BlueEye™ Ex-D

Operating Manual BlueEye™ Ex-D

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Version: 05



MEMS Based Gas Quality Analyzer

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Disclaimer of Liability

The information in this user's manual is presented in good faith and believed to be accurate. Bright Sensors SA has reviewed the contents of this publication to ensure consistency with the hardware and software described. Nevertheless, since variance cannot be precluded entirely, Bright Sensors SA cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

You are solely responsible for proper operation of the described products. The instructions in this manual do not relieve you of your obligation for safe handling during application, installation, operation and maintenance.

By using this manual, you acknowledge that Bright Sensors SA cannot be held liable for any damages in excess of the purchase liability regulation. We reserve the right to make changes to this manual at any time without notice.

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Safety Precautions

Safety, Protection, and Modification of the Product

- In order to protect the system controlled by the product and the product itself and ensure safe operation, observe the safety precautions described in this user's manual. Bright Sensors SA assume no liability for safety if users fail to observe these instructions when operating the product.
- If this product is used in a manner not specified in this user's manual, the protection provided by this product may be impaired.
- If any protection or safety circuit is required for the system controlled by the product or for the product itself, prepare it separately.
- Be sure to use the spare parts approved by Bright Sensors SA when replacing parts or consumables.
- Modification of the product is strictly prohibited.

The following safety symbols are used in this manual:



This warning notice informs you of imminently threatening dangers that can arise due to misuse/operator error. If these situations are not avoided, death or severe injuries can occur.



This warning notice informs you of potentially dangerous situations that can arise due to misuse/operator error. If these situations are not avoided, minor injuries can occur.



This notice informs you of potentially dangerous situations that can arise due to misuse/operator error. If these situations are not avoided, damage to the device or nearby property can occur.



This notice can provide you with helpful tips to make your work easier. This notice also provides you with further information about the device or the work process in order to prevent operator error.

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1. Introduction

The gas quality analyzer BlueEye™ Ex-D is designed and produced according to the state of the art and generally recognized safety standards and directives. However, its use can entail dangers that are avoidable by complying with this manual. The BlueEye™ Ex-D must only be used as intended and in technically sound condition.

The BlueEye™ Ex-D is available in the following versions:

1. BlueEye™ Ex-D Extended
2. BlueEye™ Ex-D Renewable
3. BlueEye™ Ex-D Hydrogen
4. BlueEye™ Ex-D Ultragreen

This manual is applicable to all versions of the BlueEye™ Ex-D.

WARNING

Unintended use of the device voids all warranty claims.

DANGER

All of the following safety notices must be observed! Disregard of the safety notices can result in danger to the life and limb or environmental and property damage.

1.1 Function of the BlueEye™ Ex-D

The BlueEye™ Ex-D is a MEMS (Micro-electromechanical systems) gas quality measurement device. The integrated sensor unit combines Bright Sensors` patented dynamic viscosity measurement principle with other MEMS based measurement techniques, like thermal conductivity and Integrated Infrared (INIR).
Based on Bright Sensors proprietary database of thousands of gas compositions, the gas combustion properties are calculated by industry standards. Through correlative models the measurement properties are then correlated to the gas combustion parameters.



Figure 1: Sensor cell

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The BlueEye™ Ex-D correlates these measurements to the following parameters of a gas composition:

- Gross Calorific Value – **H_s** (ISO 6976:2016 / GPA 2172:2009)
- Net Calorific Value – **H_i** (ISO 6976:2016 / GPA 2172:2009)
- Gross Wobbe Index – **WI_s** (ISO 6976:2016 / GPA 2172:2009)
- Net Wobbe Index – **WI_i** (ISO 6976:2016 / GPA 2172:2009)
- Density – **ρ** (ISO 6976:2016 / GPA 2172:2009)
- Relative Density – **ρ** rel. (ISO 6976:2016 / GPA 2172:2009)
- Compression factor – **Z** (ISO 6976:2016 / GPA 2172:2009)
- Air-Fuel ratio – **AFR** (calculated based on 20.946% oxygen in air)
- Stoichiometric Air-Fuel Ratio – **s-ARF** (calculated based on 20.946% oxygen in air)
- Methane Number – **MN** (ISO 23306:2020 and EN 16726:2015)
- Carbon dioxide mol% – **CO_2 mol%** (based on IR CO_2 sensor)
- Hydrogen mol% – **H_2 mol%** (based on Bright Sensors correlative model)

The correlative models deployed by the device are temperature- and pressure-compensated within a defined range. To ensure measurement results within specifications, the following boundary conditions **MUST** be ensured for each BlueEye™ Ex-D model individually:

BlueEye™ Ex-D Specifications

Reported values	Units	Reference conditions	Applied correlation standards
Gross Calorific Value (H_s)	MJ/m³, kWh/m³ BTU/scf, Therm/scf	0/0°C, 15/0°C, 15/15°C, 20/20°C, 25/20°C, 25/0°C at 101325 Pa and 60°F at 14.65, 14.696, 14.73 and 15.025 psi **absolute**	NIST AGA-8 ISO 6976:2016 GPA 2172:2009
Net Calorific Value (H_i)			
Gross Wobbe Index (W_s)			
Net Wobbe Index (W_i)			
Density ρ	kg/m³, lbm/scf		
Air Fuel Ratio λ	-	Volume, 20.946% O_2	Simplified method
Methane Number	-	-	ISO 23306:2020 and EN 16726:2015
CO_2 & H_2 concentration [1] [2]	**mol%**	-	**Proprietary methods**

Accuracy	**≤ 1% of reading**
Repeatability	≤ 0.2% of reading [3]
Dynamics	One measurement every 1s, reaction time T90 < 30s

Gas Composition Range					
CH_4	70-100 mol%	Higher Alkanes	0-1 mol%	O_2	≤ 3 mol%
C_2H_6	0-20 mol%	N_2	0-15 mol%	H_2O (Gaseous)	≤ 0.1 mol%
C_3H_8	0-5 mol%	**CO_2**	0-3 mol% (**20**/**100** mol%) [1]	Dust, Liquids	Without
C_4H_{10}	0-3 mol%	**H_2**	≤ 0.5 mol% (**30** mol%) [2]	H_2S	≤ 0.01 mol%
H_s addressable range	27.52 to 50.40 MJ/m³ (15°C/15°C)				
Environment temperature	0 to 50°C, 32 to 122°F				
Operating gas pressures	950 to 1100 mbar **absolute**, 13.9 to 15.95 psi **absolute**				
Flow rate	30 ml/min (+/- 10%), 0.001059 scf/min (+/- 10%) [4]				

[1] only for BlueEye™ Ex-D **Renewable** & **Ultragreen**
[2] only for BlueEye™ Ex-D **Hydrogen** & **Ultragreen**
[3] unfiltered 1 second cycle measurement
[4] flow rate range customizable on request

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1.2 Working with the BlueEye™ Ex-D



All the following safety notices must be observed! Disregard of the safety notices can result in danger to the life and limb or environmental and property damage.

Bear in mind that the safety warnings in this manual and on the device cannot cover all potentially dangerous situations, because the interaction of various conditions can be impossible to foresee. Merely following the instructions may not suffice for correct operation. Always remain attentive and consider potential consequences.

- Read this operating manual and especially the following safety notices carefully before working with the device for the first time.
- Warnings are provided in the operating manual for unavoidable residual risks for users, third parties, equipment or other property. The safety instructions used in this manual do not refer to unavoidable residual risks.
- Only operate the device in fault-free condition and in observance of the operating manual.
- Compliance with local statutory accident prevention, installation and assembly regulations is also mandatory.



All notices in the manual must be observed. Use of the BlueEye™ Ex-D is only permitted in accordance with the specifications in the operating manual. Bright Sensors SA assumes no liability for damages arising due to disregard of the operating manual.



The BlueEye™ Ex-D complies with current standards and regulations. However, danger can arise with misuse and the BlueEye™ Ex-D can be destroyed due to operator error. The technical specifications in this operation manual must be observed and followed for safe operation. Performance limits must not be exceeded. For safe operation, the BlueEye™ Ex-D must only be used in the scope of the intended use. Service and maintenance tasks or repairs that are not described in the operating manual must not be carried out without prior consultation with Bright Sensors SA.

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1.3 Dangers during installation, maintenance, and repair



The BlueEye™ Ex-D is approved to be used in hazardous areas. Observe the information given in the applicable type or unit examination certificate and the relevant country-specific regulations for installation and use in hazardous areas. No observance can result in serious injury and/or damage to the equipment. Install the device as specified in the operating manual. Improper installation can lead to the loss of the explosion protection and to life-threatening situations.



In general, the following is recommended for all persons working with or on the BlueEye™ Ex-D:

- **Training / education for work in hazardous areas.**
- **The ability to correctly estimate dangers and risks when working with the BlueEye™ Ex-D.**
- **Training / education by Bright Sensors SA for work with gas measuring devices.**
- **Education / instruction in all national standards and directives to be complied with for the work to be carried out on the BlueEye™ Ex-D.**

Operating personnel:
The operating personnel use and operate the device in the scope of the intended use.

Maintenance personnel:
Work on the device must only be carried out by qualified personnel who can carry out the respective tasks on the basis of their technical training, experience and familiarity with the applicable standards and requirements. These qualified personnel are familiar with the applicable statutory regulations for accident prevention and can independently recognize and avoid potential dangers.

Maintenance and cleaning:
Maintenance and cleaning must only be performed by appropriately qualified technicians.



The device can be damaged if it is not cleaned as specified in the operating manual. Only clean the device as specified in the operating manual. Components can be damaged if you do not use suitable tools.

- Only clean the device with a slightly damp cloth!



The BlueEye™ Ex-D enclosure is epoxy coated. Under certain extreme conditions it may generate an ignition-capable level of electrostatic charges.

- DO ensure that the equipment is NOT installed in a location where it may be subjected to external conditions (such as high-pressure steam) which might cause a build-up of electrostatic charges on non-conducting surfaces.

