

# Vacuum Measurement

Active gauges from 2000 to  $10^{-10}$  mbar





## Pressure measurement & principles

The vacuum pressure range where pressure measurements with active vacuum gauges can be performed stretches from above atmosphere to  $10^{-10}$  mbar, i.e. over 13 orders of magnitude.

Due to physical characteristics, no single vacuum sensor exists which is capable to perform high-precision measurements within the entire pressure range. For this reason Leybold offers sensors of different designs with own characteristic measurement range, usually spanning several orders of magnitude.

The main differentiating factors are between direct and indirect pressure measurements.

## User-optimized active gauges for various applications from 2000 mbar to $10^{-10}$ mbar

### Direct, gas type independent pressure measurement

Vacuum sensors:

- CERAVAC capacitive gauges equipped with diaphragms with different sensitivity covering the pressure range from  $10^{-5}$  mbar to 1333 mbar (1000 Torr) with high precision.
- DI/DU capacitive and piezo pressure sensors with a pressure range from 2000 to  $10^{-1}$  mbar in absolute pressure measurements and -1000 mbar to +1000 mbar in relative pressure measurements.

The direct (absolute) type of pressure measurement is independent of the gas type to be measured. The measurement is performed mechanically by way of the pressure acting upon the surface of a diaphragm.

### Indirect, gas type dependent pressure measurement

Vacuum sensors:

- THERMOVAC thermal conductivity vacuum gauges after Pirani.
- PENNINGVAC cold cathode ionization vacuum gauges after the inverted magnetron / Penning principle.
- IONIVAC hot cathode ionization vacuum gauges after Bayard-Alpert for pressure measurements in the ultra-high vacuum range.

Indirect pressure measurement is determined as a function of a pressure dependent property of the gas (thermal conductivity, ionization probability, for example) and the molar mass, and is therefore dependent on the specific type of gas. The measurement readout is referenced to air or nitrogen and can be applied to other gases via correction factors.



# Simple gauge & controller selection

## Gauge and measurement range

| Gauge                    | Range (mbar) |      |      |      |     |     |    |   |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                     |
|--------------------------|--------------|------|------|------|-----|-----|----|---|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|---------------------|
|                          | 2000         | 1500 | 1200 | 1000 | 200 | 100 | 10 | 1 | 1x10 <sup>-1</sup> | 1x10 <sup>-2</sup> | 1x10 <sup>-3</sup> | 5x10 <sup>-4</sup> | 1x10 <sup>-4</sup> | 5x10 <sup>-5</sup> | 1x10 <sup>-5</sup> | 1x10 <sup>-6</sup> | 1x10 <sup>-7</sup> | 1x10 <sup>-8</sup> | 1x10 <sup>-9</sup> | 5x10 <sup>-10</sup> |
| DI/DU 2000 / 2001        | ✓            | ✓    | ✓    | ✓    | ✓   | ✓   | ✓  | ✓ |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                     |
| DI/DU 200 / 201          |              |      |      |      | ✓   | ✓   | ✓  | ✓ |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                     |
| DI/DU 2001 rel.          |              |      |      | ✓    | ✓   | ✓   | ✓  |   |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                     |
| THERMOVAC TM 101         |              | ✓    | ✓    | ✓    | ✓   | ✓   | ✓  | ✓ | ✓                  | ✓                  | ✓                  |                    |                    |                    |                    |                    |                    |                    |                    |                     |
| PIEZOVAC PV 101          |              | ✓    | ✓    | ✓    | ✓   | ✓   | ✓  | ✓ |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                     |
| CERAVAC CTR 100 series   |              |      | ✓    | ✓    | ✓   | ✓   | ✓  | ✓ | ✓                  | ✓                  | ✓                  |                    |                    |                    |                    |                    |                    |                    |                    |                     |
| CERAVAC CTR 101 series   |              |      | ✓    | ✓    | ✓   | ✓   | ✓  | ✓ | ✓                  | ✓                  | ✓                  |                    |                    |                    |                    |                    |                    |                    |                    |                     |
| THERMOVAC TTR 91/97 RN   |              |      |      | ✓    | ✓   | ✓   | ✓  | ✓ | ✓                  | ✓                  | ✓                  |                    |                    |                    |                    |                    |                    |                    |                    |                     |
| THERMOVAC TTR 96 RN      |              |      |      | ✓    | ✓   | ✓   | ✓  | ✓ | ✓                  | ✓                  | ✓                  | ✓                  |                    |                    |                    |                    |                    |                    |                    |                     |
| THERMOVAC TTR 101 series |              | ✓    | ✓    | ✓    | ✓   | ✓   | ✓  | ✓ | ✓                  | ✓                  | ✓                  | ✓                  | ✓                  | ✓                  |                    |                    |                    |                    |                    |                     |
| PENNINGVAC PTR 225 / 237 |              |      |      |      |     |     |    |   |                    | ✓                  | ✓                  | ✓                  | ✓                  | ✓                  | ✓                  | ✓                  | ✓                  | ✓                  |                    |                     |
| PENNINGVAC PTR 90 series |              |      |      | ✓    | ✓   | ✓   | ✓  | ✓ | ✓                  | ✓                  | ✓                  | ✓                  | ✓                  | ✓                  | ✓                  | ✓                  | ✓                  | ✓                  | ✓                  | ✓                   |
| IONIVAC ITR 90 / 200 S   |              |      |      | ✓    | ✓   | ✓   | ✓  | ✓ | ✓                  | ✓                  | ✓                  | ✓                  | ✓                  | ✓                  | ✓                  | ✓                  | ✓                  | ✓                  | ✓                  | ✓                   |

