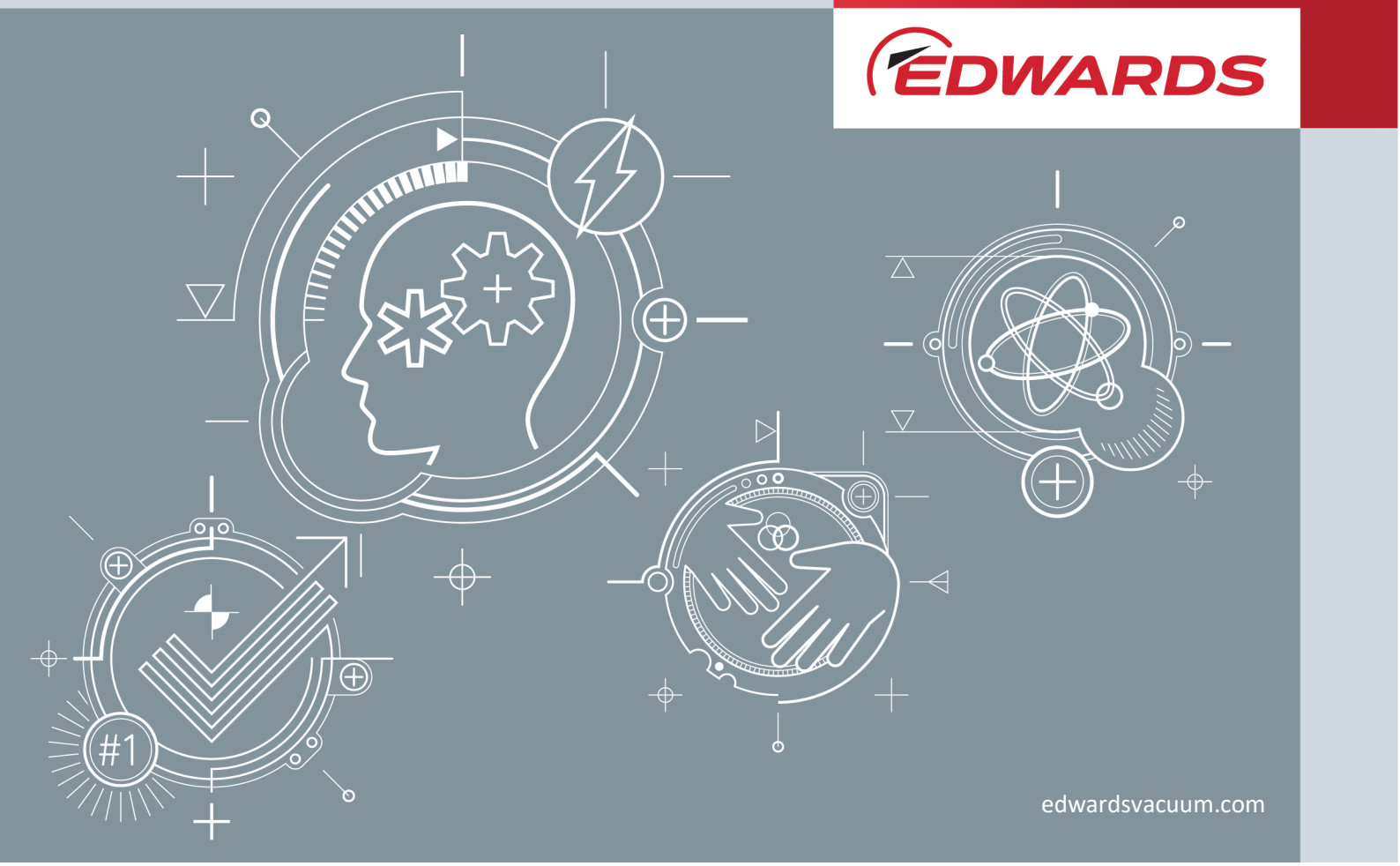


WRH Gauge

INSTRUCTION MANUAL

Copyright notice

Trademark credits

Associated publications

D02691880 *Digital Gauge Range Serial Communication*

Disclaimer

The content of this manual may change from time to time without notice. Edwards accepts no liability for any errors that may appear in this manual nor does it make any expressed or implied warranties regarding the content. So far as is reasonably practicable Edwards has ensured that its products have been designed and constructed so as to be safe and without risks when correctly installed and used in accordance with Edwards operating instructions. Edwards accepts no liability for loss of profit, loss of market or any other indirect or consequential loss whatsoever.

Product warranty and limit of liability are dealt with in Edwards standard terms and conditions of sale or negotiated contract under which this document is supplied.

To use the WRH gauge, refer to the information provided in this manual. Read this manual before you install, operate and maintain the WRH gauge.

