm / tool tightness with a 5-mm Allen key.

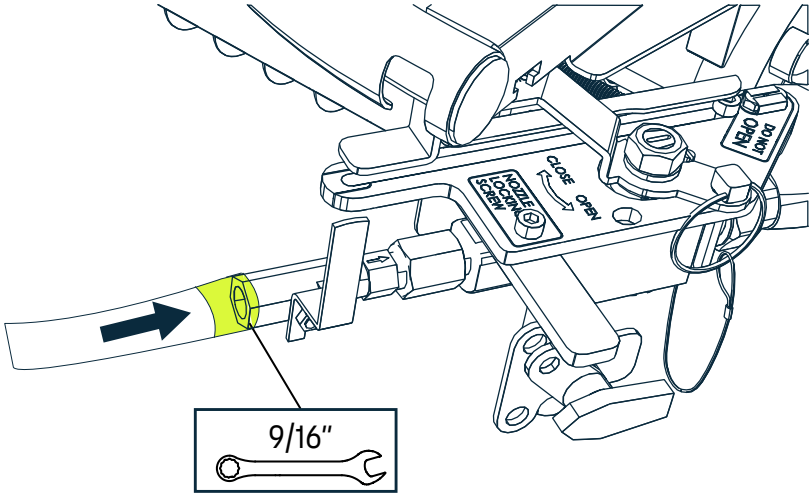


17. Attach the wash hose ball valve (delivered as a separate part in the delivery package) to the wash nozzle valve.

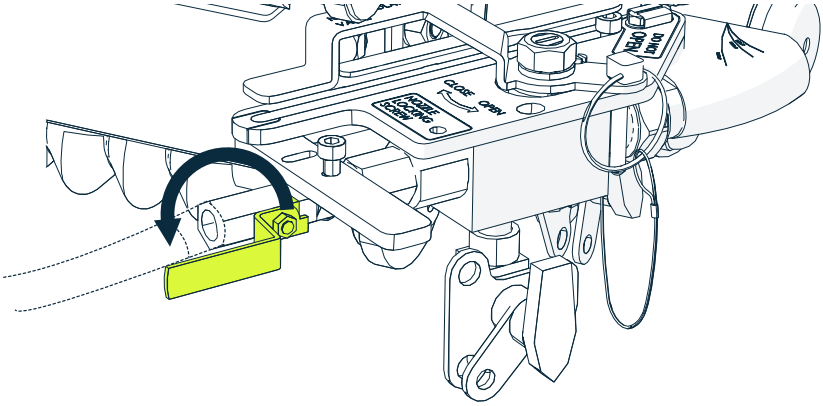


Ball valve thread type: 1/4″ NPT female. The wash nozzle valve has a thread adapter (NPT female - ISO male 1/4″). Check valve thread type: 1/4″ NPT male.

18. Add 2-3 rounds of PTFE tape to the threads of the new wash nozzle fitting,
19. Connect the hose to the wash nozzle fitting. When using the Vaisala fitting, tighten with a 9/16 in wrench.



20. Open the shut-off valve.



For further instructions on the use of the wash system, see PR53 Prism Wash System User Guide (M212808EN).

For instructions on removing and replacing the wash nozzle, see SDI5 wash nozzle removal and insertion overview (page 135).

14. Modbus registers

14.1 Modbus registers

Table 52 Measurement data registers (read-only)

Register number (decimal)	Address (hexadecimal)	Register description	Data format	Unit
3	0x0002	Concentration	32-bit float	*
	0x0003			
5	0x0004	Temperature	32-bit float	°C
	0x0005			
7	0x0006	Raw concentration	32-bit float	*
	0x0007			
9	0x0008	Refractive index	32-bit float	
	0x0009			
11	0x000A	Quality factor	16-bit integer	

* Depends on the active concentration curve

Table 53 Measurement diagnostic registers (read-only)