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1.4 Certification for hazardous areas

Hazardous area classifications:

- Zone 0: An area classified as Zone 0 will have ignitable concentrations of flammable gases, vapors or liquids either continuously present or present for long periods of time under normal operating conditions.
- Zone 1: An area classified as Zone 1 is likely to have ignitable concentrations of flammable gases, vapors or liquids present under normal operating conditions. Flameproof (Exd) detectors are suitable for use in Zone 1.
- Zone 2: An area classified as Zone 2 is not likely to have ignitable concentrations of flammable gases, vapors or liquids present under normal operating conditions. Flameproof (Exd) detectors are suitable for use in Zone 2.
- Areas that may contain flammable dusts are categorized as Zone, 20, Zone 21 and Zone 22.

Under European ATEX rules hazardous area equipment has been re-defined under 'equipment categories' where:

- Equipment Category 1 is suitable for Zone 0
- Equipment Category 2 is suitable for Zone 1
- Equipment Category 3 is suitable for Zone 2

The BlueEye™ Ex-D is Ⓔx **II 2 G Ex db IIC T6 Gb** certified and is suitable for use in **Zone 1** and **Zone 2** hazardous areas.
Interpretation of the protection mark:

- Ⓔx – Specific marking for ATEX Explosion protection
- II – Equipment group (surface use)
- 2 – Equipment category (used in zone 1 and zone 2)
- G – Environment (gas)
- Ex – Explosion protection IECEx
- db – Type of protection (flameproof enclosures)
- IIC – Gas group (hydrogen, acetylene)
- T6 – Temperature class (<85°C)
- Gb – Equipment protection level

In order to achieve "Ex db" protection, we use a certified housing, a certified cable gland and our own specifically designed (sintered metal flame arrestor) gas connectors. The details are:

- Certified enclosures (EX500-AL-S) Aluminium, epoxy coated with blind cover
  Certificate number: Sira 19ATEX1252U and IECEx SIR 19.0075U
- Certified cable gland (PAX series) for armored cable
  Certificate number: INERIS 10ATEX0029X and IECEx INE 14.0003X
- Specifically designed gas connectors with sintered metal flame arrestor as per drawing in Figure 1 on the next page. The sintered metal has the following properties:
  - R80 filter grade
  - 55 µm pore size
  - 705 Pa Bubble Point
  - 4.3 – 4.7 g/cm^3 density

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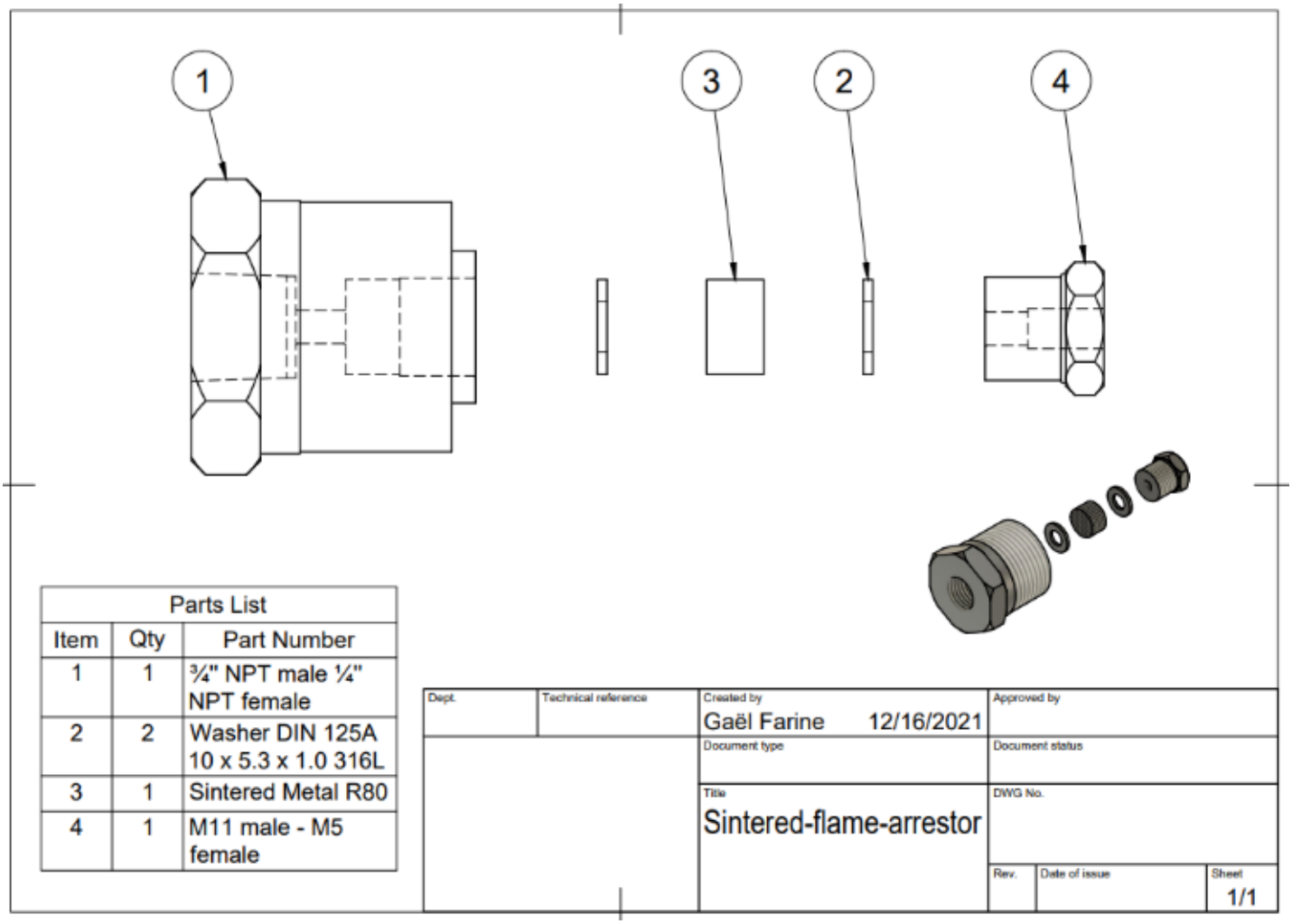
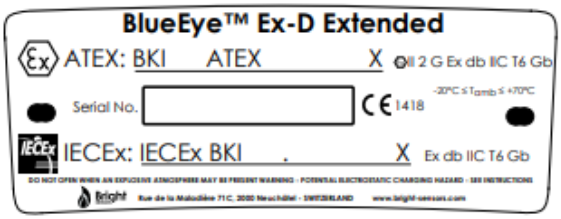
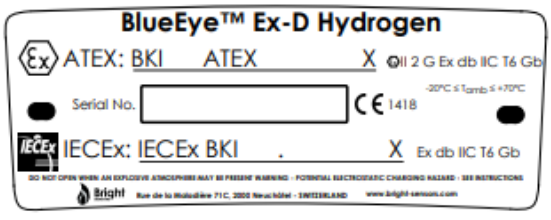
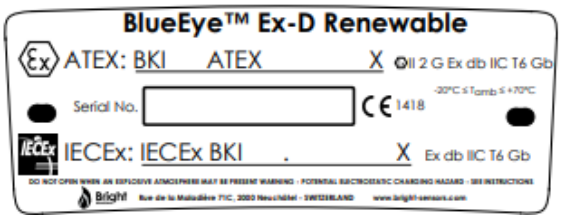


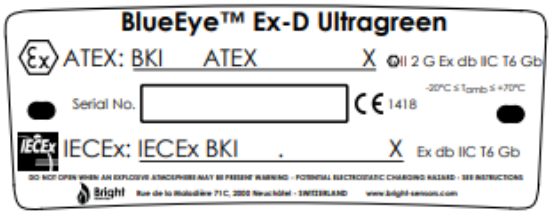
Figure 2: Specifically designed gas connector with flame arrestor

Nameplates are as follows:









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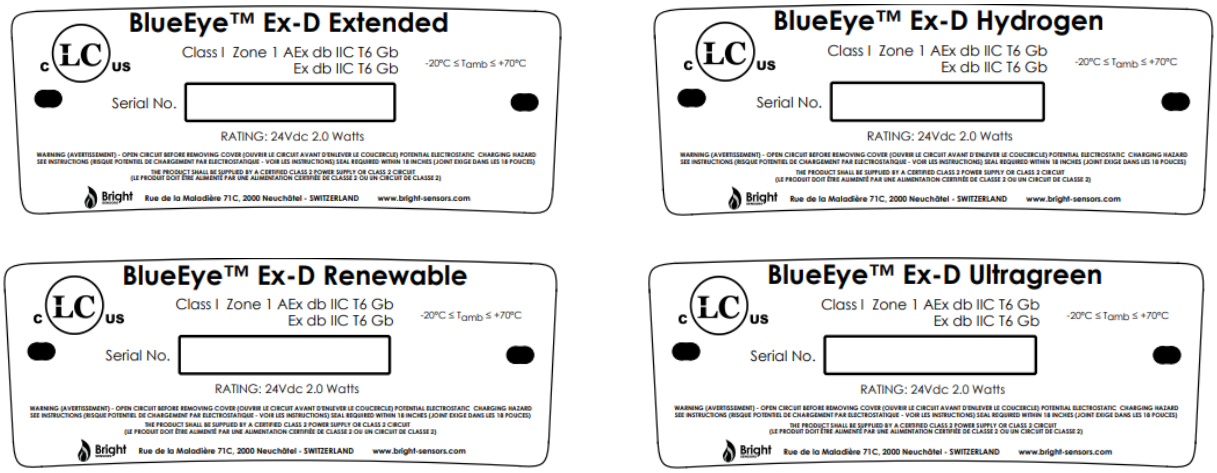
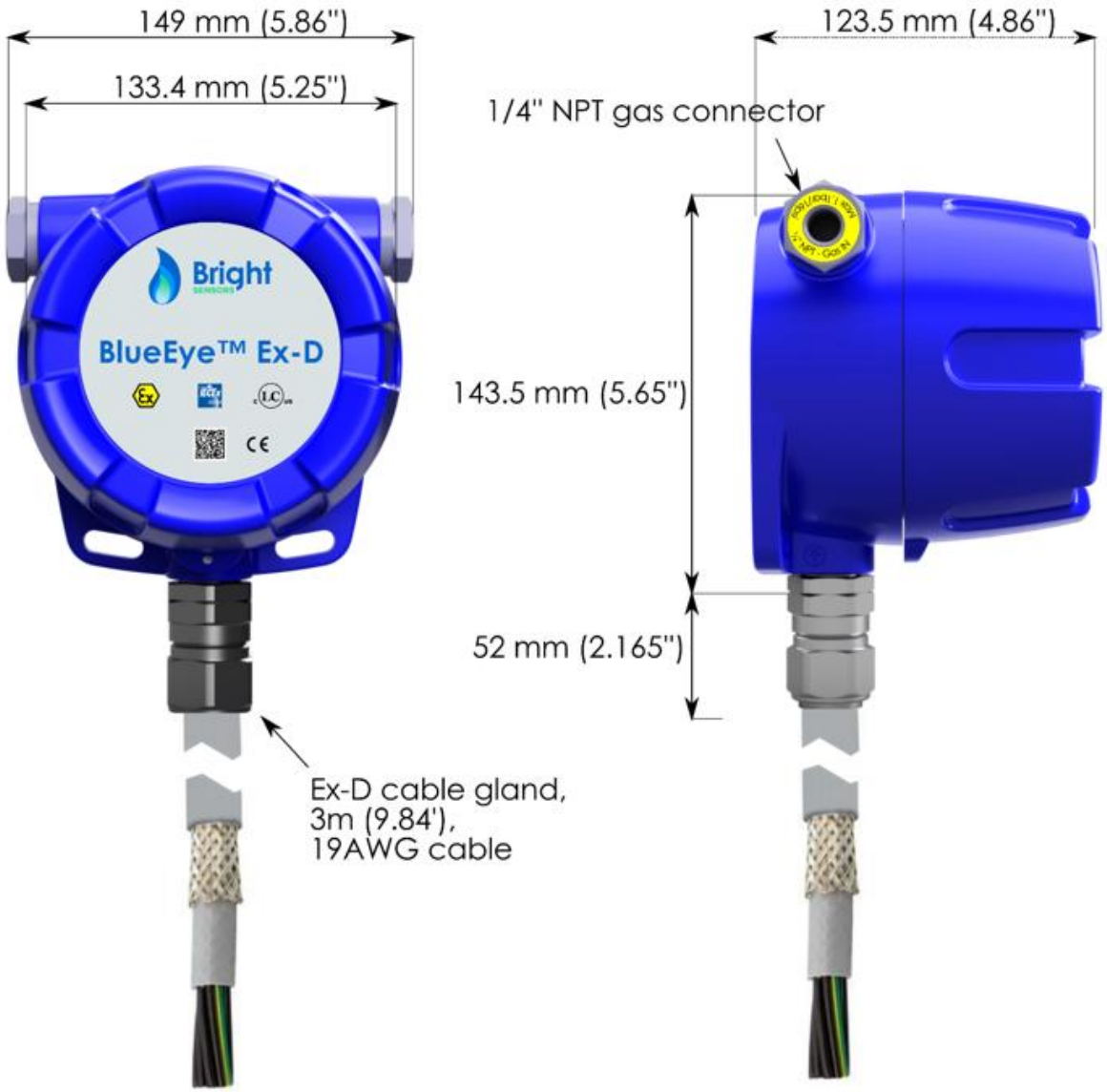


Figure 3: Nameplate layout

2. Installation

2.1 Dimensions of the BlueEye™ Ex-D

d



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2.2 Piping and Instrumentation Diagram

The BlueEye™ Ex-D is strongly recommended to be connected to a gas supply in the following way:

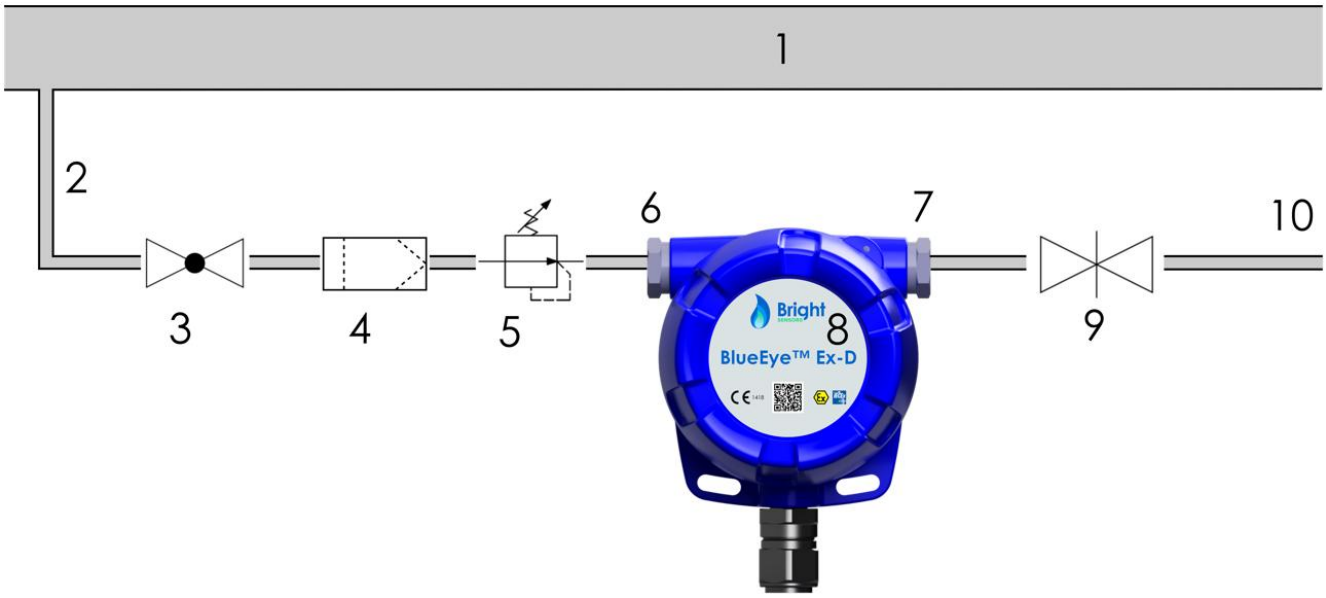


Figure 5: Connection of the BlueEye™ Ex-D to a gas pipeline

1	**Main gas supply (pipeline)**
2	Supply line: dry natural gas, as short as possible, 4 - 6 mm tube
3	Shut off valve (recommended)
4	10µm filter
5	Pressure reducer, required if main pipeline exceeds pressure of 1100 mbar absolute
6	¼" NPT female gas INLET connector
7	¼" NPT female gas OUTLET connector
8	BlueEye™ Ex-D gas quality analyzer
9	Flow reducer, to set gas low at 30 ml/min (+/- 10%)
10	Gas vent to a safe area

WARNING

Ensure that the type of gas present in the system is withing the gas composition range approved for the BlueEye™ Ex-D (see Chapter 5.4 Measured media). No observance not only could lead to possible damage to the BlueEye™ Ex-D sensor unit resulting is accuracy loss or even complete malfunction of the device.

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2.3 Mounting position and gas flow direction

The BlueEye™ Ex-D has to be mounted upright with gas connectors in horizontal position and with cable gland perpendicular to the ground (see Figure 1: Connection of the BlueEye™ Ex-D to a gas pipeline).

- Wall mounted, horizontally.
- Gas connector Inlet (6) left, gas connector Outlet (7) right.
- Cable gland pointing to the ground.

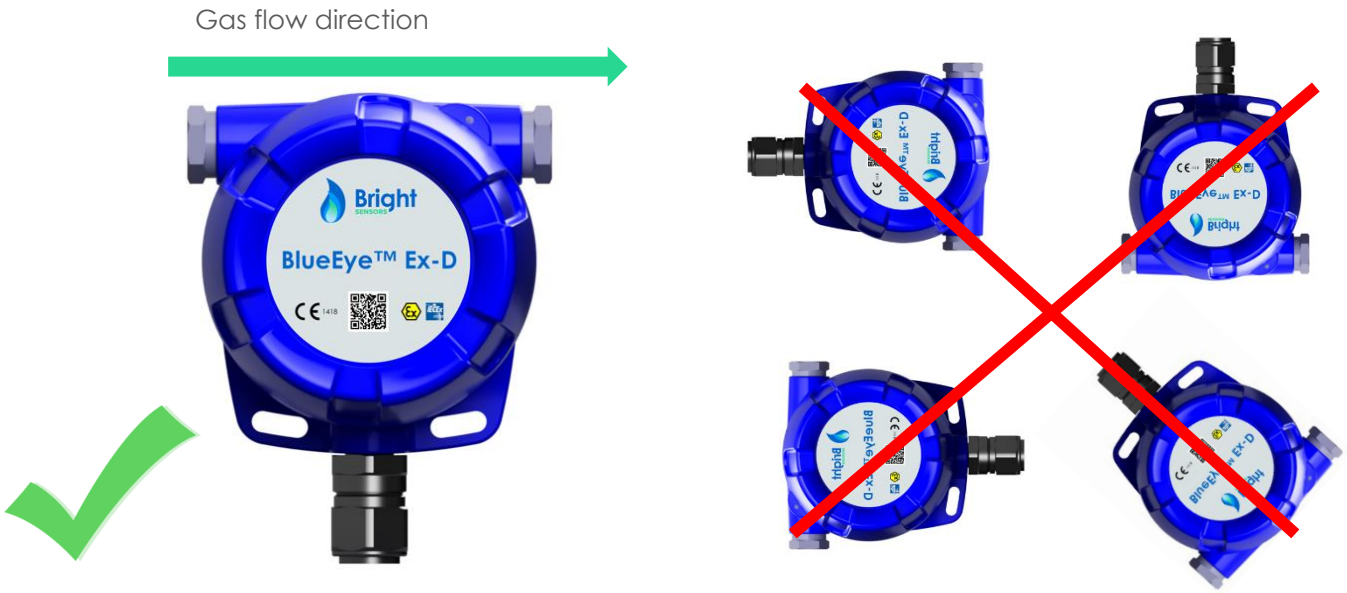


Figure 6: Gas flow direction and mounting requirements for the BlueEye™ Ex-D

2.4 Best measuring performance

The measurement will be carried out on a small amount of sample gas at low flow rates. For low latency results install a purge bypass and avoid long gas lines.