P20010249A

CE Declaration of Conformity

Edwards Ltd
Innovation Drive
Burgess Hill
West Sussex
RH15 9TW
UK

The following product

WRH gauges:

D14750100	*WRH – NW25*
D14750110	*WRH – NW40*
D14750120	*WRH – DN40CF*
D14750101	*WRH – NW25 Spare sensor*
D14750111	*WRH – NW40*
D14750121	*WRH – DN40CF*

Is in conformity with the relevant requirements of European CE legislation:

2014/30/EU	Electromagnetic compatibility (EMC) directive
2011/65/EU	Restriction of certain hazardous substances (RoHS) directive as amended by Delegated Directive (EU) 2015/863

Based on the relevant requirements of harmonised standards:

EN 61326-1:2013	Electrical equipment for measurement, control and laboratory use. EMC requirements. General requirements Class B Emissions, Industrial Immunity

Documentation Officer: Jelena Havelkova, Spielberk Office Centre, Holandska 10, Brno, 63900 Czech Republic,
✆: +42(0) 734 418 896, ✉: documentation@edwardsvacuum.com

This declaration, based on the requirements of the listed Directives and EN ISO/IEC 17050-1, covers all product serial numbers from this date on: *15th November 2019.*

Nick Barratt – Engineering Manager
Research and Development
Eastbourne, UK

Andy Marsh – General Manager
Eastbourne, UK

Additional Legislation and Compliance Information

EU EMC Directive: Class A/B Industrial equipment

Caution: This equipment is not intended for use in residential environments and may not provide adequate protection to radio reception in such environments.

EU RoHS Directive: Material Exemption Information

This product is compliant with no Annex III or IV Exemptions.

EU REACH Regulation Compliance

This product is a complex article which is not designed for intentional substance release. To the best of our knowledge the materials used comply with the requirements of REACH. The product manual provides information and instruction to ensure the safe storage, use, maintenance and disposal of the product including any substance based requirements.

Article 33.1 Declaration

This product does not knowingly or intentionally contain Candidate List Substances of Very High Concern above 0.1%ww by article as clarified under the 2015 European Court of Justice ruling in case C-106/14.

材料成分声明

China Material Content Declaration

表示该有害物质在该部件的所有均质材料中的含量低于 GB/T 26572 标准规定的限量要求。

Indicates that the hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement in GB/T 26572.

Contents

List of Figures

List of Tables

Introduction

Safety symbols

Safety procedures are highlighted as WARNING and CAUTION instructions. These instructions must be obeyed. The use of WARNINGS and CAUTIONS is defined as follows:

WARNING:

Warnings are given where failure to obey the instruction could result in injury or death to people. The actual symbol shown will change and refer to the applicable hazard.

CAUTION:

Cautions are given where failure to obey the instruction could result in damage to the equipment, associated equipment or process.

Safety precautions

- Read and obey the instructions in this manual.
- You must know the hazards that can be caused by the product.
- Obey all safety instructions and regulations.
- The ambient conditions must be considered before you install the transducer. The protection class is IP 40 (the unit has protection against penetration of foreign bodies) or IP54 when applicable electrical connectors are used.
- Obey the applicable regulations and take the necessary precautions for the process media used.
- Think of possible reactions between the materials and the process media.
- Think of possible reactions of the process media as a result of heat generated by the product.
- Do not do any unauthorized conversions or modifications to the unit.
- Before you start work, make sure that the vacuum components are not contaminated.
- Obey the applicable regulations and the necessary precautions when you handle contaminated parts.
- A Return of Edwards Equipment Declaration form must be completed and sent with the unit before you return it to Edwards.
- Give information to others about the applicable safety instructions.

Description

The transducer measures absolute pressure in gaseous media in the range of 1000 to 5.0×10^{-10} mbar. The transducer can be connected to a customer related power supply and evaluation units in compliance with the pin assignment. The analogue output signal of 1.219 V to 8.6 V has a logarithmic dependence on pressure over the whole range. The device has a serial RS485 interface for digital data transfer (see *Serial interface* on page 20).

The transducer has a metal-sealed combination sensor type Pirani/Hot Cathode (Bayard Alpert) and temperature compensated. It can be mounted to a flange connector.

Correct use

The transducer gives total pressure measurements in gaseous media in the range 1000 to 5.0×10^{-10} mbar only. It can only be connected to components specified for this function.

Incorrect use

All functions not given in *Correct use* on page 8 are regarded as incorrect, in particular:

- The connection to components not permitted in the operation instructions.
- The connection to components containing touchable, voltage carrying parts.

No liability or warranty will be accepted for claims caused by incorrect use. The user is responsible for the used process media.

The device must not be used in a corrosive gas atmosphere. Aggressive media such as halogenides, carbon or oxygen plasma can decrease the sensor life.

CAUTION: INCORRECT OPERATION

Risk of incorrect operation. Dust, oil or condensed vapours will have an unwanted effect on the sensor's performance and can cause a malfunction.

CAUTION: DAMAGE TO EQUIPMENT

Risk of damage to equipment. Oil sealed vacuum pumps can cause hydrocarbons to form in the process gas which will increase the wear and tear of the hot cathode filaments.

Orientation

These instructions give information about the installation and operation of transducers with part numbers:

D14750100, D14750110, D1470120, D14750101, D14750111 and D14750121.

The part number can be found on the product identification label. Technical modifications are reserved without prior notification.

