K-PATENTS® PROCESS REFRACTOMETER PR-43-G

FOR IN-LINE CONCENTRATION MEASUREMENT IN OIL AND GAS INDUSTRY APPLICATIONS

SB: PR-43-G_O&G-1
November 2017
TYPICAL APPLICATIONS

OIL FIELD PRODUCTION
OIL SANDS BITUMEN FROTH TREATMENT AND SOLVENT RECOVERY PROCESS: Solvent-diluted bitumen slurry, bitumen froth, solvent.

GAS-LIQUID PROCESSING
GAS GLYCOL DEHYDRATION: Diethylene glycol (DEG), Triethylene glycol (TEG).

AMINE GAS TREATING: Amine regeneration process to maintain optimum removal of carbon dioxide and hydrogen sulfide in natural gas purification: Monoethanolamine (MEA), Methyldiethanolamine (MDEA), Diethanolamine (DEA).

REFINING
HYDROTREATING: Aromatic content of the hydrocarbon stream.

SULFURIC ACID ALKYLATION: acid catalyst, spent acid recovery.

LUBE OIL REFINING: De-asphalting, Extraction, De-waxing, Furfural extraction: Raffinate

Bulk petrochemicals and intermediates: OLEFINS: Ethylene, Propylene, Butadiene. AROMATICS: Benzene, Toluene, Xylenes

DISTRIBUTION AND UTILIZATION
UREA BLENDING AND MIXING: AdBlue (AUS32), Diesel exhaust fluid (DEF).

TERMINALS AND STORAGE
LOADING AND UNLOADING: Liquid hydrocarbons

PIPELINE AND TRANSPORTATION
IDENTIFICATION: Liquid hydrocarbons

BIOFUELS
BIOETHANOL PROCESS: Bioethanol Cooking, Fermentation, Purification, Stillage. BIODIESEL PROCESS: Biodiesel Glycerol Refining

And more.
SERVING OIL AND GAS INDUSTRY NEEDS

As a supplier, K-Patents understands oil and gas industry needs and offers sophisticated and proven products, reliability and measurement accuracy, as well as expert consultancy that is built on longstanding expertise and in-depth application knowledge. K-Patents can serve EPC contractors, consultants and end-users with an engineering approach, including:

- Customized process connections and modifications
- Special wetted parts materials
- Documentation and document revision control
- Quality testing, inspections and procurement control
- FAT and SAT including third party inspections
- Material traceability certification conforming to EN 10204 3.1
- Material hardness certification
- Commissioning and start-up service
- Technical support service

Process refractometer PR-43-G is designed to measure, refine, manage and indicate liquid concentration or density and diagnostic information in diverse oil and gas industry applications. The PR-43-G Refractometer system consists of a compact or probe refractometer and a graphical user interface. The refractometer is a stand-alone device capable of operating independently. It has a measurement range of 0 to 100 % and provides an Ethernet or 4–20 mA output signal proportional to the temperature-compensated concentration value for real-time process control. Different user interface options range from a rugged, multichannel, industrial computer to a compact light-weight and a web-based version, and allow the user to select the most preferred way to access and use the refractometer measurement and diagnostics data.

PERFORMANCE OVERVIEW

PR-43-G Refractometer has a built-in web server with an instrument homepage. The homepage allows for configuring, monitoring, verifying and diagnosing the refractometer via an Ethernet connection.

The Process refractometer PR-43-G is factory-calibrated to measure concentration and temperature in standard units. Each refractometer has identical calibration. For this reason, the refractometers can be freely interchanged without optical recalibration or parameter changes. The refractometer does not require any recalibration or regular maintenance. Furthermore, the calibration of each refractometer can be verified using standard refractive index liquids and a built-in verification procedure.

K-Patents Process refractometer PR-43-G offers accuracy, repeatability and reliability even in the most extreme environments that can be corrosive, abrasive, subject to extreme temperatures, pressures, vibration or contamination, humidity and dust, or any combinations of these factors.

