

A PROCESS REFRACTOMETER  
FOR LIQUID CONCENTRATION  
MEASUREMENT FOR THE OIL  
AND GAS INDUSTRIES

**VAISALA**



Vaisala K-PATENTS® Process Refractometer PR-23-RP

# TYPICAL APPLICATIONS

## UPSTREAM, MIDSTREAM AND DOWNSTREAM OPERATIONS

The Process Refractometer PR-23-RP is used in the upstream, midstream and downstream operations of the fuel oil refining and petrochemical industry.

## TRANSPORTATION

Interface detection for gathering and transportation operations, distribution pipelines, supply and delivery stations, and railcar and truck loading and unloading: Crude oil, fuel oil, diesel oil, hydrocarbon, refined products and alternative fuels.

## SULFURIC ACID ALKYLATION

Acid catalyst, spent acid recovery.

## HYDROTREATING

Aromatic content of the hydrocarbon stream.

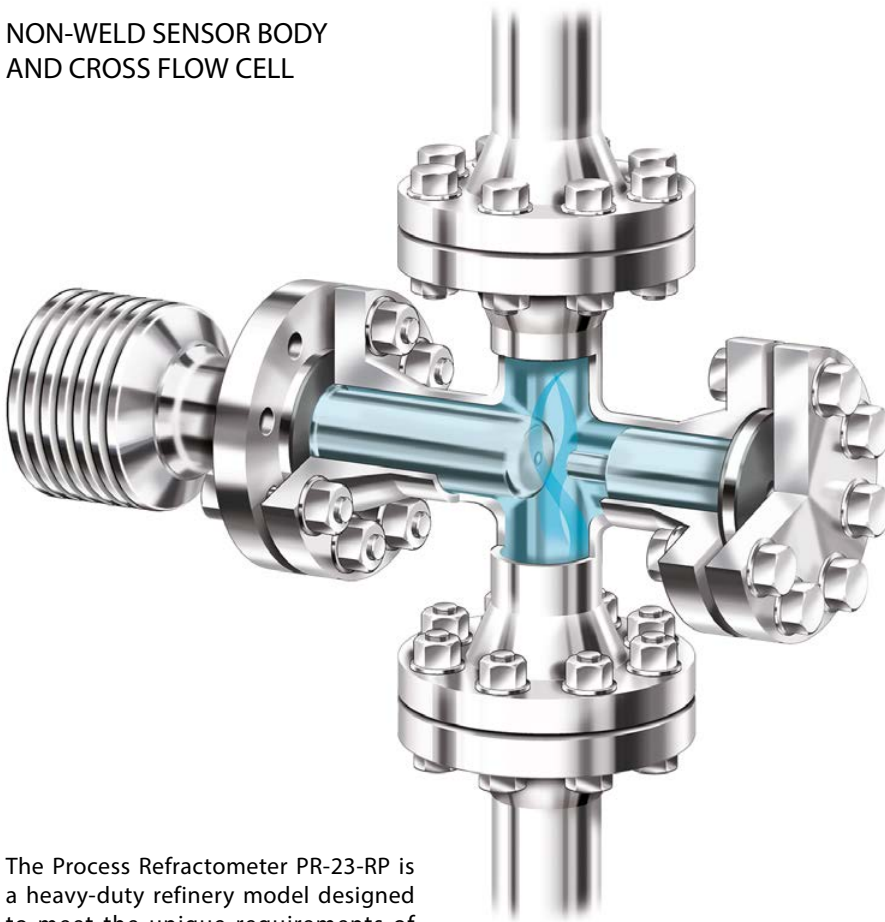
## NATURAL GAS PROCESSING

Glycol dehydration, Amine gas treating: H<sub>2</sub>S and CO<sub>2</sub> removal.



# INSTALLATION

## NON-WELD SENSOR BODY AND CROSS FLOW CELL



The Process Refractometer PR-23-RP is a heavy-duty refinery model designed to meet the unique requirements of the refining and petroleum industries. Typical applications include accurate liquid concentration measurements, e.g. acid in alkylation, glycol or amines in gas processing and multi-product (crude oil, fuel oil, diesel) interfaces in transfer operations.