Delivery content

The package includes:

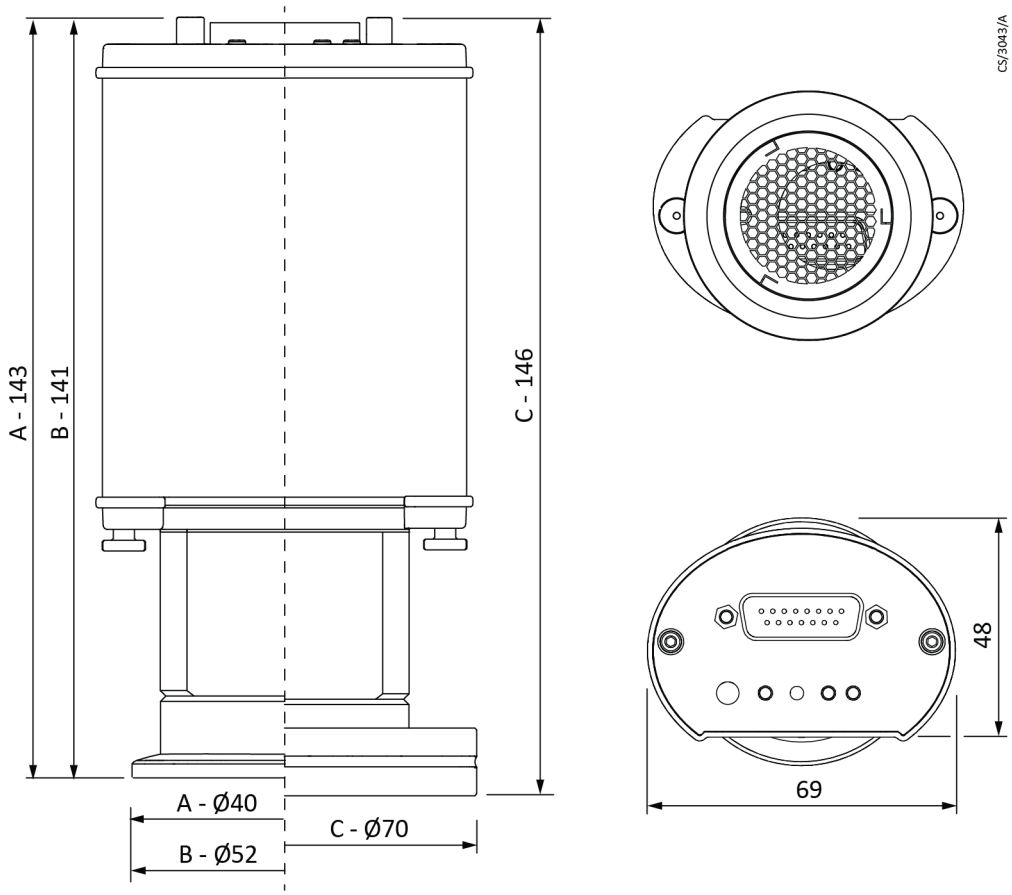
- The transducer
- The protective flange cover
- The instruction manual
- The software package

Technical data

Table 1 General

Measurement principle	Heat conduction Pirani/hot cathode Bayard Alpert depending on gas type
Measurement range	1000 to 5.0 x 10^{-10} mbar (750 to 5.0 x 10^{-10} Torr)
Maximum overload	4 bar absolute
Accuracy	1000 to 10 mbar: approximately 30% of full reading 10 to 1.0 x 10^{-8} mbar: 10 % of full reading
Repeatability	10 to 1.0 x 10^{-2} mbar: 2 % of full reading 1.0 x 10^{-2} to 1.0 x 10^{-8} mbar: 5% of full reading
Materials with vacuum contact	Stainless steel 1.4307, tungsten, nickel, glass, platinum, iridium, yttria oxide
Filaments Bayard Alpert	yttria coated iridium
Emission current	9 µA, 100 µA, 1.0 mA, and 2.0 mA
Degas method	Ohmic heating of the anode
Reaction time	50 ms (switching of emission current < 2.0 seconds)
Operating temperature	5 to 60 °C
Storage temperature	-40 to +65 °C
Bake-out temperature	Maximum 180 °C at the flange (voltage supply switched-off)
Voltage supply	20 to 30 V d.c.
Power consumption	Maximum 8 W, additionally 1 W for degas, 0.8 W for relays
Output signal	0 to 10 V d.c., minimum 10 kΩ measuring range 1.219 to 8.6 V d.c., logarithmic
Serial interface	RS485: 9.6 to 115 kBd, 8 data-bit, 1 stop-bit, no parity
Switch-points	2x relay, potential free 50 V a.c./2 A or 30 V d.c./2 A, maximum 60 VA
Electrical connection	Sub-D, 15-pole, male, lockable
Vacuum connection	D14750100: DN25 ISO KF D14750110: DN40 ISO KF D14750120: DN40 CF
Dimensions	141 x 69 x 48 mm (D14750110)
Protection class	IP 40 (IP54)
Weight	475 g (D14750110)

Figure 1 Dimensions



A. D14750100
B. D14750110
C. D14750120

Installation

Installation notes

Installation location:	Indoor

For open buildings and operation rooms without air conditioning:

Temperature:	+5 °C to +60 °C
Relative humidity:	Maximum 80% up to 30 °C, maximum 50% at 40 °C, non-condensing
Air pressure:	860 to 1060 mbar

Vacuum connection

CAUTION: DAMAGE TO EQUIPMENT

Risk of damage to equipment. Dirt and damage can have a bad effect on the function of the transducer.

- Remove the protective cover. Store the cover for future maintenance.
- Make the vacuum connection with a small flange DN25 ISO KF, DN40 ISO KF or conflat flange DN40CF.
- Use clamps which can open and close with applicable tools only (for example, a strap retainer tension ring), use sealing rings with a centring ring.
- Make sure that the sensor flange is connected to ground, for example, by having electrical contact to the grounded vacuum chamber (use metallic clamps).