NOTICE

The BlueEye™ Ex-D is calibrated for absolute pressure range between 960 and 1100mbar absolute.
To achieve an accurate measurement reading it is necessary to a stable pressure in this absolute pressure range. Fluctuating deviating pressures will result in temporarily or permanently inaccurate measurements.

2.5 Gas inlet conditions

- Gas condition: Required is dry, filtered gas (with an external particle filtration down to 10 µm).
- Gas dew point: The gas mixture should be below 10 K of the lowest operating temperature.
- Gas pressure range: 950 to 1100 mbar absolute (13.9 to 15.95 psi absolute)
- Gas temperature range: +/- 2°C (36°F) deviating from environmental temperature

DANGER

Applying a gas pressure above 1500 mbar absolute can result in danger to the life and limb or environmental and property damage.

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2.6 Pollution

Make sure there is no pollution inside the sensor in- and outlet before connecting the instrument. Do NOT use any lubricant or sealant. Pollution can damage or even destroy the sensor.

2.7 Mechanical Stress, Liquids and Dirt

Do NOT insert any item into the openings. Mechanical stress, liquids and dirt may damage or destroy the sensor. Warranty excludes failures and damage caused by the customer, such as contamination, improper electrical hook-up, dropping etc.

2.8 Maximum Torque

To avoid mechanical damage, DO NOT drive more than 13 Nm torque on 1/4" NPT gas connectors and 2 Nm on ground connector. When removing connected gas lines from the 1/4" NPT gas connectors ensure the gas connectors are not turning by using a 27mm wrench.



Turning 1/4" NPT gas connectors can lead to damaging of the sensor cell within the BlueEye™ Ex-D and will lead to loss of warranty.

2.9 Electrical connection

The cable of the BlueEye™ Ex-D has 9 wires, with the following numbers printed on each individual wire, except for the Yellow/Green wire. The numbers correspond to the following connections:

Wire ID	Description	
1, Black	Power supply	+24 VDC
2, Black	Power supply	-24 VDC
3, Black	4-20 mA Current Loop	+
4, Black	4-20 mA Current Loop	-
5, Black	T+	RS-485_A
6, Black	T-	RS-485_B
7, Black	R+ (D+)	RS-485_Y
8, Black	R- (D-)	RS-485_Z
9, Yellow/Green	GND	Ground

Wires 1 and 2 connect the 24 VDC (+/- 10%) power supply.
Wires 3 and 4 connect the 4-20 mA current loop
Wires 5, 6, 7 and 8 connect the RS-485 Modbus RTU.
Wire 9 is the ground of the BlueEye™ Ex-D.

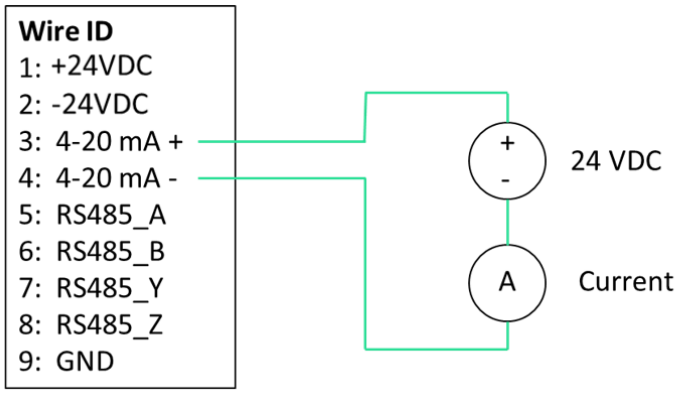


Special care must be taken with the connection of the outer end of the electrical cable of the BlueEye™ Ex-D. In case the outer end of the cable is installed within the ATEX zone, an ATEX approved junction box has to be connected to the outer end of the cable.

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2.10 Current loop wiring

The BlueEye™ Ex-D features a single, passive 4-20 mA current loop.
To use the current loop correctly, it must be powered with 24VDC as shown in the figure below.



2.11 RS-485 Modbus RTU connection

The BlueEye™ Ex-D is configured for full-duplex (4-wire) and half-duplex (2-wire) RS485 Modbus.

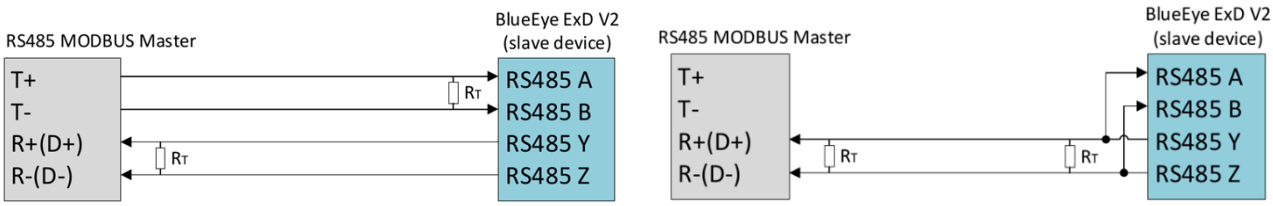


Figure 7: BlueEye™ Ex-D RS-485 Modbus RTU connection



For installation in hazardous areas ensure that the enclosure is potentially equalized. To increase immunity against electromagnetic interference, Bright Sensors SA recommends connecting the shield of the cable to earth at the outer end. Attention for applications in hazardous areas, it must be ensured that potential equalization exists between the various earthing points (i.e. between the hazardous area and safe area). For more information, please refer to standard EN 60079-14. Cover flying leads with fine wires by an end splice (cable preparation).



Ensure that supplied voltage adheres to the specified electrical characteristics and never exceeds the maximum limit.



Electrostatic discharge can damage equipment, impair electrical circuitry, and can result in complete or intermittent failures. Always place the protective caps on the connector when they are not used and do not touch the connector pins.

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3. Operation

The BlueEye™ Ex-D has no external or internal switches. By connecting wire 1 to +24 VDC and wire 2 to -24 VDC (as shown in the table under heading 2.9 "Electrical connection"), the BlueEye™ Ex-D will automatically start operating. After approximately 3 minutes of data communication via RS485 Modbus RTU is activated and the 4-20 mA current loop will provide a signal.

3.1 Communication with the BlueEye™ Ex-D

There are two ways to communicate with the BlueEye™ Ex-D:

1. Over RS485 Modbus RTU
2. By using Bright Sensors` Modbus USB Windows Interface Package

Communication over RS485 Modbus RTU requires the user to connect the BlueEye™ Ex-D to its own Modbus system. Communication over Bright Sensors` Modbus USB Windows Interface Package allows the user to operate the BlueEye™ Ex-D in a Plug and Play way. It has additional functionalities such as charting, storing the output parameters in CSV format, and switching reference condition and units, applying moving averages, etc.

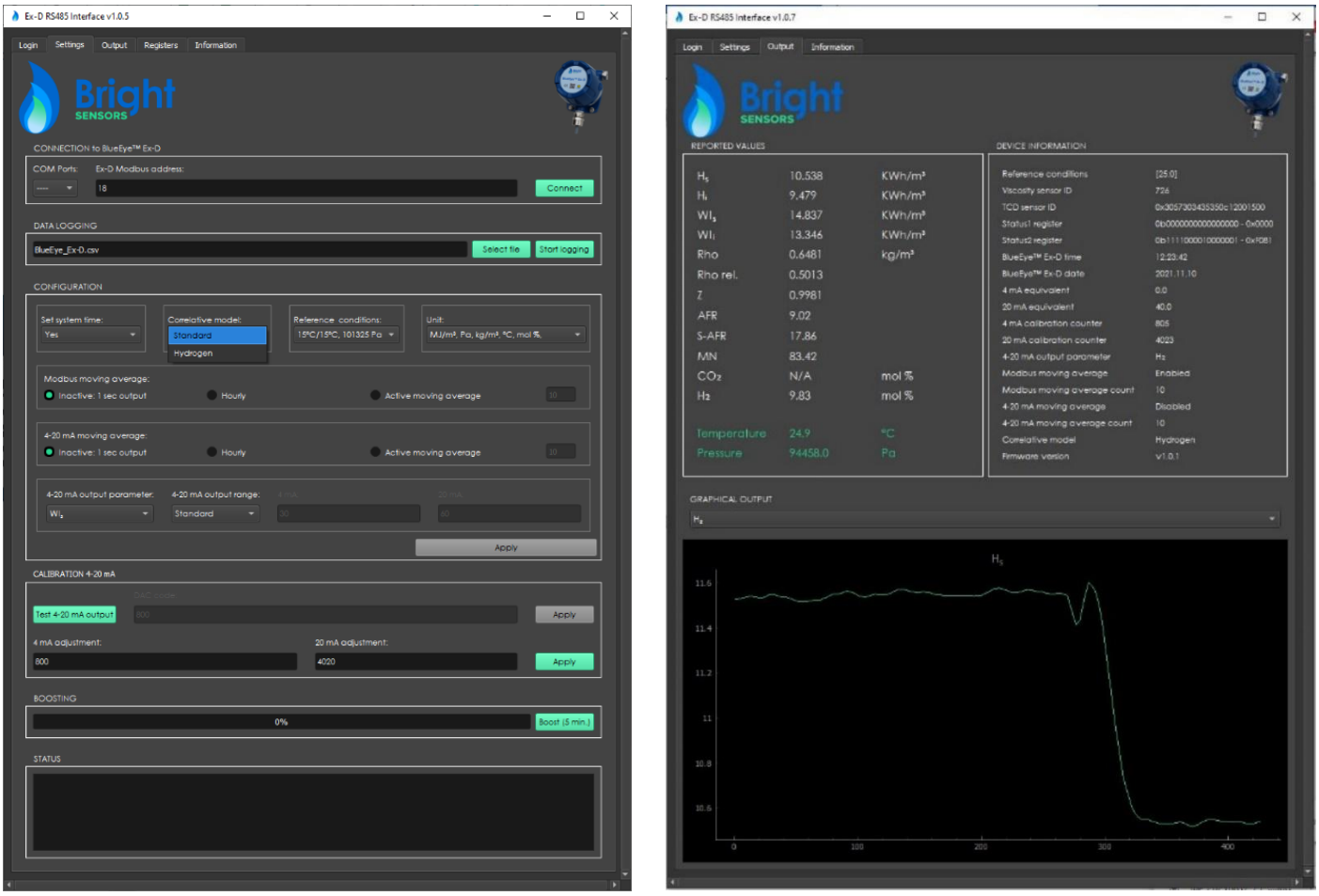


Figure 8: BlueEye™ Ex-D Modbus USB Windows Interface Package

For more specific information on the Modbus USB Windows Interface Package please read the Modbus USB Windows Interface Package manual, to be found here: https://www.bright-sensors.com/blueeye-ex-d/

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3.2 First time usage

To reduce warmup time during first operation when the BlueEye™ Ex-D is for the first time connected to a gas supply, it is recommended to use the "Boosting" function. This function can be activated by Modbus or by using the Modbus USB Windows Interface Package.