- Designed to Pressure Equipment Directive PED 97/23/EC and ASME Section VIII Division 1 - Pressure Vessels.
- The refractometer wetted parts construction has no welds for increased safety.
- Different IP codes (IEC 60529) and NEMA ratings are available for the refractometer and user interface proving harsh conditions tight.
- Non-incendive (Ex n) and intrinsic safety (Ex ia) approvals are available for hazardous area installations.

WIDE RANGE OF INSTALLATION OPTIONS

The PR-43-G refractometer compact or long probe model can be installed in the main processing line, bypass line or vessel either directly with Flange or Sandvik coupling process connection, or via a large variety of cost-effective and easy to mount flow cell options.

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<tr>
<th>COMPACT PROBE</th>
<th>2.5 INCH AND LARGER</th>
<th>2 INCH</th>
<th>1.5 INCH</th>
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<tr>
<td>Sandvik L coupling connection for 1.5 inch, 2 inch, 2.5 inch and larger</td>
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<tr>
<th>LONG PROBE</th>
<th>2.5 INCH AND LARGER</th>
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<tr>
<td>Flange connection for 2 inch, 2.5 inch and larger</td>
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Sandvik L coupling and GFC flow through cell connection for 0.5 inch and 1 inch (vertical and horizontal pipe lines)

Flange and FTC flow through cell connection for 0.5 inch, 1 inch, 1.5 inch and 2 inch
STANDARD PACKAGES

**PROCESS REFRACTOMETER PR-43-G AND MULTICHANNEL USER INTERFACE MI**

K-Patents fully equipped system with refractometer, interconnecting cable and multichannel user interface with high performance industrial computing, wash control and high expandability capabilities and connectivity.

The multichannel user interface MI provides the highest level of industrial computing, intelligence and sophisticated features as well as environmental protection.

**PROCESS REFRACTOMETER PR-43-G AND COMPACT USER INTERFACE CI**

K-Patents compact, single device connectivity system with refractometer, interconnecting cable and compact user interface for applications where a local or remote display and access is preferred and where no wash is required.

**PROCESS REFRACTOMETER PR-43-G AND WEB USER INTERFACE WI**

K-Patents stand-alone system with refractometer, interconnecting cable and web user interface designed particularly for direct control system integration in applications where no industrial computer (e.g. to control prism wash) or monitoring display is required.
USER INTERFACES

K-Patents Process refractometer PR-43-G can be equipped with different user interface options for handling the user and refractometer as well as refractometer and control system interaction.

MULTICHANNEL USER INTERFACE MI
• High-performance, industrial computing system
• Expandable system and connectivity for up to four (4) PR-43-G refractometers and eight (8) I/O modules
• Environmentally sealed IP67, Type 4X, rugged 316 stainless steel enclosure that withstands the corrosive cleaning agents and frequent washes
• Ideal for demanding field and outdoor conditions (0−50°C, 32−122°F)
• Prism wash diagnostics and control
• Trend display that shows one or two graphs over a selected period of time
• Embedded measurement apps: The apps are small programs that give different types of measurement data and functionality.
• Modules, e.g. mA-output and mA-input module
• 10” graphical touchscreen color display
• User identification and management, electronic data records and data-logging, event log/audit trail

COMPACT USER INTERFACE CI
• Single device connectivity
• Local and/or remote display and access
• Light-weight, aluminum enclosure for control room conditions and epoxy coated IP66, Type 4x enclosure with polycarbonate display shield for field conditions
• Trend display
• 10” graphical touchscreen color display.

WEB USER INTERFACE WI
• Web browser interface via Ethernet connection to a control system or any type of computer
• Output values are transmitted through 4-20 mA output and output values, diagnostic information and trends are transmitted via an Ethernet connection using a UDP/IP protocol

FIELD COMMUNICATOR FC-11
The user can remotely operate and configure the refractometer using the K-Patents hand-held Field Communicator FC-11. The FC-11 provides an identical window into the process, showing measurement and diagnostic data including the optical image, and facilitating real time analysis and configuration directly at the refractometer.
**DIGITAL MEASUREMENT PRINCIPLE**

The light source sends light to 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 sector and a light sector is created. The angle corresponding to the shadow line is called the critical angle of total internal reflection.