The transducer can be installed in any orientation. If installed with the flange at the top, it can lead to early contamination and malfunction.

An upright orientation with the flange to the bottom is recommended to keep particles and condensates out of the sensor cell. The transducer is adjusted in the upright position. Reorientation without a readjustment will decrease accuracy at pressures above 20 mbar.

WARNING: PRESSURIZED CONTAINER

Risk of injury or death. A release of parts and process gases because of system overpressure more than 1 bar causes a hazard. Do not open any clamps while the vacuum system is pressurized. Use clamps designed for overpressure conditions.

WARNING: PRESSURIZED CONTAINER

Risk of injury or death. A release of process gases because of system overpressure more than 1.5 bar causes a hazard. KF flange connections with elastomer seals cannot resist such pressures. Use O-rings with an outer centring ring.

WARNING: NOT FAIL-SAFE DESIGNED

Risk of death. Do not use the gauge for safety critical applications. The gauge is not intended to be fail-safe.

CAUTION: DAMAGE TO EQUIPMENT

Risk of damage to equipment. Prevent forced twisting or violent opening when you install the transducer. This can damage the transducer.

Electrical connection

CAUTION: DAMAGE TO EQUIPMENT

Risk of damage to equipment. Do not connect or disconnect the transducer when the cable is on circuit.

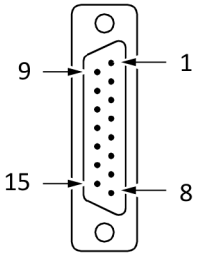
Operation with other supply and evaluation units

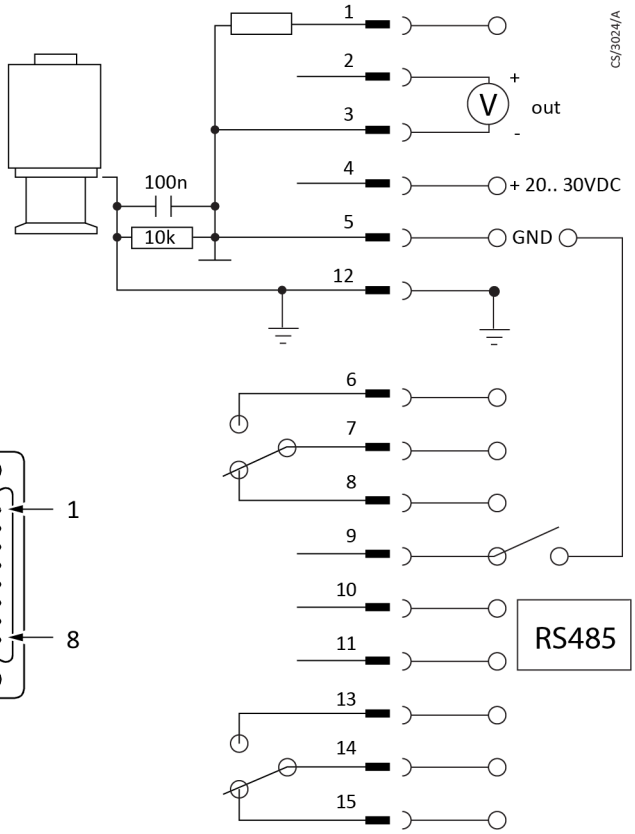
The transducer can operate with customer related display units or voltage supplies.

Use an applicable cable for the electrical connection and consider the EMI demands while you refer to the pin description shown in *Figure 2* on page 14.

Figure 2 Pin description

Socket Type Sub-D, 15-pole, male
Pin 1: Identification: 160 kΩ
Pin 2: Signal output 0-10 V d.c.
Pin 3: AGND
Pin 4: Voltage supply 24V d.c.
Pin 5: Supply common
Pin 6: Relay 1, N.O.
Pin 7: Relay 1, common
Pin 8: Relay 1, N.C.
Pin 9: Degas, external
Pin 10: RS485 +
Pin 11: RS485 -
Pin 12: Shield
Pin 13: Relay 2, N.O.
Pin 14: Relay 2, common
Pin 15: Relay 2, N.C.





Note:

We recommend to have a shield (Pin 12) and a supply common (Pin 5) grounded in the supply unit.

CAUTION: DAMAGE TO EQUIPMENT

Risk of damage to equipment. An incorrect connection or supply voltage can damage the transducer. Make sure the supply is connected and is of the correct voltage.

Operation

General

Measurement principle

The transducer has a Pirani/hot cathode internal combination sensor.

The Pirani principle uses the heat conduction of gases to measure vacuum. A sensor filament in a Wheatstone bridge circuit is heated to a constant temperature, so the bridge voltage is a measure for total gas pressure.

The hot cathode sensor of Bayard Alpert type ionizes gas molecules by electron bombardment. The ion current that results is a measure for the number of gas molecules in the sensor and proportional to the absolute pressure.

Output signal

The output signal 1.219 to 8.6 V of your transducer has a logarithmic dependence on pressure over the whole measurement range of 5.0×10^{-10} to 1000 mbar.