3.3 Reported output

The BlueEye™ Ex-D writes every second the following parameters to dedicated registers and continuously reports 1 selected parameter via the single 4-20mA current loop:

- Gross Calorific Value – **H_s**
- Net Calorific Value – **H_i**
- Gross Wobbe Index – **WI_s**
- Net Wobbe Index – **WI_i**
- Density – **ρ**
- Relative Density – **ρ** rel.
- Compression factor – **Z**
- Air-Fuel ratio – **AFR**
- Stoichiometric Air-Fuel Ratio – **s-ARF**
- Methane Number – **MN**
- Carbon dioxide mol% – **CO_2 mol%** only for Renewable and Ultragreen models
- Hydrogen mol% – **H_2 mol%** only for Hydrogen and Ultragreen models

Please check the Modbus Manual in Appendix A for the Modbus. The default 4-20mA current loop ranges are defined as per table below and can be modified individually via the Modbus registers. The 4-20mA current loop output and range can be user defined via the Modbus registers.

Selectable Measurement Output				**One of Parameters: H_s, H_i, WI_s, WI_i, ρ, ρ rel., Z, AFR, s-AFR, MN, CO_2, H_2**							
Default Output Range Definition				**Default ranges per table below. Customization range possible via Modbus.**							
Output	**Ref Con**	**Range**	**Units**	**Output**	**Ref Con**	**Range**	**Units**	**Output**	**Ref Con**	**Range**	**Units**
WIs	00/00	32 - 63	MJ/m³	HHV	00/00	26 - 58	MJ/m³	LHV	00/00	23 - 53	MJ/m³
WIs	15/00	32 - 63	MJ/m³	HHV	15/00	26 - 58	MJ/m³	LHV	15/00	23 - 53	MJ/m³
WIs	15/15	30 - 60	MJ/m³	HHV	15/15	25 - 55	MJ/m³	LHV	15/15	22 - 50	MJ/m³
WIs	20/20	29 - 59	MJ/m³	HHV	20/20	25 - 54	MJ/m³	LHV	20/20	22 - 49	MJ/m³
WIs	25/00	32 - 63	MJ/m³	HHV	25/00	26 - 58	MJ/m³	LHV	25/00	23 - 53	MJ/m³
WIs	00/00	9 - 18	kWh/m³	HHV	00/00	7 - 16	kWh/m³	LHV	00/00	6 - 15	kWh/m³
WIs	15/00	9 - 18	kWh/m³	HHV	15/00	7 - 16	kWh/m³	LHV	15/00	6 - 15	kWh/m³
WIs	15/15	8 - 17	kWh/m³	HHV	15/15	7 - 15	kWh/m³	LHV	15/15	6 - 14	kWh/m³
WIs	20/20	8 - 17	kWh/m³	HHV	20/20	7 - 15	kWh/m³	LHV	20/20	6 - 14	kWh/m³
WIs	25/00	9 - 18	kWh/m³	HHV	25/00	7 - 16	kWh/m³	LHV	25/00	6 - 15	kWh/m³
WIs	60/14.696	805 - 1610	BTU/scf	HHV	60/14.696	670 - 1480	BTU/scf	LHV	60/14.696	590 - 1342	BTU/scf

Selectable Measurement Output				One of following parameters: H_s, H_i, WI_s, WI_i, ρ, ρ rel., Z, AFR, s-AFR, MN, CO_2, H_2, Temperature, Absolute pressure							
Default Output Range Definition				Default ranges per table below. Customization range possible via Modbus.							
Output	**Ref Con**	**Units**	**Range**	**Output**	**Ref Con**	**Units**	**Range**	**Output**	**Ref Con**	**Units**	**Range**
Hs	00/00	MJ/m3	26 - 58	**Hi**	**00/00**	**MJ/m3**	**23 - 53**	WIs	00/00	MJ/m3	32 - 63
Hs	15/00	MJ/m3	26 - 58	**Hi**	**15/00**	**MJ/m3**	**23 - 53**	WIs	15/00	MJ/m3	32 - 63
Hs	15/15	MJ/m3	25 - 55	**Hi**	**15/15**	**MJ/m3**	**22 - 50**	WIs	15/15	MJ/m3	30 - 60
Hs	20/20	MJ/m3	25 - 54	**Hi**	**20/20**	**MJ/m3**	**22 - 49**	WIs	20/20	MJ/m3	29 - 59
Hs	25/00	MJ/m3	26 - 58	**Hi**	**25/00**	**MJ/m3**	**23 - 53**	WIs	25/00	MJ/m3	32 - 63
Hs	25/20	MJ/m3	25 - 54	**Hi**	**25/20**	**MJ/m3**	**22 - 49**	WIs	25/20	MJ/m3	29 - 59
Hs	00/00	kWh/m3	7 - 16	**Hi**	**00/00**	**kWh/m3**	**6 - 15**	WIs	00/00	kWh/m3	9 - 18
Hs	15/00	kWh/m3	7 - 16	**Hi**	**15/00**	**kWh/m3**	**6 - 15**	WIs	15/00	kWh/m3	9 - 18