Register number (decimal)	Address (hexadecimal)	Register description	Data format	Unit/ Valid range /Writable
529	0x0210	Light area	32-bit float	%
	0x0211			
531	0x0212	Ambient light	32-bit integer	
	0x0213			
533	0x0214	Internal temperature	32-bit float	°C
	0x0215			
535	0x0216	Internal relative humidity	32-bit float	%RH
	0x0217			
537	0x0218	Light exposure	32-bit float	%
	0x0219			

Register number (decimal)	Address (hexadecimal)	Register description	Data format	Unit/ Valid range /Writable
539	0x021A 0x021B	Analog output 1 output level	32-bit float	mA
541	0x021C 0x021D	Adjusted concentration	32-bit float	*
543	0x021E 0x021F	Adjusted temperature	32-bit float	°C
545	0x0220 0x0221	Raw temperature	32-bit float	°C
547	0x0222 0x0223	Measurement number	32-bit integer	
553	0x0228	Temperature stable	16-bit integer	0 = not stable 1 = stable
53249	0xD000	Optical image	Raw[114]	
53306	0xD039	Slope image	Raw[114]	
53363	0xD072	Optical and slope images	Raw[228]	

* Depends on the active concentration curve

Table 54 Status registers (read-only)

Register number (decimal)	Address (hexadecimal)	Register description	Data format
515	0x0202 0x0203	Error code	32-bit integer
517	0x0204 0x0205	Error subcode	32-bit integer

Error subcode is meant to be sent to Vaisala service along with error code.

Table 55 Error code encoding

MSB	30	29	28	27	26	25	24	...	17	16	15	14	13	12	11	10	...	6	5	4	3	2	1	LSB

System		Environment	Calculation		Temperature	Image

Error code register value	Corresponding error
Image detection status	
1	Image quality low.
2	External light level high.
3	Prism coating detected.
4	No liquid detected.
5	No optical image.
6	External light level too high.
Temperature measurement status	
1	Temperature measurement error.

Measurement statuses are listed in priority order. Higher values are prioritized.

Error code register value	Corresponding error
Calculation errors	
0x01	Concentration out of concentration curve range.
0x02	Temperature out of concentration curve range.
0x04	Invalid calculation parameters.
0x08	Calibration mode active.
Environmental errors	
0x01	Internal temperature too high.
0x02	Internal humidity too high.
System errors	
0x01	Blank image corrupted.

If several errors are active at the same time, the Modbus error code register contains the sum of currently active error codes.

Table 56 Device information registers (read-only)

Register number (decimal)	Address (hexadecimal)	Register description	Data format	Example output
7425	0x1D00–0x1D07	VendorName	text	“Vaisala Oyj”

Register number (decimal)	Address (hexadecimal)	Register description	Data format	Example output
7433	0x1D08–0x1D0F	ProductCode	text	“PR53”
7441	0x1D10–0x1D17	SerialNumber	text	“J1140501”
7449	0x1D18–0x1D1F	FirmwareVersion	text	“1.2.3”

Table 57 Configuration registers

Register number (decimal)	Address (hexadecimal)	Register description	Data format	Unit / Valid range
Damping				
771	0x0302	Damping type	16-bit integer	0 = Exponential 1 = Linear 2 = Slew rate
772	0x0303	Damping time	16-bit integer	s
773	0x0304	Slew rate	32-bit float	*
	0x0305			
775	0x0306	Tolerance time	16-bit integer	s
Concentration curve management				
776	0x0307	Number of concentration curves	16-bit integer	Read-only
778	0x0309	Select curve	16-bit integer	0 = concentration curve 1 1 = concentration curve 2 2 = concentration curve 3 3 = concentration curve 4
1032	0x0407	Decimal places [1)]	16-bit integer	0–5
Communication				
1537	0x0600	Address	16-bit integer	1–247