Conversion of the voltage signal and pressure is done according to the following formula:

$$V_{out}/V = 0.6 \log (p/mbar) + 6.8$$

$$p/mbar = 10^{((Vout/V - 6.8)/0.6)}$$

Serial interface RS485

The absolute pressure measured can be read out digitally by the transducers serial RS485 interface. Additionally you can set various parameters like gas correction factors or setpoints. For further information see *Communication* on page 20.

Warm-up time

The signal output of the transducer is available for approximately 2 seconds after the unit is switched on. To get the maximum accuracy of the unit, you should allow 5 minutes for stabilization, especially when extreme pressure changes have occurred.

Accuracy

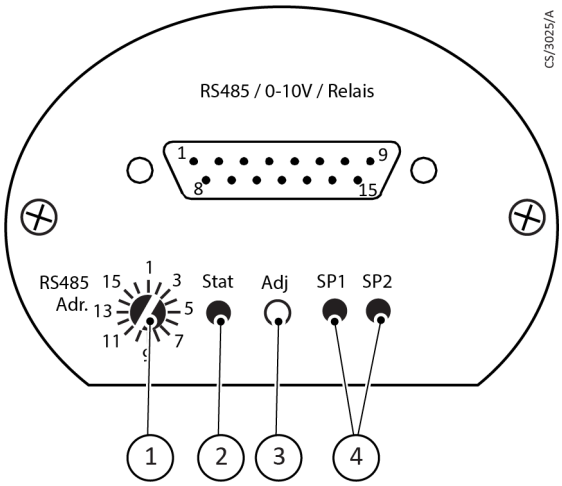
The unit is adjusted ex works in the upright position and a 24 V d.c. voltage supply. Through contamination, ageing, extreme climatic conditions or alternate mounting orientation, readjustment can become necessary. Accuracy is decreased in the range above 20 mbar.

Dependence on gas type

The composition and the type of the gas being measured controls the output signal. The unit is adjusted for nitrogen and dry air. For other gases correction factors for both sensor types can be set by the RS485 (see *Sensor parameters* on page 23). This results in a correct pressure display below 0.1 mbar.

Operate the transducer

Figure 3 General arangement



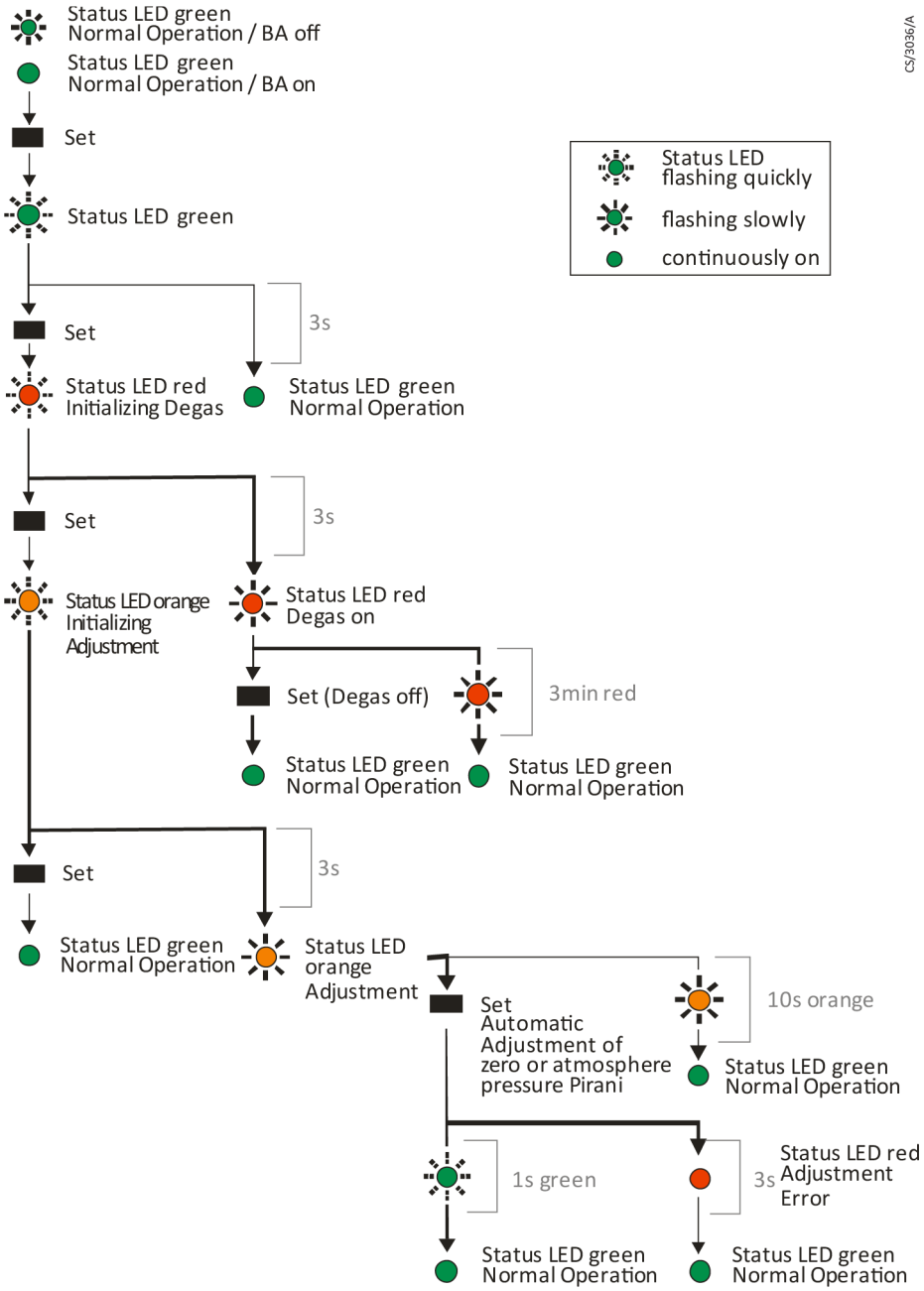
1. Address switch
2. Status LED
3. Pushbutton
4. Switch-point LEDs