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Hs	15/15	kWh/m3	7 - 15	**Hi**	**15/15**	**kWh/m3**	**6 - 14**	WIs	15/15	kWh/m3	8 - 17
Hs	20/20	kWh/m3	7 - 15	**Hi**	**20/20**	**kWh/m3**	**6 - 14**	WIs	20/20	kWh/m3	8 - 17
Hs	25/00	kWh/m3	7 - 16	**Hi**	**25/00**	**kWh/m3**	**6 - 15**	WIs	25/00	kWh/m3	9 - 18
Hs	25/20	kWh/m3	7 - 15	**Hi**	**25/20**	**kWh/m3**	**6 - 14**	WIs	25/20	kWh/m3	8 - 17
Hs	00/00	BTU/scf	697.8 - 1556.7	**Hi**	**00/00**	**BTU/scf**	**617.3 - 1422.5**	WIs	00/00	BTU/scf	858.9 - 1690.9
Hs	15/00	BTU/scf	697.8 - 1556.7	**Hi**	**15/00**	**BTU/scf**	**617.3 - 1422.5**	WIs	15/00	BTU/scf	858.9 - 1690.9
Hs	15/15	BTU/scf	671 - 1476.2	**Hi**	**15/15**	**BTU/scf**	**590.5 - 1342**	WIs	15/15	BTU/scf	805.2 - 1610.4
Hs	20/20	BTU/scf	671 - 1449.3	**Hi**	**20/20**	**BTU/scf**	**590.5 - 1315.1**	WIs	20/20	BTU/scf	778.3 - 1583.5
Hs	25/00	BTU/scf	697.8 - 1556.7	**Hi**	**25/00**	**BTU/scf**	**617.3 - 1422.5**	WIs	25/00	BTU/scf	858.9 - 1690.9
Hs	25/20	BTU/scf	671 - 1449.3	**Hi**	**25/20**	**BTU/scf**	**590.5 - 1315.1**	WIs	25/20	BTU/scf	778.3 - 1583.5
Hs	00/00	therm/scf	0.007 - 0.0156	**Hi**	**00/00**	**therm/scf**	**0.0062 - 0.0142**	WIs	00/00	therm/scf	0.0086 - 0.0169
Hs	15/00	therm/scf	0.007 - 0.0156	**Hi**	**15/00**	**therm/scf**	**0.0062 - 0.0142**	WIs	15/00	therm/scf	0.0086 - 0.0169
Hs	15/15	therm/scf	0.0067 - 0.0148	**Hi**	**15/15**	**therm/scf**	**0.0059 - 0.0134**	WIs	15/15	therm/scf	0.0081 - 0.0161
Hs	20/20	therm/scf	0.0067 - 0.0145	**Hi**	**20/20**	**therm/scf**	**0.0059 - 0.0132**	WIs	20/20	therm/scf	0.0078 - 0.0158
Hs	25/00	therm/scf	0.007 - 0.0156	**Hi**	**25/00**	**therm/scf**	**0.0062 - 0.0142**	WIs	25/00	therm/scf	0.0086 - 0.0169
Hs	25/20	therm/scf	0.0067 - 0.0145	**Hi**	**25/20**	**therm/scf**	**0.0059 - 0.0132**	WIs	25/20	therm/scf	0.0078 - 0.0158
Hs	60/14.696	MJ/m3	25 - 55.1	**Hi**	**60/14.696**	**MJ/m3**	**22 - 50**	WIs	60/14.696	MJ/m3	30 - 60
Hs	60/14.65	MJ/m3	25 - 55.1	**Hi**	**60/14.65**	**MJ/m3**	**22 - 50**	WIs	60/14.65	MJ/m3	30 - 60
Hs	60/14.73	MJ/m3	25 - 55.1	**Hi**	**60/14.73**	**MJ/m3**	**22 - 50**	WIs	60/14.73	MJ/m3	30 - 60
Hs	60/15.025	MJ/m3	25 - 55.1	**Hi**	**60/15.025**	**MJ/m3**	**22 - 50**	WIs	60/15.025	MJ/m3	30 - 60
Hs	60/14.696	kWh/m3	6.9 - 15.3	**Hi**	**60/14.696**	**kWh/m3**	**6.1 - 13.9**	WIs	60/14.696	kWh/m3	8.3 - 16.7
Hs	60/14.65	kWh/m3	6.9 - 15.3	**Hi**	**60/14.65**	**kWh/m3**	**6.1 - 13.9**	WIs	60/14.65	kWh/m3	8.3 - 16.7
Hs	60/14.73	kWh/m3	6.9 - 15.3	**Hi**	**60/14.73**	**kWh/m3**	**6.1 - 13.9**	WIs	60/14.73	kWh/m3	8.3 - 16.7
Hs	60/15.025	kWh/m3	6.9 - 15.3	**Hi**	**60/15.025**	**kWh/m3**	**6.1 - 13.9**	WIs	60/15.025	kWh/m3	8.3 - 16.7
Hs	60/14.696	BTU/scf	670 - 1480	**Hi**	**60/14.696**	**BTU/scf**	**590 - 1342**	WIs	60/14.696	BTU/scf	805 - 1610
Hs	60/14.65	BTU/scf	670 - 1480	**Hi**	**60/14.65**	**BTU/scf**	**590 - 1342**	WIs	60/14.65	BTU/scf	805 - 1610
Hs	60/14.73	BTU/scf	670 - 1480	**Hi**	**60/14.73**	**BTU/scf**	**590 - 1342**	WIs	60/14.73	BTU/scf	805 - 1610
Hs	60/15.025	BTU/scf	670 - 1480	**Hi**	**60/15.025**	**BTU/scf**	**590 - 1342**	WIs	60/15.025	BTU/scf	805 - 1610
Hs	60/14.696	therm/scf	0.0067 - 0.0148	**Hi**	**60/14.696**	**therm/scf**	**0.0059 - 0.0134**	WIs	60/14.696	therm/scf	0.0081 - 0.0161
Hs	60/14.65	therm/scf	0.0067 - 0.0148	**Hi**	**60/14.65**	**therm/scf**	**0.0059 - 0.0134**	WIs	60/14.65	therm/scf	0.0081 - 0.0161
Hs	60/14.73	therm/scf	0.0067 - 0.0148	**Hi**	**60/14.73**	**therm/scf**	**0.0059 - 0.0134**	WIs	60/14.73	therm/scf	0.0081 - 0.0161
Hs	60/15.025	therm/scf	0.0067 - 0.0148	**Hi**	**60/15.025**	**therm/scf**	**0.0059 - 0.0134**	WIs	60/15.025	therm/scf	0.0081 - 0.0161
WIs	**00/00**	**MJ/m3**	**32 - 63**	ρ	00/00	kg/m3	0.65 - 0.9	**AFR**	**00/00**	-	**8 - 11**
WIs	**15/00**	**MJ/m3**	**32 - 63**	ρ	15/00	kg/m3	0.65 - 0.9	**AFR**	**15/00**	-	**8 - 11**
WIs	**15/15**	**MJ/m3**	**30 - 60**	ρ	15/15	kg/m3	0.65 - 0.85	**AFR**	**15/15**	-	**8 - 11**
WIs	**20/20**	**MJ/m3**	**29 - 59**	ρ	20/20	kg/m3	0.6 - 0.85	**AFR**	**20/20**	-	**8 - 11**
WIs	**25/00**	**MJ/m3**	**32 - 63**	ρ	25/00	kg/m3	0.65 - 0.9	**AFR**	**25/00**	-	**8 - 11**
WIs	**25/20**	**MJ/m3**	**29 - 59**	ρ	25/20	kg/m3	0.6 - 0.85	**AFR**	**25/20**	-	**8 - 11**
WIs	**00/00**	**kWh/m3**	**9 - 18**	ρ	00/00	lb/scf	0.041 - 0.056	**AFR**	**60/14.696**	-	**8 - 11**
WIs	**15/00**	**kWh/m3**	**9 - 18**	ρ	15/00	lb/scf	0.041 - 0.056	**AFR**	**60/14.65**	-	**8 - 11**
WIs	**15/15**	**kWh/m3**	**8 - 17**	ρ	15/15	lb/scf	0.041 - 0.053	**AFR**	**60/14.73**	-	**8 - 11**
WIs	**20/20**	**kWh/m3**	**8 - 17**	ρ	20/20	lb/scf	0.037 - 0.053	**AFR**	**60/15.025**	-	**8 - 11**
WIs	**25/00**	**kWh/m3**	**9 - 18**	ρ	25/00	lb/scf	0.041 - 0.056	**s-AFR**	**00/00**	-	**12 - 18**
WIs	**25/20**	**kWh/m3**	**8 - 17**	ρ	25/20	lb/scf	0.037 - 0.053	**s-AFR**	**15/00**	-	**12 - 18**
WIs	**00/00**	**BTU/scf**	**858.9 - 1690.9**	ρ	60/14.696	kg/m3	0.65 - 0.85	**s-AFR**	**15/15**	-	**12 - 18**
WIs	**15/00**	**BTU/scf**	**858.9 - 1690.9**	ρ	60/14.65	kg/m3	0.65 - 0.85	**s-AFR**	**20/20**	-	**12 - 18**
WIs	**15/15**	**BTU/scf**	**805.2 - 1610.4**	ρ	60/14.73	kg/m3	0.65 - 0.85	**s-AFR**	**25/00**	-	**12 - 18**
WIs	**20/20**	**BTU/scf**	**778.3 - 1583.5**	ρ	60/15.025	kg/m3	0.65 - 0.85	**s-AFR**	**25/20**	-	**12 - 18**
WIs	**25/00**	**BTU/scf**	**858.9 - 1690.9**	ρ	60/14.696	lb/scf	0.041 - 0.053	**s-AFR**	**60/14.696**	-	**12 - 18**
WIs	**25/20**	**BTU/scf**	**778.3 - 1583.5**	ρ	60/14.65	lb/scf	0.041 - 0.053	**s-AFR**	**60/14.65**	-	**12 - 18**
WIs	**00/00**	**therm/scf**	**0.0086 - 0.0169**	ρ	60/14.73	lb/scf	0.041 - 0.053	**s-AFR**	**60/14.73**	-	**12 - 18**
WIs	**15/00**	**therm/scf**	**0.0086 - 0.0169**	ρ	60/15.025	lb/scf	0.041 - 0.053	**s-AFR**	**60/15.025**	-	**12 - 18**
WIs	**15/15**	**therm/scf**	**0.0081 - 0.0161**	**ρ rel.**	**00/00**	-	**0.5 - 1**	MN	00/00	-	65 - 100
WIs	**20/20**	**therm/scf**	**0.0078 - 0.0158**	**ρ rel.**	**15/00**	-	**0.5 - 1**	MN	15/00	-	65 - 100
WIs	**25/00**	**therm/scf**	**0.0086 - 0.0169**	**ρ rel.**	**15/15**	-	**0.5 - 1**	MN	15/15	-	65 - 100
WIs	**25/20**	**therm/scf**	**0.0078 - 0.0158**	**ρ rel.**	**20/20**	-	**0.5 - 1**	MN	20/20	-	65 - 100
WIs	**60/14.696**	**MJ/m3**	**30 - 60**	**ρ rel.**	**25/00**	-	**0.5 - 1**	MN	25/00	-	65 - 100
WIs	**60/14.65**	**MJ/m3**	**30 - 60**	**ρ rel.**	**25/20**	-	**0.5 - 1**	MN	25/20	-	65 - 100

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WIs	**60/14.73**	**MJ/m3**	**30 - 60**	**ρ rel.**	**60/14.696**	**-**	**0.5 - 1**	MN	60/14.696	-	65 - 100
WIs	**60/15.025**	**MJ/m3**	**30 - 60**	**ρ rel.**	**60/14.65**	**-**	**0.5 - 1**	MN	60/14.65	-	65 - 100
WIs	**60/14.696**	**kWh/m3**	**8.3 - 16.7**	**ρ rel.**	**60/14.73**	**-**	**0.5 - 1**	MN	60/14.73	-	65 - 100
WIs	**60/14.65**	**kWh/m3**	**8.3 - 16.7**	**ρ rel.**	**60/15.025**	**-**	**0.5 - 1**	MN	60/15.025	-	65 - 100
WIs	**60/14.73**	**kWh/m3**	**8.3 - 16.7**	Z	00/00	-	0.99 - 1	**CO2**	**00/00**	**-**	**0 - 20**
WIs	**60/15.025**	**kWh/m3**	**8.3 - 16.7**	Z	15/00	-	0.99 - 1	**CO2**	**15/00**	**-**	**0 - 20**
WIs	**60/14.696**	**BTU/scf**	**805 - 1610**	Z	15/15	-	0.99 - 1	**CO2**	**15/15**	**-**	**0 - 20**
WIs	**60/14.65**	**BTU/scf**	**805 - 1610**	Z	20/20	-	0.99 - 1	**CO2**	**20/20**	**-**	**0 - 20**
WIs	**60/14.73**	**BTU/scf**	**805 - 1610**	Z	25/00	-	0.99 - 1	**CO2**	**25/00**	**-**	**0 - 20**
WIs	**60/15.025**	**BTU/scf**	**805 - 1610**	Z	25/20	-	0.99 - 1	**CO2**	**25/20**	**-**	**0 - 20**
WIs	**60/14.696**	**therm/scf**	**0.0081 - 0.0161**	Z	60/14.696	-	0.99 - 1	**CO2**	**60/14.696**	**-**	**0 - 20**
WIs	**60/14.65**	**therm/scf**	**0.0081 - 0.0161**	Z	60/14.65	-	0.99 - 1	**CO2**	**60/14.65**	**-**	**0 - 20**
WIs	**60/14.73**	**therm/scf**	**0.0081 - 0.0161**	Z	60/14.73	-	0.99 - 1	**CO2**	**60/14.73**	**-**	**0 - 20**
WIs	**60/15.025**	**therm/scf**	**0.0081 - 0.0161**	Z	60/15.025	-	0.99 - 1	**CO2**	**60/15.025**	**-**	**0 - 20**
H2	00/00	-	0 - 40	**Temp**	**00/00**	**°C**	**0 - 50**	Pressure	00/00	Pa	98000 - 110000
H2	15/00	-	0 - 40	**Temp**	**15/00**	**°C**	**0 - 50**	Pressure	15/00	Pa	98000 - 110000
H2	15/15	-	0 - 40	**Temp**	**15/15**	**°C**	**0 - 50**	Pressure	15/15	Pa	98000 - 110000
H2	20/20	-	0 - 40	**Temp**	**20/20**	**°C**	**0 - 50**	Pressure	20/20	Pa	98000 - 110000
H2	25/00	-	0 - 40	**Temp**	**25/00**	**°C**	**0 - 50**	Pressure	25/00	Pa	98000 - 110000
H2	25/20	-	0 - 40	**Temp**	**25/20**	**°C**	**0 - 50**	Pressure	25/20	Pa	98000 - 110000
H2	60/14.696	-	0 - 40	**Temp**	**60/14.696**	**°C**	**0 - 50**	Pressure	60/14.696	Pa	98000 - 110000
H2	60/14.65	-	0 - 40	**Temp**	**60/14.65**	**°C**	**0 - 50**	Pressure	60/14.65	Pa	98000 - 110000
H2	60/14.73	-	0 - 40	**Temp**	**60/14.73**	**°C**	**0 - 50**	Pressure	60/14.73	Pa	98000 - 110000
H2	60/15.025	-	0 - 40	**Temp**	**60/15.025**	**°C**	**0 - 50**	Pressure	60/15.025	Pa	98000 - 110000
				Temp	**00/00**	**°F**	**32 - 122**	Pressure	00/00	psi	14.2 - 16
				Temp	**15/00**	**°F**	**32 - 122**	Pressure	15/00	psi	14.2 - 16
				Temp	**15/15**	**°F**	**32 - 122**	Pressure	15/15	psi	14.2 - 16
				Temp	**20/20**	**°F**	**32 - 122**	Pressure	20/20	psi	14.2 - 16
				Temp	**25/00**	**°F**	**32 - 122**	Pressure	25/00	psi	14.2 - 16
				Temp	**25/20**	**°F**	**32 - 122**	Pressure	25/20	psi	14.2 - 16
				Temp	**60/14.696**	**°F**	**32 - 122**	Pressure	60/14.696	psi	14.2 - 16
				Temp	**60/14.65**	**°F**	**32 - 122**	Pressure	60/14.65	psi	14.2 - 16
				Temp	**60/14.73**	**°F**	**32 - 122**	Pressure	60/14.73	psi	14.2 - 16
				Temp	**60/15.025**	**°F**	**32 - 122**	Pressure	60/15.025	psi	14.2 - 16