## Gauge and controller selection

| Gauge                            | Controller  |             |               |             |               |
|----------------------------------|-------------|-------------|---------------|-------------|---------------|
|                                  | GRAPHIX ONE | GRAPHIX TWO | GRAPHIX THREE | DISPLAY ONE | DISPLAY THREE |
| DU series                        | ✓           | ✓           | ✓             | ✓           | ✓             |
| CERAVAC CTR 100 / 101 series     | ✓           | ✓           | ✓             |             |               |
| THERMOVAC TTR 91/96/97 RN series | ✓           | ✓           | ✓             | ✓           | ✓             |
| THERMOVAC TTR 101 series         | ✓           | ✓           | ✓             | ✓           | ✓             |
| PENNINGVAC PTR 225 / 237         | ✓           | ✓           | ✓             |             | ✓             |
| PENNINGVAC PTR 90 series         | ✓           | ✓           | ✓             | ✓           | ✓             |
| IONIVAC ITR 90 / 200 S           | ✓           | ✓           | ✓             |             |               |

# Application - gauge requirements

## Application - gauge requirements

| Application                         | CERAVAC CTR | Linear pressure sensors DI/DU | THERMOVAC TTR | PENNINGVAC PTR | IONIVAC ITR |
|-------------------------------------|-------------|-------------------------------|---------------|----------------|-------------|
| Research and development            | ✓           | possible                      | ✓             | ✓              | ✓           |
| Chemical/ Chemistry processes       | ✓           | ✓                             | ✓             | ✓              |             |
| Heat Treatment/ Metallurgy          | ✓           | possible                      | ✓             | ✓              | ✓           |
| Automotive industry                 | ✓           | ✓                             | ✓             | ✓              |             |
| Space simulation                    | ✓           | possible                      | ✓             | ✓              | ✓           |
| Analytical                          | possible    | possible                      | ✓             | ✓              | possible    |
| Refrigeration and air conditioning  |             | ✓                             | ✓             |                |             |
| Chemistry and research laboratories | ✓           |                               | ✓             | ✓              | ✓           |
| Mechanical engineering              | ✓           | ✓                             | ✓             | possible       | possible    |
| Sputter systems                     | ✓           | possible                      | ✓             | ✓              | ✓           |
| Process industry                    | ✓           | ✓                             | ✓             | ✓              | possible    |
| Solar                               | ✓           | ✓                             | ✓             |                |             |

For further application examples, please refer to our full line catalog.



## Benefits of Leybold vacuum sensors

Leybold transmitters are specially suited for system integration.  
Our high-precision vacuum sensors meet your demands

## Reliability

- Highly reliable fore vacuum and high vacuum pressure measurement with cutting edge technology
- Simple operation and integration
- Highly reproducible measurement results

## Integration

- Control of multiple gauges allowing different locations to be controlled in parallel
- Simple, cost effective and space saving installation
- Direct data transfer to PLC/computer via digital/ analog interface
- Increased transmission distances (up to 100 m) between measurement location and processing station

## Peace of mind

- Increased electromagnetic compatibility (EMC) requirements
- Compliance with international standards and regulations (CE, RoHS, WEEE etc.)