The transducer has a status LED which indicates the following operational states:

- Normal operation/hot cathode on (green LED continuously on)
- Normal operation/hot cathode off (green LED flashes slowly)
- Initialize input (green LED flashes quickly)
- Error (red LED continuously on)
- Degas on (red LED flashes slowly)
- Initialize degas (red LED flashes quickly)
- Warning: Hot cathode filament 1 defective (orange LED continuously on)
- Ready for adjustment (orange LED flashes slowly)
- Initialize adjustment (orange LED flashes quickly)

The switch-point LEDs are illuminated when the related relay is activated.

The transducer ADJ pushbutton can start the "degas" and "adjustment" functions.



Degas

Deposition or adsorbed gas molecules on the electrodes of the hot cathode sensor may lead to increased degassing in ultra-high vacuum or even cause instabilities of the measurement signal.

If this occurs, clean the sensor anode from the deposited material and adsorbed gas molecules by degassing. This is done at pressure below 2.0 x 10^{-6} mbar by ohmic heating of the anode to temperatures approximately 800 °C.

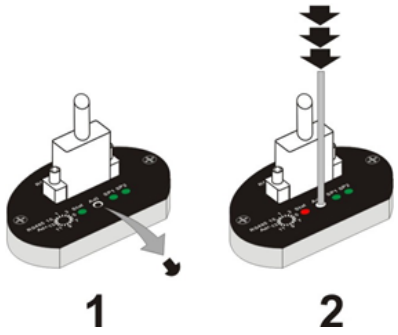
Degas control by pushbutton

The degas function can be activated by the pushbutton on the transducer (see *Operate the transducer* on page 16).

To do this:

1. Remove the rubber cap above the ADJ pushbutton (1).
2. Press the button several times with a small screwdriver or similar tool (2) until the red status LED starts flashing quickly.
3. After 3 seconds, the degas process starts, red status LED flashes slowly.
4. The degas procedure will end automatically after approximately 3 minutes. To stop the degas procedure anytime before the process ends automatically, press any key.
5. Insert the rubber cap again.

Figure 4 Manual degas



Degas control by external voltage signal

Degas is started when you connect Pin 9 (see *Operation with other supply and evaluation units* on page 13) to GND for a minimum of 20 milliseconds.

The degas procedure will stop automatically after approximately 3 minutes, but can be stopped any time by reconnecting Pin 9 to its previous state.

The red status LED flashes when the sensor degasses.

Degas control with a software command

See *Sensor parameters* on page 23.

Bake-out

CAUTION: DAMAGE TO EQUIPMENT

Risk of damage to equipment. The voltage supply to the transducer must be stopped while the chamber is heated. If not, damage to the electronic components can result.

When a bake-out operation of the vacuum chamber is done with the transducer being installed to the chamber, the temperature at the sensor flange must be less than 180 °C.

Readjustment

The transducer is adjusted and works with a 24 V d.c. voltage supply in the upright position, with the flange to the bottom.

Re-adjustment of the Pirani sensor can be necessary if orientation changes, operation under different climatic conditions, extreme temperature changes, ageing or contamination occurs.

Readjustment by pushbutton

Readjustment at atmospheric or zero pressure can be done by the transducer ADJ pushbutton (see *Operate the transducer* on page 16). The transducer will automatically tell which adjustment point is related.

Note:

Zero adjustment actual pressure should be less than 5 x 10^{-5} mbar.

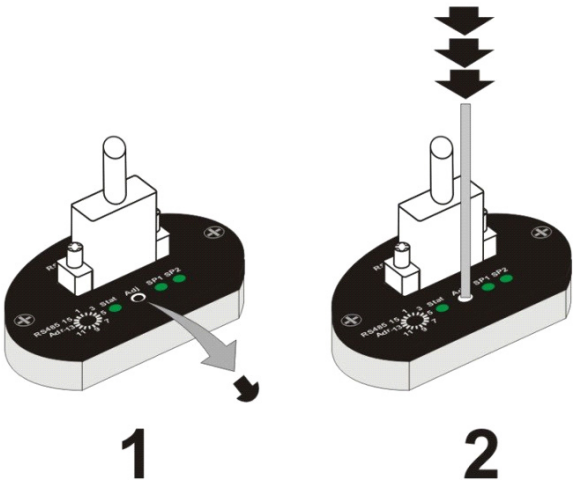
Note:

To get optimum results of the adjustment, we recommend a minimum warm-up time of 10 minutes at the applicable calibration pressure before any adjustment.