This angle is a function of the refractive index and therefore the concentration of the solution. A CCD-camera detects the optical image. The image is transformed point-by-point into a digital signal. Digital signal processing is used to locate the exact shadow line position and to determine the refractive index nD.

A built-in temperature sensor measures the temperature T on the interface of the process liquid. The sensor converts the refractive index nD and temperature T into Brix units.

The diagnostics program ensures that the measurement is reliable.

**UNIQUE 3-LAYER CALIBRATION**

The concentration calibration of the K-Patents PR-43-G refractometer is organized in three (3) layers: the Refractometer nD calibration, chemical curve and field calibration. The advantages of the layer feature are free interchangeability of refractometers, applications and recipes without any need for mechanical calibration adjustment in the field.

The optical image information is detected by the CCD-element and transformed into a number (CCD). The process temperature T is measured by a Pt-1000 resistance.

**LAYER 1:**
- The refractometer calibration: The actual refractive index nD is calculated from the CCD.

**LAYER 2:**
- The chemical curve: The refractometer calculates the Brix or concentration value based on nD and TEMP. The result is a temperature compensated calculated concentration value CALC.

**LAYER 3:**
- Field calibration: Adjustment of the calculated concentration value CALC may be required in order to compensate for some process conditions or to fit the measurement to the laboratory results. The Field calibration procedure determines the appropriate adjustment to CALC. The adjusted concentration is called CONC.

Output signal: The output signal is transmitted over the 4–20 mA current output or through the Ethernet connection.
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 is mechanically isolated from the influence of external forces and vibrations. The CORE-optics contains no mechanical adjustments.
## SPECIFICATIONS

| REFRACTOMETER MODELS | REFRACTOMETER PR-43-G
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<td>Optional</td>
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<td>PR-43-GC Compact</td>
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<td>Optional</td>
<td>PR-43-GP Probe</td>
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### Refractive Index range
- Full range, \( nD = 1.3200...1.5300 \) corresponds to hot water...100% by weight.
- \( nD = 1.260...1.470 \)
- \( nD = 1.410...1.620 \)
- \( nD = 1.520...1.730 \)

### Accuracy
- Across the full range of 0−100%: Refractive index \( nD \pm 0.0002 \) corresponds typically to ±0.1% by weight.

### Repeatability
- Across the full range of 0−100%: \( nD \pm 0.00004 \) (corresponds typically to ±0.02% by weight).

### Speed of response
- 1 s undamped, damping time selectable up to 5 min.

### Calibration
- With NIST traceable Cargille standard R.I. liquids over full range.
- Patented CORE-Optics
- No mechanical adjustments and digital measurement with 3648 pixel CCD element, sodium D-line light emitting diode (LED), built-in PR-1000 temperature sensor (linearization according to IEC 751).

### Temperature compensation
- Automatic, digital compensation.

### Instrument verification
- With NIST traceable Cargille standard R.I. liquids and guided procedure, including a printable verification report.

### Process connection
- PR-43-GC: Sandvik coupling L 60.3 mm (2 inch) for pipe size of 2 inch; via reducing ferrule PR-9285 for pipe size of 1.5 inch; via Flow through cell GFC connection with 0.5 or 1 inch NPT or R 7/1 threads, 0.5 or 1 inch ANSI 150 lbs or 300 lbs, DIN/EN DN15 or DN25 PN40 or JIS 10K A15 or A25 flange connections.
- PR-43-GC: Sandvik coupling L 76.1 mm (2.5 inch) for pipe sizes of 2.5 inch and larger; via Pipe flow cell PFC for pipe line size of 1 inch. Pipe flow cell process connection with ANSI 150 lbs, DIN/EN PN 25 or JIS 10K.
- PR-43-GP: ANSI 2 inch, 3 inch or 4 inch with 150 lbs or 300 lbs, DN50, 80 or 100 PN25, JIS 50A, 80A or 100A with 10k; Sandvik L coupling 88 mm (3 inch) welded construction; via Pipe flow cell PFC for pipe sizes of 1 inch or 2 inch. Flow through cell process connection with ANSI 150 lbs or 300 lbs, DIN/EN PN25 or JIS 10K.