# Active sensors / Vacuum transmitters



## — CERAVAC transmitters CTR 100 / CTR 101

**Capacitance vacuum gauges suited for corrosive process gases.**

- Leading levels of accuracy (0.2%) achieved via the ceramic capacitive sensor
- Excellent temperature compensation regardless of ambient conditions
- Fast and accurate response times to pressure changes
- Long-term stability: no calibration shifts after bursts of pressure
- Measurement/display range: from 1000 Torr to  $10^{-5}$ , depending on the model

## — DI/DU Linear Pressure Sensors

**Excel through a high overload response as well as excellent corrosion & vibration resistance.**

- Rugged sensor with IP54 rating making it suitable for harsh environments
- Very compact: just one sensor needed
- Relative measurement option for load lock applications
- Utilizes either capacitive or Piezo based sensor dependent on model
- Measurements from 2000 mbar to 0.1 mbar





## — THERMOVAC transmitters TTR 101

**Suited for almost any applications, the combination of Pirani and Piezo measuring gives increased accuracy**

- Two-in-one sensor: Pirani and capacitive sensors together deliver a cost and space saving measurement solution from 1500 to 5 x10<sup>-5</sup> mbar
- Fast response and high accuracy: time saving and highly reliable
- Analogue or digital outputs available
- Options with display for local reading of pressure

## — THERMOVAC transmitters TTR 91 RN / TTR 96 RN / TTR 97 RN

**Suited for almost any applications. Versions with set point relays for improved process control are available.**

- New filament Pirani sensor for high resistance against corrosive gasses and particle contamination
- Fast response and high accuracy: time saving and highly reliable
- Analogue or digital, 360° LED status ring or integrated screen, options available
- Able to measure from atmosphere to 1 x 10<sup>-4</sup> mbar





## — PENNINGVAC transmitters PTR 90 / PTR 225 / PTR 237

Providing very long life time due to a low ionisation current and stainless steel body.  
PTR 90

- Pirani / cold cathode combination for cost and time-saving measurements across a wide pressure range
- Complete coverage of the measurement range from  $5 \times 10^{-9}$  mbar to atmosphere
- Automatic ignition from the Pirani to the cold cathode
- Modular design for easy serviceability

PTR 225 / PTR 237

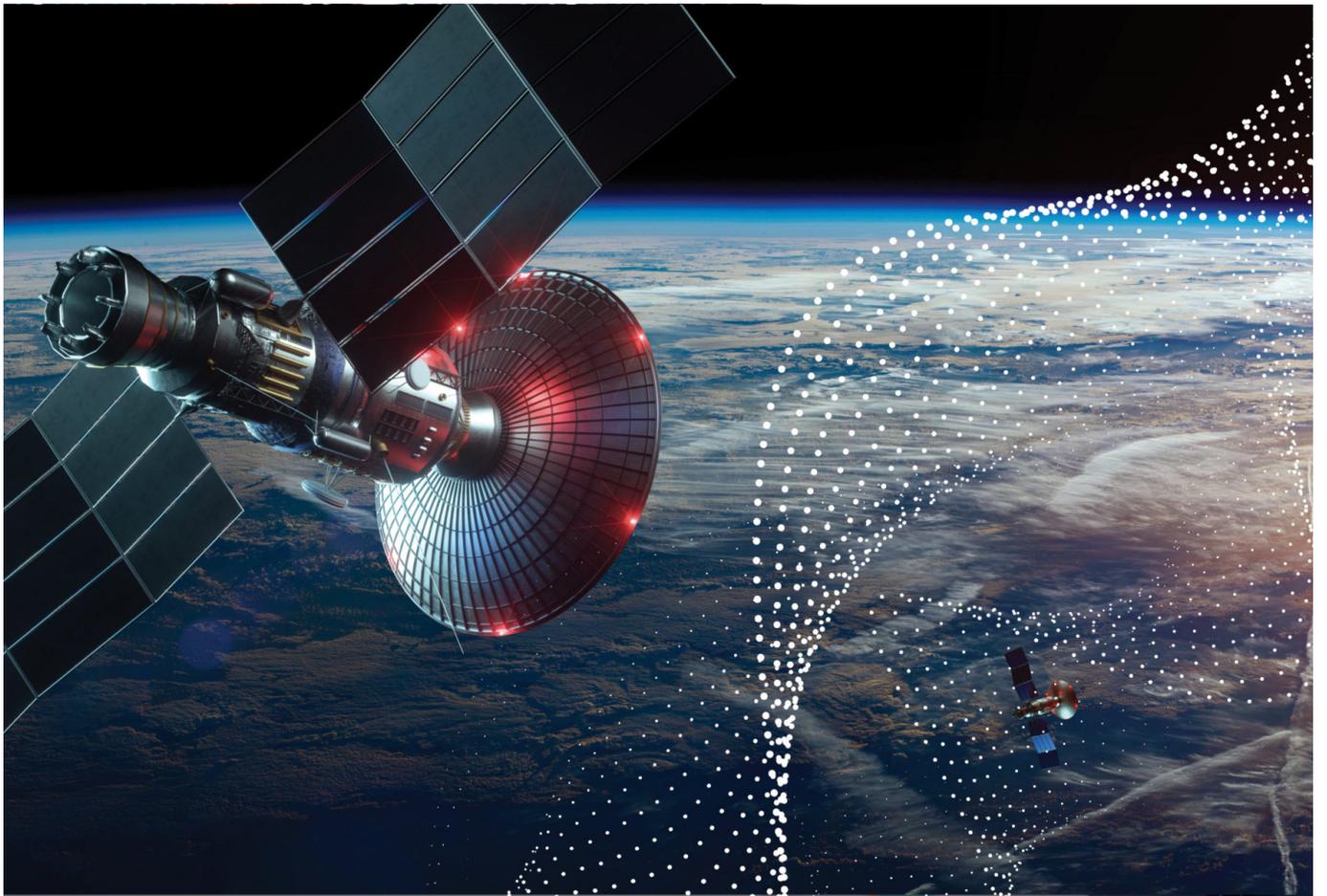
- Robust cold cathode sensing cell: reliable measurements and high process quality
- Modular design provides low total cost of ownership by easy and inexpensive servicing
- Measurement range from  $1 \times 10^{-9}$  to  $1 \times 10^{-2}$  mbar