The Refractometer sensor is installed in the process, either directly by welding stud, or via a 1 inch, 2 inch or 3 inch cross flow cell. Due to the sensor's rugged, innovative non-weld sensor body, and self-cleaning or optional automatic wash system capabilities, the PR-23-RP functions accurately and reliably in harsh refinery conditions. Intrinsically safe and hazardous area certification is provided for hazardous areas.

The PR-23-RP comes with user-specified supplementary tests and documents. The following items can be specified and ordered: metallurgical and material hardness certification (e.g. compliance with the NACE MR0103 or NACE MR0175/ISO 15156 standard), API recommended tests and welding documents (e.g. WPS, PQR, WQR, NDE, radiographic test and hydrostatic shell test), material traceability certification and the positive material identification (PMI) test. A factory acceptance test (FAT), site acceptance test (SAT), and customized drawings stating client specific information are also available on request.

# OPERATION

The Process Refractometer PR-23-RP sensor is factory calibrated to measure refractive index  $n_D$  and temperature  $T$  in standard units. Each sensor has identical calibration  $n_D=1.32...1.53$  (corresponding to 0-100% by weight). One or two sensors can be connected to one indicating transmitter.

Measurement accuracy is unaffected by undissolved particles and impurities, bubbles, and color or temperature changes in the process medium. The PR-23-RP Refractometer does not require recalibration or regular maintenance.

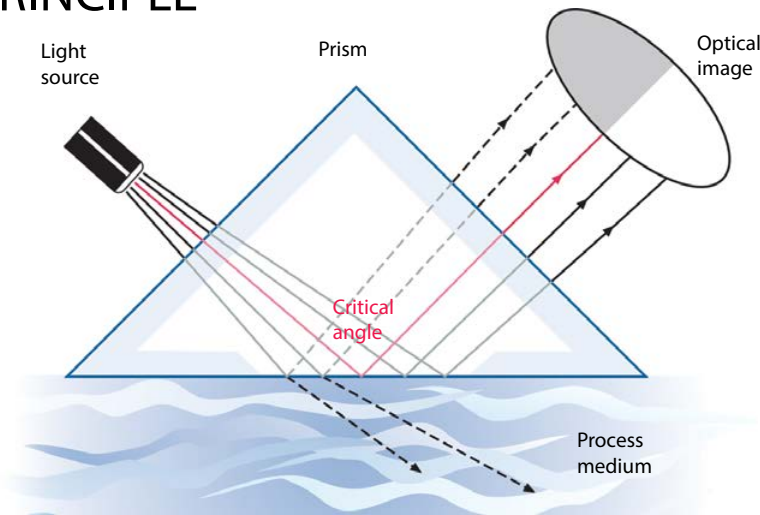
Because PR-23 sensors have identical calibration, and each sensor gives the Refractive Index  $n_D$  and temperature as outputs, all sensors can be freely interchanged without the inconvenience of optical calibration or parameter changes.

Non-linear conversion from the refractive index to concentration units and temperature compensation are based on standard tables. These are programmed into the transmitter, independently of the sensor.

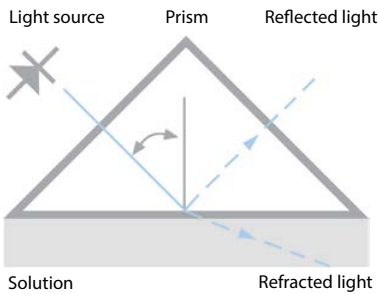
Our manufacturing process is ISO 9001 certified. We also support verification as part of the user's own quality system.

Each sensor is provided with a calibration certificate comparing a set of standard liquids to actual sensor output. Calibration and accuracy can therefore easily be verified on-site, using certified refractive index liquids and our documented verification procedure.