### Process pressure
- Sandvik L 60.3 (2 inch) up to 40 bar (580 psi) at 20°C (70°F); PR-43-GC: Sandvik coupling L 76.1 mm (2.5 inch) up to 25 bar (350 psi); PR-43-GP: flange and L coupling connections up to 25 bar (350 psi) at 20°C (70°F).

### Process temperature
- PR-43-GC: \(-40°C...130°C (-40°F...266°F)\); PR-43-GP: \(-40°C...150°C (-40°F...302°F)\). For higher temperatures, consult the factory.

### Ambient temperature
- Refractometer: min. \(-40°C \) (\(-40°F)\), max. \(45°C\) (\(113°F)\); for higher ambient temperatures a cooling cover for refractometer electronics housing is available; Multichannel user interface MI: min. 0°C (32°F), max. 50°C (122°F); Compact user interface CI: min. 0°C (32°F), max. 50°C (122°F).

### Process wetted parts
- AISI 316L stainless steel, prism sapphire, prism gasket modified PTFE.

### Refractometer protection class
- IP67, Type 4X (for outdoor use).

### Refractometer weight
- PR-43-GC (2 inch): 1.7 kg (3.7 lbs), PR-43-GP (2 inch): 6.7 kg (14.8 lbs).

### Current output
- Isolated 4-20 mA, max. load 1000 Ohm, galvanic isolation 1000 VDC or AC (peak), hold function during prism wash.

### Remote and Ethernet connections
- 10/100BaseT Ethernet, web server for configuration and diagnostics, UDP/IP Protocol connection for data acquisition.

### INTERCONNECTING CABLES
- Standard length 10 m. Interconnecting cable length is field-adjustable with Platform 4 Cable extender for up to 100 m.

### USER INTERFACE MODELS
- Multichannel user interface MI, Compact user interface CI, Web user interface WI.

### Multichannel user interface MI
- Environmentally sealed 316 stainless steel IP67 (door closed), IP66 (door open)/Type 4X for demanding field and outdoor conditions. Prism wash diagnostics and control. Trends, Apps. Eight (8) module slots, 10" graphical touchscreen color display. Expandable system and I/O options: connect up to four (4) PR-43-G refractometers and up to eight (8) I/O modules. Wall and table-top mount.

### Compact user interface CI
- Light-weight aluminum enclosure for control room conditions; Epoxy coated IP66, Type 4X enclosure with polycarbonate display shield for field conditions. Trends. 10" graphical touchscreen color display. Wall, table-top and panel mount.

### Web user interface WI
- Output values are transmitted through 4-20 mA output and output values, diagnostic information and trends are transmitted via Ethernet connection using a UDP/IP protocol.

### User interface weight
- Multichannel user interface MI: 13.6 kg (29 lbs), Compact user interface CI: 5.4 kg (11 lbs).

### POWER SUPPLY
- Refractometer: \(+24\) VDC +/-10%, Max 2 VA; Multichannel user interface MI: AC input 100-240 VAC/50-60HZ or 24 VDC, 60W; Compact user interface CI: \(+24\) VDC +/-10%, Max. 8.5W.

### OPTIONS
- Prism wash, Non-incendive (Ex n) and intrinsic safety (Ex ia) approvals are available for hazardous area installations.

### SERVICES
- To ensure continuous support before and after purchase of our products, we offer local application consultation, training, maintenance and support expertise via our authorized sales representative network. Please refer to www.kpatents.com to contact your nearest representative.

### PATENTS
- See www.kpatents.com

We reserve right to technical alterations.

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