Register number (decimal)	Address (hexadecimal)	Register description	Data format	Unit / Valid range
1538	0x0601	Bit rate (b/s)	16-bit integer	0 = 300 1 = 600 2 = 1200 3 = 2400 4 = 4800 5 = 9600 6 = 19200 7 = 28800 8 = 38400 9 = 57600 10 = 76800 11 = 115200
1539	0x0602	Parity, data, stop bits	16-bit integer	0 = None, 8, 1 1 = None, 8, 2 2 = Even, 8, 1 3 = Even, 8, 2 4 = Odd, 8, 1 5 = Odd, 8, 2
1540	0x0603	Response delay	16-bit integer	0–1000 ms
1541	0x0604	Restart device	16-bit integer	When writing to register: 1 = Restart the device
Analog output 1				
1794	0x0701	Scale low end	32-bit float	*
	0x0702			
1796	0x0703	Scale high end	32-bit float	*
	0x0704			
1798	0x0705	Error output level	32-bit float	3.2–20.5 mA
	0x0706			
1800	0x0707	No sample error output	16-bit integer	0 = Disabled 1 = Enabled
1801	0x0708	No sample error output level	32-bit float	3.2–20.5 mA
	0x0709			

Register number (decimal)	Address (hexadecimal)	Register description	Data format	Unit / Valid range
Temperature offset				
8967	0x2306	T offset	32-bit float	°C

1) Applicable from firmware version 1.2.3 onwards.

* Depends on the active concentration curve

Table 58 Concentration curve configuration registers

Register number (decimal)	Address (hexadecimal)	Register description	Data format	Unit	Writable
0 + base	0x0000– 0x0004 + base	Identifier	text		No
5 + base	0x0005 + base	Solvent type	16-bit integer	0 = Other 1 = Water-based	No
6 + base	0x0006 + base 0x0007 + base	Concentration minimum	32-bit float	*	No
8 + base	0x0008 + base 0x0009 + base	Concentration maximum	32-bit float	*	No
10 + base	0x000A + base 0x000B + base	Temperature minimum	32-bit float	°C	No
12 + base	0x000C + base 0x000D + base	Temperature maximum	32-bit float	°C	No
14 + base	0x000E– 0x002D + base	Description	text		No

Register number (decimal)	Address (hexadecimal)	Register description	Data format	Unit	Writable
95 + base	0x005F + base 0x0060 + base	Chemical coefficients, C00	32-bit float		Yes
97 + base	0x0061 + base 0x0062 + base	Chemical coefficients, C01	32-bit float		Yes
99 + base	0x0063 + base 0x0064 + base	Chemical coefficients, C02	32-bit float		Yes
101 + base	0x0065 + base 0x0066 + base	Chemical coefficients, C03	32-bit float		Yes
103 + base	0x0067 + base 0x0068 + base	Chemical coefficients, C10	32-bit float		Yes
105 + base	0x0069 + base 0x006A + base	Chemical coefficients, C11	32-bit float		Yes
107 + base	0x006B + base 0x006C + base	Chemical coefficients, C12	32-bit float		Yes
109 + base	0x006D + base 0x006E + base	Chemical coefficients, C13	32-bit float		Yes
111 + base	0x006F + base 0x0070 + base	Chemical coefficients, C20	32-bit float		Yes

Register number (decimal)	Address (hexadecimal)	Register description	Data format	Unit	Writable
113 + base	0x0071 + base 0x0072 + base	Chemical coefficients, C21	32-bit float		Yes
115 + base	0x0073 + base 0x0074 + base	Chemical coefficients, C22	32-bit float		Yes
117 + base	0x0075 + base 0x0076 + base	Chemical coefficients, C23	32-bit float		Yes
119 + base	0x0077 + base 0x0078 + base	Chemical coefficients, C30	32-bit float		Yes
121 + base	0x0079 + base 0x007A + base	Chemical coefficients, C31	32-bit float		Yes
123 + base	0x007B + base 0x007C + base	Chemical coefficients, C32	32-bit float		Yes
125 + base	0x007D + base 0x007E + base	Chemical coefficients, C33	32-bit float		Yes
127 + base	0x007F ... 0x009E + base	Name	text		Yes
159 + base	0x009F + base 0x00A0 + base	Field offset	32-bit float	*	Yes
131 + base	0x00A1 + base 0x00A2 + base	Field gain	32-bit float		Yes
Concentration curve bases					
3073	0x0C00	Concentration curve 1			