3.4 Calibration 4-20 mA current loop

The BlueEye™ Ex-D is factory delivered with a calibrated 4-20 mA current loop. Since actual mA output is influenced by the (customer specific) current loop system, it is strongly advised to re-calibrate the current loop once connected to your specific current loop system. This can be done over Modbus, or with Bright Sensors' Modbus USB Windows Interface Package.

Please refer to the Modbus manual for details on the registers affiliated with the current loop. To recalibrate the current loop via Modbus, please perform the following steps:

- Enable changes to the holding register by entering the passcode 27521 in holding register 50.
- Enter the integer 1 in holding register 32 to override the standard current loop operation.
- Enter an integer between 0 and 4096 in holding register 33. Measure the current loop output of your current loop system.
- Adjust the input integer (typically 800) in holding register 33 until the measured current equals 4 mA. Enter the final input integer in holding register 30.
- Adjust the input integer (typically 4000) in holding register 33 until the measured current equals 20 mA. Enter the final input integer in holding register 31.
- Enter the value 0 in holding register 32 to restart the standard current loop operation.

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- The current loop has now been calibrated for your system. The calibration values from the steps above are now visible in input registers 64 and 65, for the 4 mA setpoint and 20 mA setpoint, respectively.
- Finally, disable further changes to the holding register by saving value 0 to holding register 50.

For details on how to calibrate the current loop using Bright Sensors' Modbus USB Windows Interface Package, please consult the GUI (graphical use interface) manual to be found here: https://www.bright-sensors.com/blueeye-ex-d/.

3.5 Combustion and Metering reference conditions

Combustion and Metering Reference conditions vary by geographical location and application. Combustion reference conditions are specified as: temperature, **t1**, and pressure, **p1**, at which the fuel is notionally **burned**. Metering reference conditions are specified as: temperature, **t2**, and pressure, **p2**, at which the volume of fuel to be burned is notionally **determined**. There is no a priori reason for the metering reference conditions to be the same as the combustion reference conditions. In the BlueEye™ Ex-D the following reference conditions can be selected: 0/0°C, 15/0°C, 15/15°C, 20/20°C, 25/20°C at 101325 Pa and 60°F at 14.65 psi, 14.696 psi, 14.73 psi and 15.025 psi absolute.

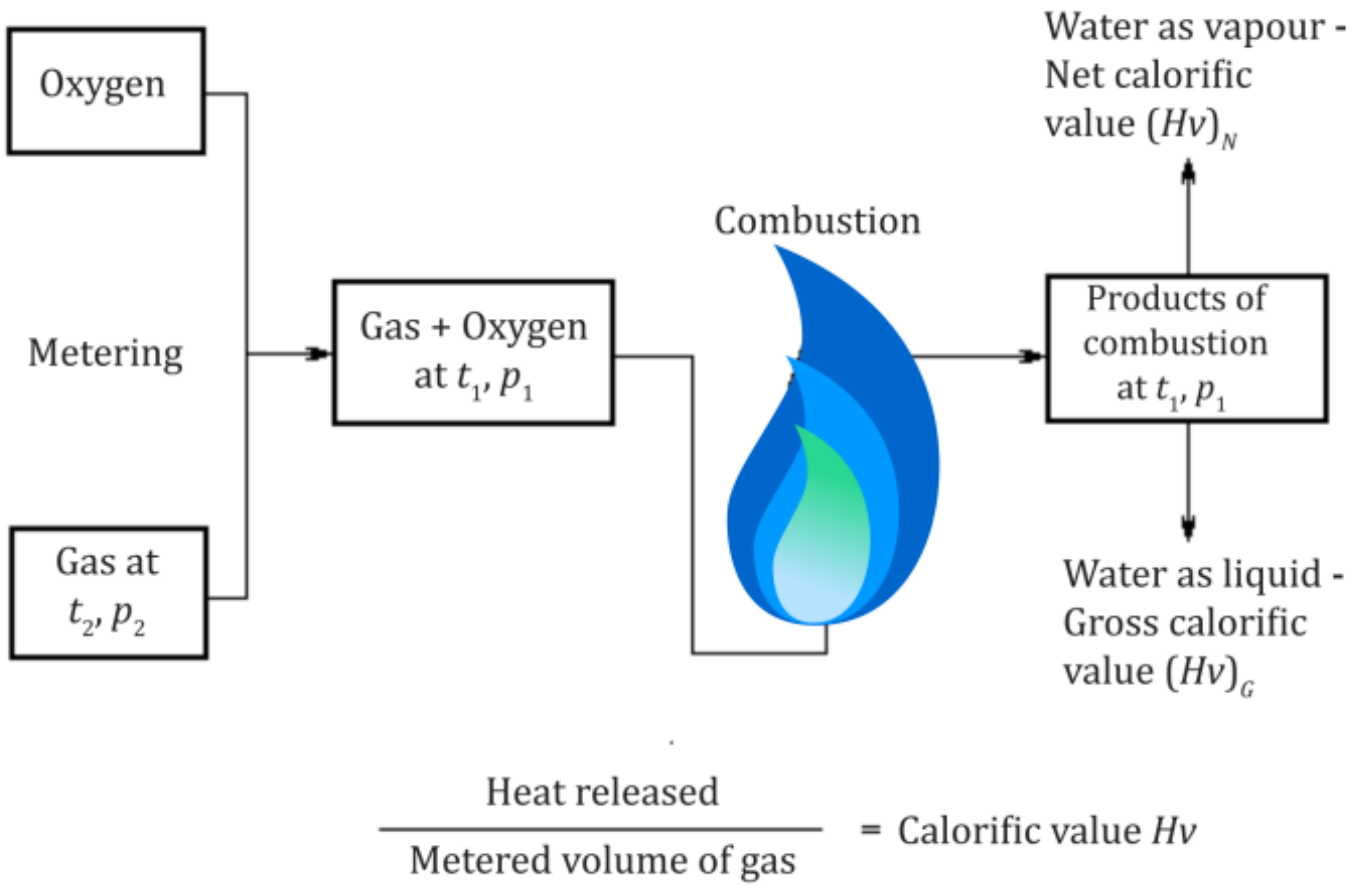


Figure 9: Reference conditions according to ISO 6976

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NOTICE

The BlueEye™ Ex-D expresses the combustion properties in all generally used metering and reference conditions. Please ensure the correct reference conditions are selected to avoid structural offset between BlueEye™ Ex-D output and comparing values.

3.6 Data logging

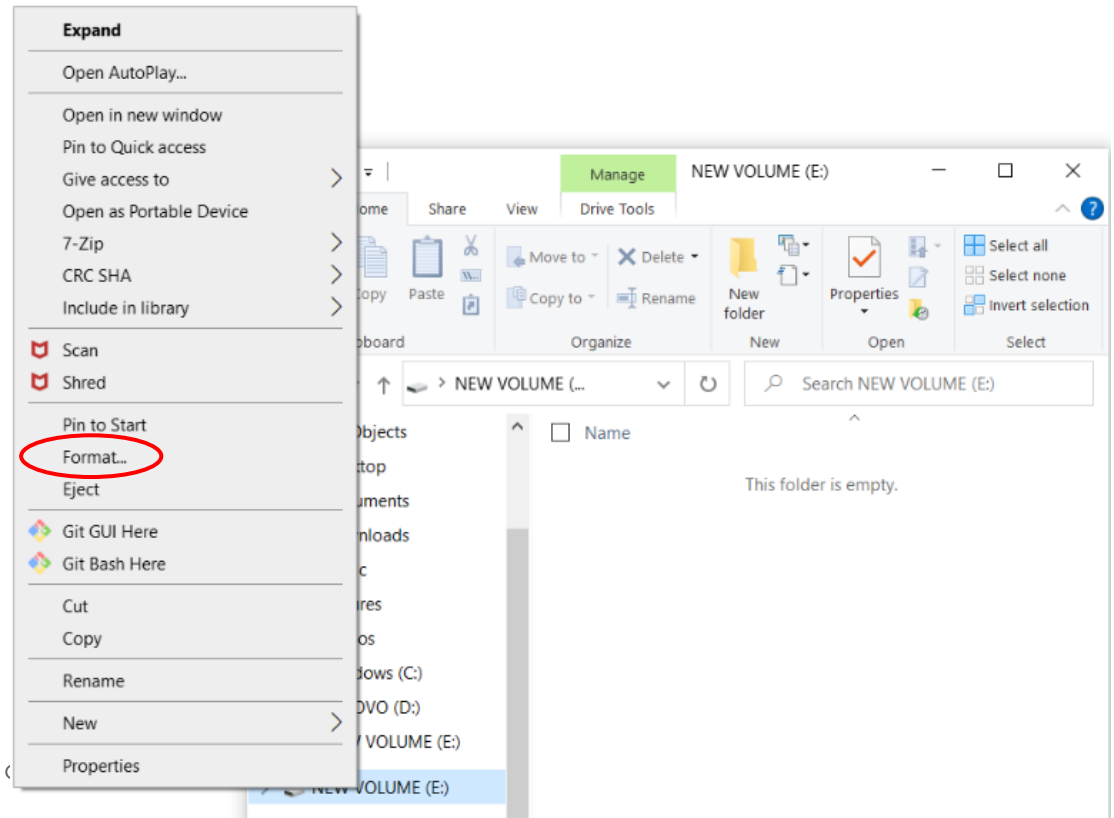
The BlueEye™ Ex-D has a dedicated microSD card slot for continuous logging of measurement and system data to a microSD card. The size of the microSD card is **required** to be 16GB.