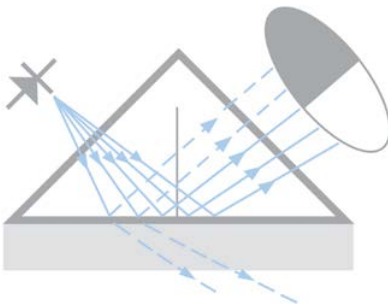
# DIGITAL MEASUREMENT PRINCIPLE



The light source emits light at the interface, between a prism and the process solution, where the rays meet the surface at different angles.

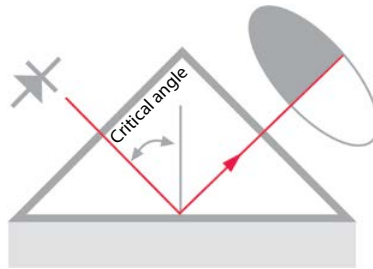


Depending on the angle, some rays undergo a total internal reflection. The rest of the light is refracted into the process solution.



Thus, an optical image with a dark and light sector is created.

The angle corresponding to the shadow line is called the Critical Angle of Total Reflection. The Critical Angle is a function of the refractive index and therefore the concentration of the solution.



A digital CCD-camera detects the optical image and shadow line. The camera transforms the optical image point-by-point into an electrical signal. In this way, the exact shadow line position is located and the refractive index  $n_D$  is determined.

A built-in temperature sensor measures the temperature  $T$  on the interface of the process liquid. The indicating transmitter converts the refractive index  $n_D$  and temperature  $T$  into concentration units.

The diagnostics program ensures that the measurement is reliable.