Register number (decimal)	Address (hexadecimal)	Register description	Data format	Unit	Writable
3329	0x0D00	Concentration curve 2			
3585	0x0E00	Concentration curve 3			
3841	0x0F00	Concentration curve 4			

* Depends on the active concentration curve

Table 59 Test value registers

Register number (decimal)	Address (hexadecimal)	Register description	Data format	Test value
7937	0x1F00	Signed integer test	16-bit integer	-12345
7938	0x1F01	Floating point test	32-bit float	-123.45
	0x1F02			
7940	0x1F03	Text string test	text	Text string "-123.45"
	0x1F04			
	0x1F05			
	0x1F06			

Table 60 Device identification objects

Object ID	Object ID (hexadecimal)	Object name	Example contents
0	0x00	VendorName	"Vaisala"
1	0x01	ProductCode	"PR53"
2	0x02	MajorMinorVersion	"1.2.3"
3	0x03	VendorUrl	"https://www.vaisala.com"
4	0x04	ProductName	"Polaris™ process refractometer"
5	0x05	ModelName	"PR53AC"
128	0x80	SerialNumber [1)]	"J1140501"

Object ID	Object ID (hexadecimal)	Object name	Example contents
129	0x81	CalibrationDate [1)]	”2023-04-21” Calibration date in YYYY-MM-DD format. Empty string if not set/valid.
130	0x82	CalibrationText [1)]	”Vaisala/HEL” Calibration information text. Empty string if not set/valid.

1) Vaisala-specific device information object

More information

- Configuring Modbus communication settings with Insight (page 75)

Appendix A. Principle of measurement

The Vaisala K-PATENTS® inline process refractometer determines the refractive index (RI) of the process solution. It measures the critical angle of refraction using a yellow LED light source with the same wavelength (589 nm) as the sodium D line. Light from the light source (L) in the following figure 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.

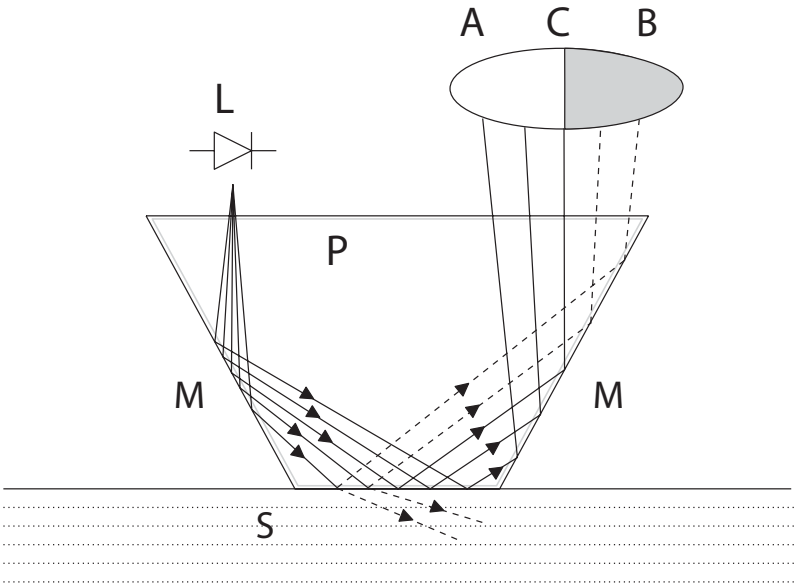


Figure 58 Refractometer principle

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 can then be determined from this position.

The refractive index changes with the process solution concentration and temperature. For most solutions the refractive index 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 the following figure. The color of the solution, gas bubbles or undissolved particles do not affect the position of the shadow edge (C).