To adjust:

1. Remove the rubber cap above the ADJ button (1).
2. Press the pushbutton several times with a screwdriver or other suitable tool (2) until the orange status LED flashes.
3. After 3 seconds, a slow flashing status LED means the transducer can be readjusted. Push the button once again.
4. Reinsert the rubber cap.

Figure 5 Manual readjustment



Readjustment with a software command

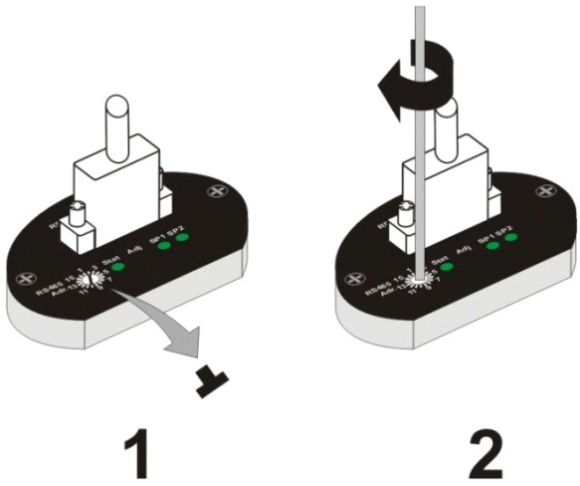
See *Readjustment (761)* on page 23.

Communication

Serial interface

The transducer has a serial RS485 interface. To set the device address for communication by the RS485, remove the rubber cap from address switch (1) and then set the address switch to a value between 1 and 16 with a small screwdriver or a similar tool (2). Reinsert the rubber cap.

Figure 6 Set the address



Communication telegrams are transmitted as ASCII text according to the Edwards DX protocols. Detailed information is given in the instruction manual D02691880.

Note:

The analogue output signal, 0 to 10 V d.c., is available with the RS485.

Interface parameter

9.6 / 14.4 / 19.2 / 38.4 / 57.6 / 115.2 kBd, 8 data bits, 1 stop-bit, no parity

Survey of commands

Table 2 Survey of commands

Command	Code
Gauge type	0
Serial number	790
Run hours	769
Baud rate	780
Gauge control	752
Relay 1	754
Relay 2	764
Adjust	761
DeGas	762
Transition mode	763
Filament control	765
Gas type	756

Device parameters and information

Gauge type (0):
Query of device type

Serial Number (790):
Query of device serial number

Run hours (769):
Read out hours operated counter

The counter starts when the gauge is connected to the voltage supply, 15 minute increments

Baud rate (780):
Set the baud rate for data transmission

Value range: 9600, 14400, 19200, 28800, 38400, 57600, 115200 baud

Measurement query

Measurement Value 752:
Query current pressure measurement.

Switch-points (754/764)

The transducer gives 2 independent, potential-free relay switch-points. These are available as changeover switches at the connector according to the pin assignment given in *Operation with other supply and evaluation units* on page 13.

Relay R1, R2:

The relays can be independently configured for the various switching modes. The parameter is used to query and set the switching modes. For details on setting and reading relays, see instruction manual D02691880.

CAUTION: DAMAGE TO THE RELAY

Risk of damage to equipment. Setting the “open/close” as equal is not permitted. A gap between the thresholds being too small will result in flickering and damage to the relay.

Setting E:	Relay closes if a device error occurs.
Setting !E:	Relay opens if a device error occurs.
Setting U:	Relay closes if pressure underrange occurs.
Setting !U:	Relay opens if pressure underrange occurs.
Setting C:	Relay closes when the hot cathode is switched on.
Setting !C:	Relay opens when the hot cathode is switched on.

Setting W: Relay closes if one of the BA-filaments is defective.

Setting !W: Relay opens if one of the BA-filaments is defective.

Note:

The control LEDs on top of the transducer will be illuminated if the related relay is activated.

Readjustment (761)

The transducer is adjusted and works with a 24 V d.c. voltage supply in the upright position, and the flange to the bottom.

Other orientation, operation under different climatic conditions, extreme temperature changes, ageing or contamination can result in the need for readjustment of the Pirani sensor.

Adjust High

Adjustment of the Pirani sensor at atmosphere pressure.

Adjust Low

Adjustment of the Pirani sensor at zero pressure. For this purpose the actual pressure must be less than 5.0×10^{-5} mbar.

Note:

To achieve optimum results from the adjustment we recommend to consider a warm-up of a minimum of 10 minutes at the applicable calibration pressure before adjustment.

Sensor parameters

Degas (762)

Deposition or adsorbed gas molecules on the electrodes of the hot cathode sensor may lead to increased degassing in ultra high vacuum or cause instabilities of the measurement signal.

If this occurs, clean the sensor anode from the deposited material and adsorbed gas molecules by degassing. This is done at pressures below 2.0×10^{-6} mbar by ohmic heating of the anode to temperatures around 800 °C.

The parameter is used to control the degas procedure and query the status.

"0": Degas off

"1": Degas on

Note:

The degas procedure stops automatically after approximately 3 minutes, but can be cancelled at any time. The red status LED will flash when the sensor degasses.

Sensor Transition (763)

By default the transducer performs a continuous transition between a Pirani and a hot cathode range where an assimilation of the sensor signals is carried out.