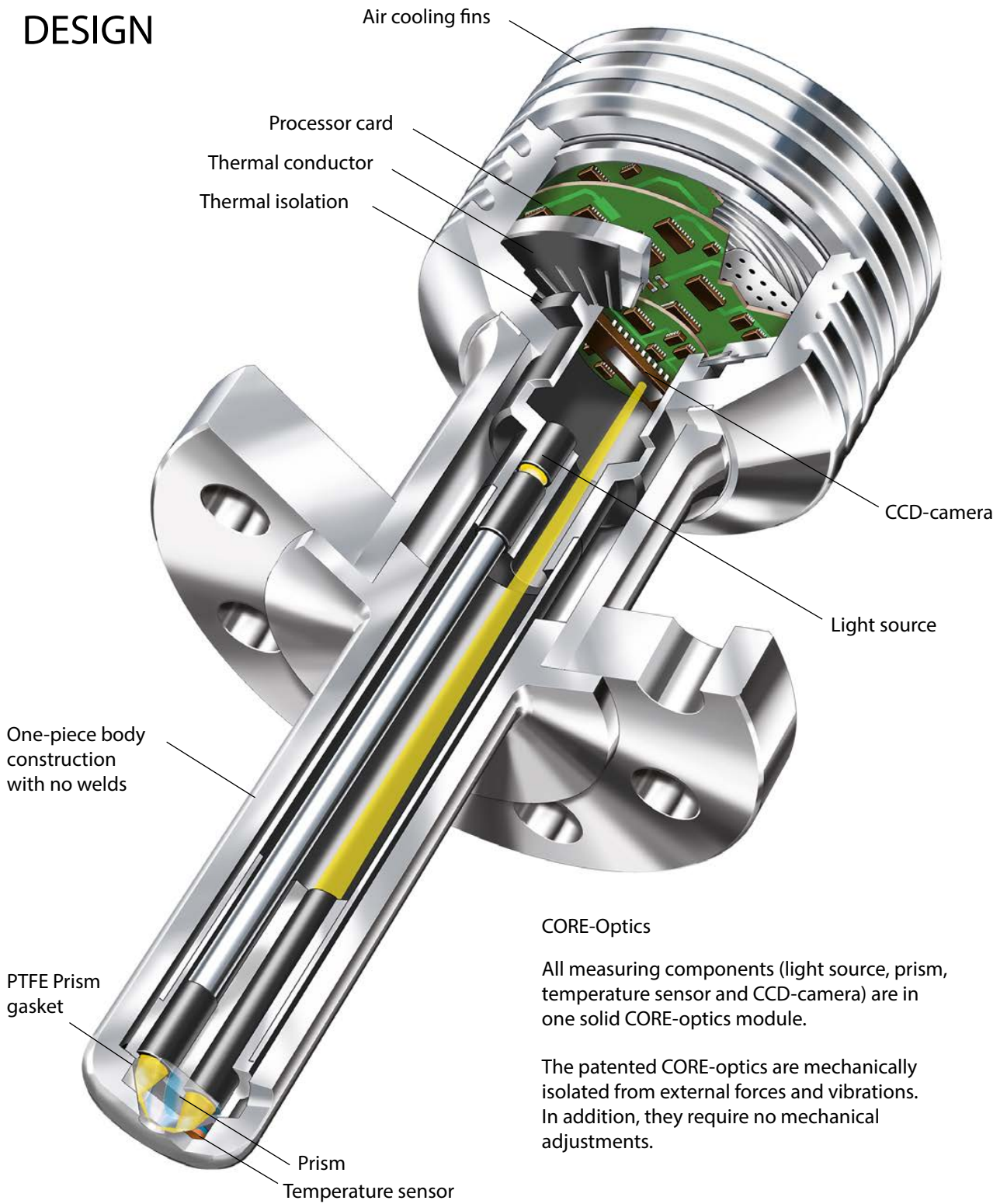
# DATA LOGGING VIA ETHERNET

The PR-23-RP Refractometer includes an Ethernet-based communications solution, which allows connection to computer networks (LAN) and to the Internet. Real-time measurement data and diagnostic information can be obtained through this interface, making it a valuable service tool for parameter changes and software updates.

Only a cross-over cable and data acquisition software are needed for collecting data from a PR-23 refractometer. Communication is built on standard protocols (UDP/IP) and we offer ready-to-install data acquisition software.

This software is expandable if the user wishes to modify the program. Being written in Java, the program is system independent and can be tailored to almost any computing environment.

# DESIGN



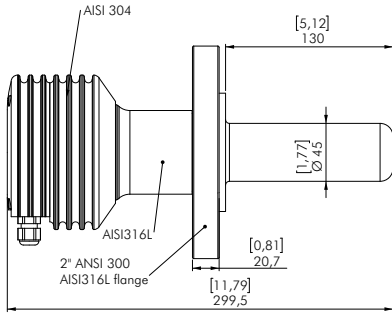
## CORE-Optics

All measuring components (light source, prism, temperature sensor and CCD-camera) are in one solid CORE-optics module.

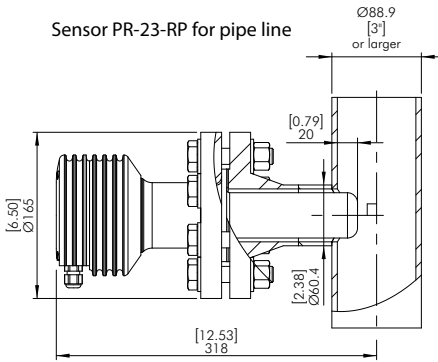
The patented CORE-optics are mechanically isolated from external forces and vibrations. In addition, they require no mechanical adjustments.