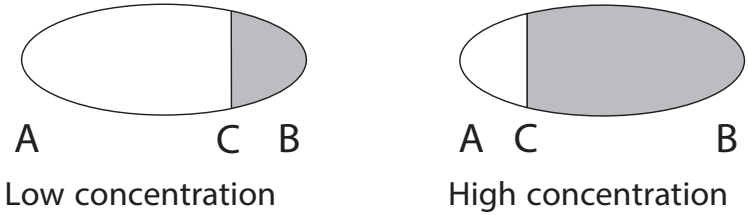


Figure 59 Optical images

The position of the shadow edge is measured digitally using a CCD element and is converted to a refractive index value by a processor inside the instrument. This value is used together with the measured process temperature to calculate the concentration.

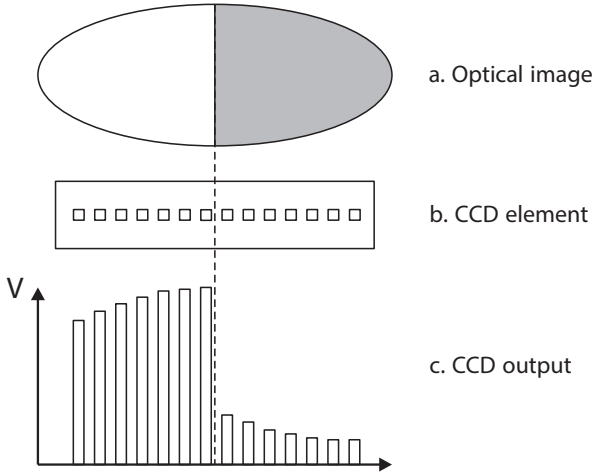


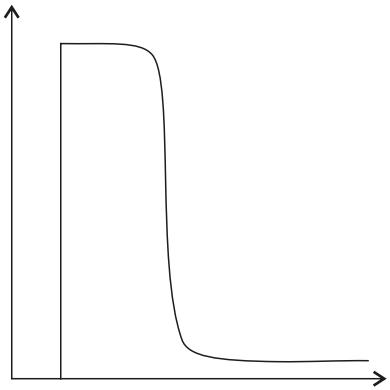
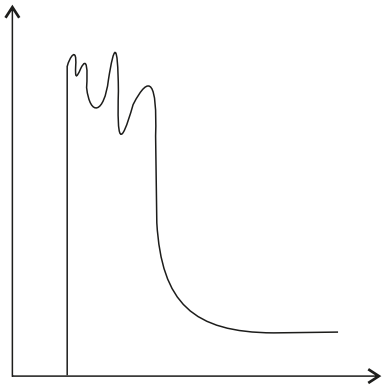
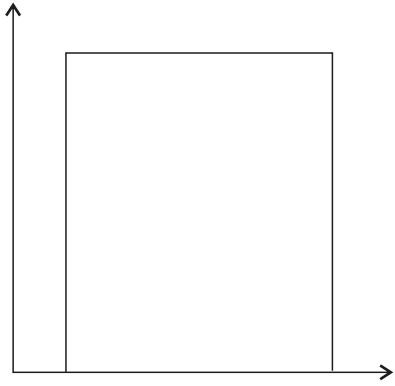
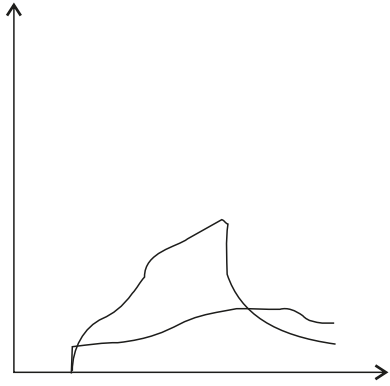
Figure 60 Optical image detection

Appendix B. Analyzing optical image

The optical image can tell you about problems, for example, with the condition of the prism.

Y-axis is light intensity and X-axis the position of the shadow edge. RI calibration follows the X-axis. The position of RI measurement on X-axis is at the steepest curve drop, being the highest angle at the corner.