## — IONIVAC transmitters ITR 90 / ITR 200

Permitting vacuum pressure measurements on non-combustible gases & gas mixtures within a wide range of pressures.

- The Pirani / hot cathode ionization (Bayard-Alpert) combination allows continuous pressure measurements from atmosphere to  $5 \times 10^{-10}$
- Just one gauge required to cover a wide measurement range
- Cost effective, and space-saving, solution
- High process reliability of the ITR 200 through two cathodes





# Technical data

## Direct pressure measurement

| Technical data                    |      | CERAVAC  |  | Linear pressure sensors  |  |
|-----------------------------------|------|--|--|--|--|
| Vacuum transmitter                |      | CTR 100  | CTR 101  | DI / DU 200 / 201  | DI / DU 2000/2001/2001 rel.                                      |
| Principle of measurement          | mbar | Capacitance diaphragm ceramic diaphragm sensor   | Capacitance diaphragm ceramic diaphragm sensor   | Capacitive ceramic diaphragm sensor  | Piezo resistive ceramic diaphragm                                |
| Measurement range / Display range | mbar | 1000 / 1 x 10 <sup>-1</sup> Torr*<br>100 / 1 x 10 <sup>-2</sup> Torr<br>20 / 2 x 10 <sup>-3</sup> Torr<br>10 / 1 x 10 <sup>-3</sup> Torr<br>1 / 1 x 10 <sup>-4</sup> Torr<br>0.1 / 1 x 10 <sup>-5</sup> Torr | 1000 / 1 x 10 <sup>-1</sup> Torr*<br>100 / 1 x 10 <sup>-2</sup> Torr<br>10 / 1 x 10 <sup>-3</sup> Torr<br>1 / 1 x 10 <sup>-4</sup> Torr<br>0.1 / 1 x 10 <sup>-5</sup> Torr | 0.1 to 200   | 1 to 2000<br>DI/DU 2001 rel.<br>-1000 to +1000 relative pressure |
| Measurement uncertainty           | mbar | 0.2% of reading<br>± temperature effect<br>0.5% of reading<br>± temperature effect (0.1 Torr)  | 0.15% of reading<br>± temperature effect   | 0.25 % of full scale linearity, reproducibility and hysteresis                       |  |
| Status indicators                 |      | LED  |  | -  | -  |
| Max. bakeout temperature          | °C   | not bakeable   |  | 70   |  |
| Overpressure limit                | bar  | 3.1  |  | 6  | 5  |
| Protection class                  | IP   | 40   |  | 54   |  |
| Setpoints                         |      | 2  | 2  | -  | -  |
| Max. cable length                 | m    | 30 (type C)  |  | 25   |  |
| Electrical connection             |      | Sub-D, 15 pin  |  | DI: 7 pole diode plug (5 m)   DU: FCC 68 (5 m)                                       |  |
| Interfaces                        |      | 0-10 V, RS 232   |  | DI: 4 - 20 mA / DU: 2 - 10 V   |  |
| Controller type                   |      | GRAPHIX series   |  | DI: GRAPHIX and DISPLAY series via signal converter   DU: DISPLAY and GRAPHIX series |  |