# SPECIFICATIONS

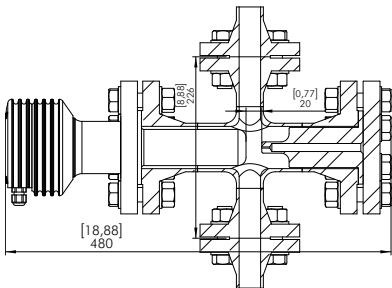
Sensor PR-23-RP



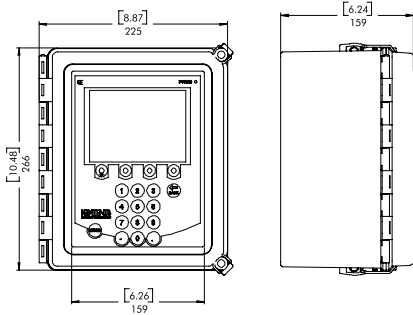
Sensor PR-23-RP for pipe line



Sensor PR-23-RP and Cross flow cell CF-RP-M20-M10 for 1 inch pipe line size



Indicating transmitter DTR



Refractive Index range:	Standard: Full range, $n_D = 1.3200...1.5300$ (corresponds to 0...100 % b.w.)
Accuracy:	Refractive index $n_D \pm 0.0002$ (typically corresponds to $\pm 0.1\%$ by weight) Repeatability $n_D \pm 0.0001$ (typically corresponds to $\pm 0.05\%$ by weight)
Speed of response:	1 s undamped, damping time selectable up to 5 min
Calibration:	With Cargille standard R.I. liquids over full range of $n_D 1.3200...1.5300$
CORE-Optics:	No mechanical adjustments (US Patent No. US6067151)
Digital measurement:	3648 pixel CCD element
Light source:	Light emitting diode (LED), 589 nm wavelength, sodium D-line
Temperature sensor:	Built-in Pt-1000, linearization according to IEC 751
Temperature compensation:	Automatic, digital compensation
Instrument verification:	According to ISO 9000 quality system: with standard R.I. liquids and Transmitter's menu guided procedure
Ambient temperature:	Sensor: max. 45°C (113°F), optional max. 65°C (149°F), min. -20°C (-4°F) Indicating transmitter: max. 50°C (122°F), min. 0°C (32°F)

## SENSOR PR-23-RP AND CROSS FLOW CELL CF-RP:

Sensor type:	Probe type, seamless one-piece wetted parts construction with no welds
Process connection:	ANSI-flange 300 lbs, 2 inches, insertion length 130 mm (51 inches)
Cross Flow Cell process connection:	ANSI-flange 300 lbs for nominal pipe sizes of 1 inch, 2 inches or 3 inches
Process pressure:	up to 25 bar (350 psi)
Process temperature:	-40°C...150°C (-40°F...302°F)
Process wetted parts, standard:	AISI 316L stainless steel, Alloy 20 or Hastelloy C-276; prism sapphire, prism gaskets PTFE
Sensor protection class:	IP67, Nema 4X
Sensor weight:	7.89 kg (17.4 lbs)
Cross flow cell weight:	10.9 kg (24 lbs)
ASME Code compliance:	The main physical properties have been designed in accordance with ASME Section VIII, Division 1 and Division 2

## INDICATING TRANSMITTER DTR:

Display:	320x240 pixel graphical LCD with LED backlight
Keypad:	18 membrane keys
Current output:	Two independent current outputs, 4-20 mA, max. load 1,000 Ohm, galvanic isolation 1,500 VDC or AC (peak), hold function during prism wash
Fieldbus and industrial Ethernet connectivity	Through Fieldbus converter to Modbus/TCP, Modbus RTU and Ethernet/ IP networks
Power:	AC input 100-240 VAC/50-60 Hz, optional 24 VDC, 30 VA
Alarms/Wash relays:	Two built-in signal relays, max. 250 V/3 A
Sensor connectivity:	One or two sensors can be connected to the DTR. Sensors independent of each other: own parameter sets and usable in different applications. Two current outputs configurable independently to indicate process concentration or temperature of either sensor.
Transmitter protection class:	Polycarbonate enclosure IP66, Type 4X (Indoor use); AISI 304 Stainless steel enclosure IP66 (Indoor use).

Indicating transmitter weight:	4.5 kg (10 lbs)
INTERCONNECTING CABLE:	IEC 61158-2 compliant two-wire cable
Interconnecting cable length:	Standard 10 m (33 ft), max. 200 m (660 ft)
OPTIONS:	Prism wash, intrinsic safety and hazardous area approvals, cable fittings to the indicating transmitter: European cable glands M20x1.5 or US conduit hubs

ORDERING INFORMATION:	- Sensor model and process connection	- Process pipe size
	- Desired scale	- Process flow rate
	- Properties of process solution	- Supply voltage and frequency
	- Process temperature range	- Options and accessories
	- User specified tests and documents	

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www.vaisala.com/requestinfo

We reserve the right to make technical alterations.