In order to adapt the performance of the transducer to the requirements of the vacuum process, the RS485 Sensor Transition parameter can be configured to:

"0":	No transition, but direct switch-over between the Pirani and the hot cathode sensor at 4 x 10^{-4} mbar (hot cathode on at 4 x 10^{-4} mbar and off at 6 x 10^{-4} mbar)
"1":	(Default) continuous transition in the range 1.0 to 2.0 x 10^{-3} mbar (hot cathode on at 3 x 10^{-3} mbar and off at 4 x 10^{-3} mbar)
"2":	Continuous transition in the range 2.0 to 5.0 x 10^{-3} mbar (hot cathode on at 8 x 10^{-3} mbar and off at 9 x 10^{-3} mbar)

Cathode Control (752)

Some vacuum processes can require the automatic start of the hot cathode sensor to be suppressed, which is normally controlled by the transducer electronics. Therefore, it is possible to disable the hot cathode by software command Cathode Control with the RS485 interface:

"0":	Disabled - hot cathode sensor remains switched-off
"1":	Enabled (default) - hot cathode start is automatically controlled

When the hot cathode is disabled the transducer is like a Pirani transducer with a range 1000 to 1 x 10^{-4} mbar.

If less than 1 x 10^{-4} mbar, the serial interface sends a "ur" signal for underrange, the analogue output remains at a voltage corresponding to 1 x 10^{-4} mbar.

Note:

The parameter Cathode Control is temporarily saved in the transducer memory. After the mains supply is switched to “off” or disconnected, the parameter will be reset to "1" and the hot cathode enabled.

Filament Control (765)

The Bayard Alpert hot cathode sensor of the transducer has two filaments. This parameter defines the manner these filaments will be used:

"0":	(Default) filament 1 active, if a defect occurs the sensor will switch to filament 2
"1":	Only filament 1 will be used
"2":	Only filament 2 will be used
"3":	Filament 1 and 2 will be used alternately. When the hot cathode sensor is switched off the other filament will be activated at the restart of the sensor.

Gas correction factor (756)

The output signal of the transducer depends on the type and composition of the gas to be measured. The unit is adjusted for nitrogen and dry air. For other gases, the pressure display can be corrected below 0.1 mbar by setting the correction factors for both sensor types with the RS485.

The measurement results of both sensors are then individually multiplied with its correction factor by the units micro controller. The transducer can then give a corrected pressure signal as analogue and digital output.

Value range: 0.20 to 8.0 for main gas types. To permanently correct the gas type use the values listed in instruction manual D02691880.

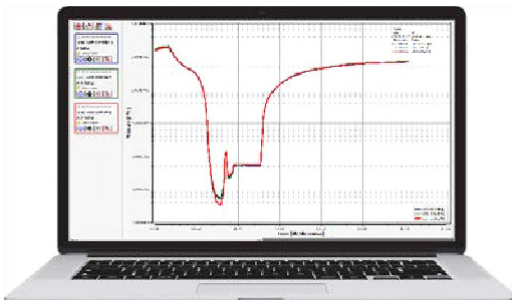
Correction factor Pirani:							
Ar	1.6	CO_2	0.89	He	1.0	Ne	1.4
CO	1.0	H_2	0.57	N_2	1.0	Kr	2.4
Correction factor hot cathode:							
Ar	0.80	H_2	2.4	N_2	1.0	Kr	0.60
CO_2	0.74	He	5.9	Ne	3.5	Xe	0.41

VacuGraph™ Software

VacuGraph™ software has been developed for use with Edwards WRH and P3 gauges and is available for Windows and Android operating systems.

VacuGraph™ can plot and save the measurement data as well as configure all device parameters.

Figure 7 VacuGraph™ software



Functions:

- Plot, analyse and save measurement curves
- Compare multiple plots
- Export measurement data for MS Excel
- Automatic calculation of leak rates by rate-of-rise measurements
- Easy configuration of all device parameters
- Scaling wizard with graphic support to adjust the voltage output characteristic.

Maintenance and service

WARNING: CONTAMINATED PARTS

Contaminated parts can cause personal injuries. Internal parts can become contaminated due to process. Make sure to obey instructions and take necessary protective measures.

The unit requires no maintenance. External dirt and soiling can be removed by a damp cloth.

If a defect or damage occur on the transducer, return the instrument to us for repair along with a Return of Edwards Equipment Declaration (HS2 Form).

CAUTION: DAMAGE TO EQUIPMENT

The unit is not a customer repair item. A defective sensor head can be exchanged on-site with a calibrated replacement sensor (spare parts D14750101, D14750111, or D14750121).

Note:

The warranty is void if contamination or wear and tear are the cause of the defect.

Error messages and fault finding

	High measurement error
Cause	**Contamination, ageing, extreme temperature, wrong adjustment.**
Remedy	Readjustment, replace sensor or send to Edwards for repair.
	Pirani zero adjustment not possible
Cause	**Measurement error exceeds possible range of readjustment.**
Remedy	Replace sensor or send to Edwards for repair.
	0.5 V < output signal < 1.0 V "UR" by RS485
Cause	**Pressure underrange.**
Remedy	Pressure < 5 x 10^{-10} mbar.
	Output signal < 0.5 V/"ERROR1" by RS485 or status LED continuously red
Cause	**Defective electronics or sensor.**
Remedy	Replace sensor or send to Edwards for repair.
	Status LED continuously orange
Cause	**Hot cathode filament 1 defective.**
Remedy	Replace sensor.

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