\* 1 Torr = 1.333 mbar

\*\* Example, please refer to catalog for further details

## Indirect pressure measurement

| Technical Data                    |       | THERMOVAC   |                                 | PENNINGVAC  |  | IONIVAC                      |           |
|-----------------------------------|-------|---|---------------------------------|---|--|------------------------------|-----------|
|                                   |       | TTR 91 / 96 / 97 RN   | TTR 101                         | PTR 90  | PTR 225 / PTR 237  | ITR 90                       | ITR 200 S |
| Principle of measurement          | ✓     | Filament Pirani   | Filament Pirani and capacitance | Cold cathode according to the inverted magnetron and Pirani | Cold cathode according to the inverted Penning principle | Hot cathode and Pirani       |           |
| Measurement range / Display range | mbar* | 5 x 10 <sup>-4</sup> - 1000 (91/97)<br>1 x 10 <sup>-4</sup> - 1000 (96) | 5 x 10 <sup>-5</sup> - 1500     | 5 x 10 <sup>-9</sup> - 1000                                 | 1 x 10 <sup>-9</sup> - 1 x 10 <sup>-2</sup>              | 5 x 10 <sup>-10</sup> - 1000 |           |

## Indirect pressure measurement

| Technical Data                             |       | THERMOVAC   |  | PENNINGVAC   |   | IONIVAC   |           |
|--|-------|---|--|--|---|---|-----------|
|  |       | TTR 91 / 96 / 97 RN   | TTR 101  | PTR 90   | PTR 225 / PTR 237   | ITR 90  | ITR 200 S |
| Measurement uncertainty                    | mbar* | <b>91/97 RN</b><br>$5 \times 10^{-4}$ to $1 \times 10^{-3}$<br>$\pm 50$ % of reading<br>$1 \times 10^{-3}$ to 100<br>$\pm 15$ % of reading<br>100 to atm<br>$\pm 50$ % of reading<br><b>96 RN</b><br>$5 \times 10^{-4}$ to $1 \times 10^{-3}$<br>$\pm 50$ % of reading<br>$1 \times 10^{-3}$ to 10<br>$\pm 15$ % of reading<br>10 to 100<br>$\pm 50$ % of reading | $5 \times 10^{-4}$ to $1 \times 10^{-3}$<br>$\pm 50$ % of reading<br>$1 \times 10^{-3}$ to 100<br>$\pm 15$ % of reading<br>100 to 950<br>$\pm 5$ % of reading<br>950 to 1050<br>$\pm 2.5$ % of reading | $1 \times 10^{-8}$ to 100<br>$\pm 30$ % of reading | $1 \times 10^{-8}$ to $1 \times 10^{-3}$<br>$\pm 30$ % of reading | $15\%$ at $1 \times 10^{-8}$ - $1 \times 10^{-2}$<br>$> 15\%$ at $10^{-1}$ - 1000 |           |
| Status indicators                          |       | LED-ring (360°) with pressure indication  | LED / screen option  | LED-ring (360°) / screen option                    |   | LED / screen option   |           |
| Max. bakeout temperature                   | °C    | 150 (electronics removed)   | 85, non-operating  | 85, non-operating                                  |   | 150 with bake-out extension   | 80        |
| Overpressure limit                         | bar   | 10  | 10   | 6  | 6   | 2   |           |
| Protection class                           | IP    | 40  | 40   | 40   | 40  | 30-   |           |
| Setpoints                                  |       | 0 / 1 / 2   | 2  | 0  | 0/1   | -   | 1 - 2     |
| Max. cable length<br>Electrical connection | m     | 100 (type A)<br>FCC 68 / RJ45<br>or Sub-D 9 Pin   | 100 (type A)<br>1 x FCC 68 or<br>2 x FCC 68 + 1 x<br>Sub-D 15 pin  | 100 (type A)<br>FCC 68 / RJ 45                     | 100 (type A)<br>FCC 68 / RJ 45 RS 232                             | 100 (type C)<br>Sub-D, 15-way male  |           |
| Interfaces                                 |       | 0-10 V, RS 232, RS485   | 0-10 V, RS 232,<br>Display   | 0-10 V   |   | 0-10 V, RS232, Profibus   |           |
| Controller type                            |       | DISPLAY and GRAPHIX series  | DISPLAY and GRAPHIX series   | DISPLAY and GRAPHIX series                         | DISPLAY THREE and GRAPHIX series                                  | GRAPHIX series  |           |