Table 61 Analyzing the optical image

Optical image with a reference RI liquid 	Erosion of the prism 
No sample 	Process liquid is leaking into the refractometer 

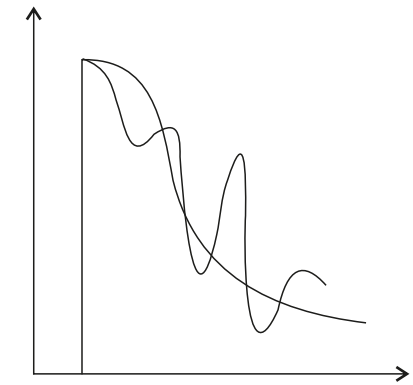
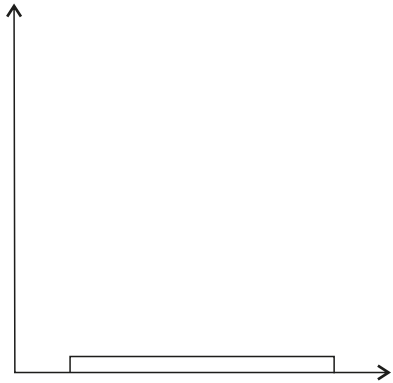
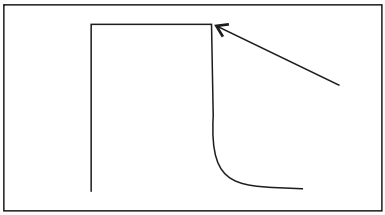
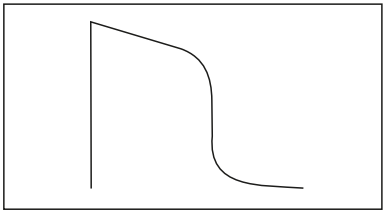
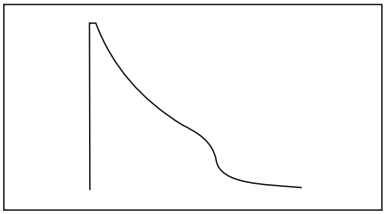
Prism coated 	CCD card is disconnected or faulty, or LED card is disconnected or faulty, or the optical fiber is broken 

Table 62 Prism scaling

	**Good** • Measurement status **Normal operation**. • Observe the angle, drop from high intensity light to low light intensity should be as steep as possible.
	**Compromised** • Measurement status **Normal operation**. • Scaling has started • Measurement starts to drift up • Perform manual cleaning
	**Heavy scaling** • Measurement status **No liquid detected.** or **Prism coating detected.** • Measurement 0% • Immediate manual wash needed. See PR53 Prism Wash System User Guide (M212808EN).

Maintenance and calibration services

Vaisala offers comprehensive customer care throughout the life cycle of our measurement instruments and systems. Our factory services are provided worldwide with fast deliveries. For more information, see vaisala.com/calibration.

- Vaisala Online Store at store.vaisala.com is available for most countries. You can browse the offering by product model and order the right accessories, spare parts, or maintenance and calibration services.
- To contact your local maintenance and calibration expert, see vaisala.com/contactus.

Warranty

For warranty terms and conditions and the warranty claim process, see vaisala.com/warranty. Note that warranty coverage may not apply if the product is damaged due to normal wear and tear, exceptional operating conditions, negligent handling or installation, or unauthorized modifications. See the applicable supply contract or Conditions of Sale for details of the warranty for each product.

Technical support

You can contact Vaisala technical support at vaisala.my.site.com/myvaisala or helpdesk@vaisala.com. You can find all our support channels at vaisala.com/support.

When contacting technical support, provide the following as applicable:

- Product name, model, and serial number
- Software/Firmware version
- Name and location of the installation site
- Name and contact information of a technical person who can provide further information
- Diagnostics package for the application

If applicable, also provide the following details:

- What failed (what worked / did not work)?
- Where did it fail (location and environment)?
- When did it fail (date, immediately / after a while / periodically / randomly)?
- How many failed (only one defect / other same or similar defects / several failures in one unit)?
- What was done when the failure was noticed?
- What was connected to the product and to which connectors?
- What is the input power source type, voltage, and what else (such as lighting, heaters, and motors) was connected to the same power output?
- Are all parts connected and grounded properly? Take a photo to help the troubleshooting.

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