\* 1 Torr = 1.333 mbar

Note: Examples please refer to catalog for further details

# Ordering information | Display and operating instruments

## Ordering information (extract from the product range)

| Sensor type             | Model      | Description   | Pressure range                         | Part. No.  |
|-------------------------|------------|---|--|------------|
| CERAVAC                 | CTR 100    | DN 16 ISO-KF  | 1 x 10 <sup>-1</sup> Torr - 1000 Torr  | 230300V01  |
|                         | CTR 101    | DN 16 ISO-KF  | 1 x 10 <sup>-1</sup> Torr - 1000 Torr  | 230320V01  |
| Linear pressure sensors | DI 200     | DN 16 ISO-ISO-KF, incl. 5 m connection cable        | 0.1 mbar - 200 mbar                    | 15812V01   |
|                         | DU 200     | DN 16 ISO-ISO-KF, incl. 5 m connection cable        | 0.1 mbar - 200 mbar                    | 230500V01  |
| THERMOVAC               | TTR 91 RN  | DN 16 ISO-KF  | 5 x 10 <sup>-4</sup> mbar to 1000 mbar | 21L1011100 |
|                         | TTR 96 RN  | DN 16 ISO-KF corrosion resistant                    | 1 x 10 <sup>-4</sup> mbar to 1000 mbar | 21L2011100 |
|                         | TTR 91 RNS | DN 16 ISO-KF 2 switching points                     | 5 x 10 <sup>-4</sup> mbar to 1000 mbar | 21L2011100 |
|                         | TTR 96 RNS | DN 16 ISO-KF corrosion resistant 2 switching points | 1 x 10 <sup>-4</sup> mbar to 1000 mbar | 21L2211100 |
|                         | TTR 101    | DN 16 ISO-KF  | 5 x 10 <sup>-5</sup> mbar - 1500 mbar  | 230350V01  |
|                         | TM 101     | DN 15 ISO-KF portable gauge                         | 5 x 10 <sup>-4</sup> mbar to 1200 mbar | 230081V01  |
| PENNINGVAC              | PTR 90     | DN 25 ISO-KF  | 5 x 10 <sup>-9</sup> mbar - 1000 mbar  | 230070     |
|                         | PTR 90     | DN 40 CF  | 5 x 10 <sup>-9</sup> mbar - 1000 mbar  | 230085V72  |
|                         | PTR 225    | DN 25 ISO-KF  | 1 x 10 <sup>-9</sup> mbar - 1000 mbar  | 15734      |
| IONIVAC                 | ITR 90     | DN 25 ISO-KF  | 5 x 10 <sup>-10</sup> mbar - 1000 mbar | 120 90     |
|                         | ITR 200 S  | DN 25 ISO-KF  | 5 x 10 <sup>-10</sup> mbar - 1000 mbar | 230 250    |

For more detailed information and the entire product range, please refer to the Leybold full line catalog.  
Visit our webshop [www.leyboldproducts.com](http://www.leyboldproducts.com)

## Display and operating instruments

| Active sensors  | Operating units for active sensors |               |   |
|---|------------------------------------|---------------|---|
|   | DISPLAY ONE                        | DISPLAY THREE | GRAPHIX ONE, GRAPHIX TWO, GRAPHIX THREE |
| PENNINGVAC transmitters (FCC 68) PTR 90, PTR 225, PTR 237                             | TYP A                              | TYP A         | TYP A                                   |
| CERAVAC transmitters (RS 232 / 0-10v) CTR 101, CTR 101 (digital signal)               | -                                  | -             | TYP C                                   |
| IONIVAC transmitters (RS 232 / 0-10v) ITR 90, ITR 200 S                               | -                                  | -             | TYP C                                   |
| THERMOVAC transmitters (FCC 68) TTR 91 RN, TTR 96 RN, TTR 97 RN, TTR 101, TTR 101 NS2 | TYP A                              | TYP A         | TYP A                                   |
| THERMOVAC transmitters (RS 232) TTR 101, TTR 200 N                                    | -                                  | -             | TYP G                                   |

# VACUUM MEASUREMENT



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