The measurement data is logged with 1 second granularity to a .csv file. Once the data log file reaches 10 MB in size it is compressed and saved, and a new log file is created for continued logging. The BlueEye™ Ex-D will store up to 200 compressed data log files (approx. 6 months of data) before deleting the oldest file to free up memory.

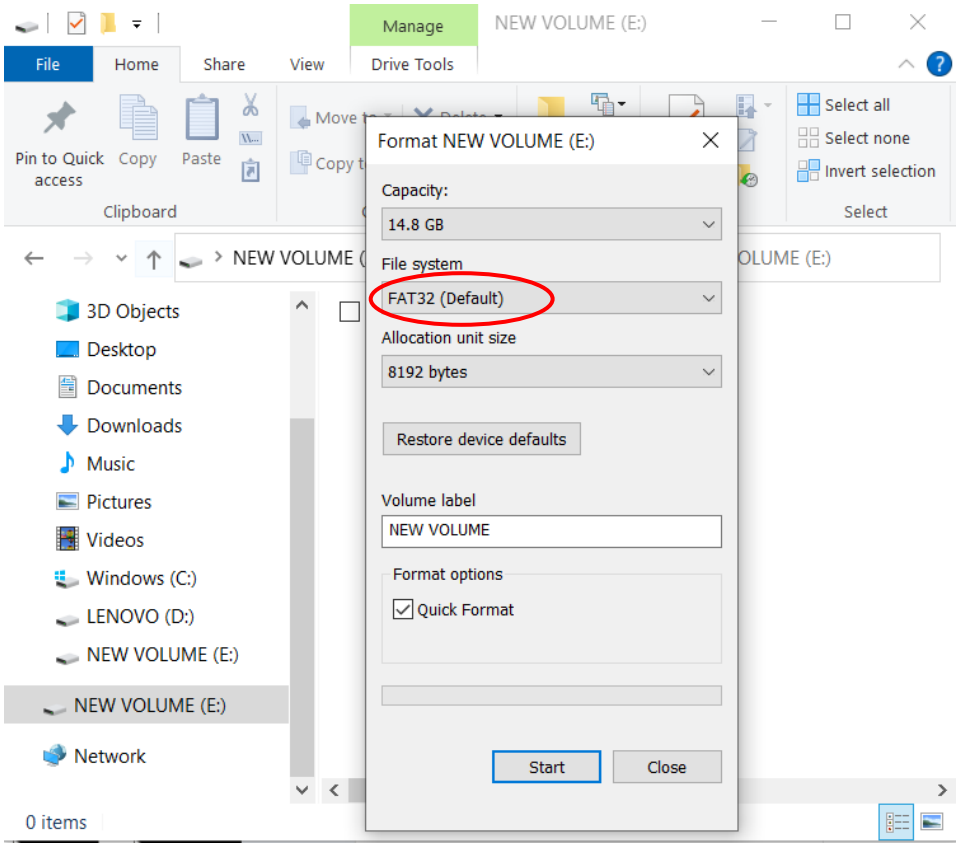
The system data is logged in real-time to a text file and is used to debug the BlueEye™ Ex-D in the unlikely event of a malfunction. Once the system data log file reaches 1 MB in size a new file is created for continued logging. The BlueEye™ Ex-D stores up to 5 system data log files (approx. 1 week of data) before deleting the oldest file to free up memory.

The following procedure must be followed to activate the datalogging:

1. Prepare the microSD card for logging.
    a. Insert the microSD card in a PC.
    b. Right click the microSD card volume and choose “Format…”:



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2. Insert the microSD card in the BlueEye™ Ex-D.
    a. Power down the BlueEye™ Ex-D.
    b. Remove the top lid of the BlueEye Ex-D enclosure.
    c. Insert the microSD card in the corresponding slot on the PCB as shown in below picture.
    d. Power up the BlueEye™ Ex-D to continue measuring as well as logging to the microSD card.



Figure 10: BlueEye™ Ex-D PCB with microSD card

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Escaping gas can lead to serious injury. In event of failure, components can be ejected at elevated speed or gas exhausted under high pressure. Open the connections only after the system has been depressurised. Ensure that the pressure in the system as a whole cannot exceed the lowest maximum pressure of any of its components. If variations of the pressure level or different pressure levels are to be expected in the system, components must be used that can withstand the maximum expected pressure levels and peaks. Observe the working conditions in accordance with BlueEye™ Ex-D datasheet. Actions or alterations to the gas quality instrument, which are not described in these operating instructions, are not permitted. Ensure that the mounting point has been made absolutely free from burrs and is clean. After installation, use a gas leak detector sensitive to the used gas to ensure that there is no leak.

In addition, measurement data storage functionality is also provided through the interface of the Modbus USB Windows Interface Package: for more details, please consult the GUI (graphical use interface) manual to be found here: https://www.bright-sensors.com/blueeye-ex-d/

4. Maintenance & regular checks

The BlueEye™ Ex-D doesn`t have any moving parts, doesn`t combust the medium flowing through and doesn`t chemically reacts with the medium. As a result, under normal operations, there are minimum maintenance requirements. However, since the BlueEye™ Ex-D can`t control the medium quality flowing through it, the recommend inspection interval is every 12 months. Please consult Bright Sensors or your distributor for inspection interval based on the specific conditions of your application.

Regular checks are recommended to establish:

- Correct pressure and flow rate
- No contamination of the flame arrestors or sensor unit has occurred
- Accuracy of reported values is within required specifications

The BlueEye™ Ex-D is factory calibrated and a calibration report is provided with the device upon purchase. The Calibration values are determined under the following conditions:

- Gas medium used: pure Methane (CH_4) N45 ($CH_4 \geq 99{,}995$ %)
- A temperature between 20 °C and 30 °C of both the device and the pure Methane (CH_4) N45
- Pressure: stable at 1050 mbar absolute
- 1 time boosting directly after starting to flow pure Methane (CH_4) N45
- Minimum operating time before measurement: 20 mins
- Measurement time: 10 mins

To validate if the drift is within the required accuracy the BlueEye™ Ex-D should be tested as close as possible under the same conditions when the calibration values were established. By comparing the calibrated values with the validation values the possible drift can be quantified. Bright Sensors recommends recalibrating or replacing the sensor unit if the average 10-minute values are deviating more than 0.25%. See for more information Appendix C: Calibration Report example.



At normal use, routine inspection is advised to be performed on the BlueEye™ Ex-D on a yearly interval. Have repairs performed by Bright Sensors or Bright Sensors appointed representatives only to prevent losing warranty claim.

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Power Off. Do NOT separate the device when its energized. Power supply must be switched off and disconnected at main before cleaning or repair.



Do NOT open pressurized connections. Open pressurized connections only after the pressure of the system or the appropriate section has been released to atmospheric level.



Escaping gas can lead to serious injury. In event of failure, components can be ejected at elevated speed or gas exhausted under high pressure. Open the connections only after the system has been depressurised. Ensure that the pressure in the system as a whole cannot exceed the lowest maximum pressure of any of its components. If variations of the pressure level or different pressure levels are to be expected in the system, components must be used that can withstand the maximum expected pressure levels and peaks. Observe the working conditions in accordance with BlueEye™ Ex-D datasheet. Actions or alterations to the gas quality instrument, which are not described in these operating instructions, are not permitted. Ensure that the mounting point has been made absolutely free from burrs and is clean. After installation, use a gas leak detector sensitive to the used gas to ensure that there is no leak.



For hazardous media such as flammable gases, in addition to all standard regulations, the appropriate existing codes or regulations must also be followed. Reduce the risk of creating hazardous areas by controlling and monitoring the gas release in relation to the properties of the specific media (e.g. IEC 60079-20).



The instrument is factory calibrated. Please contact Bright Sensors SA for re-calibration or re-ranging.



Instantly remove a damaged or unsafe instrument from service and mark it to prevent accidental usage. Have repairs performed by Bright Sensors or Bright Sensors appointed representatives only.



Please verify in advance, if the correct pressure is being applied (valves/ ball valve etc. open), the right supply voltage and wiring has been chosen.

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5. Technical Data

5.1 Electrical Parameter



Before connecting the voltage supply, ensure that all gas lines to the measuring element and the measuring element itself have been flushed.

Supply voltage:	+24 VDC ± 10 %
Power consumption:	< 2.0 W

5.2 Gas pressure parameter

Inlet pressure:	min. 960 mbar **absolute**, max. 1.100 mbar **absolute**
Permissible overload:	1.150 mbar **absolute**
Outlet pressure:	Equal to inlet pressure minus pressure drop of around 10 mbar

5.3 Operating temperature

Adhere to the permissible ambient and medium temperatures which are valid for this area on the basis of the specified temperature classes. The maximum permissible temperature range is specified on the type plate of the BlueEye™ Ex-D. Operation of the device is only permitted within these specified ranges.

Ambient air temperature range:	-20°C to 70°C
Operating gas temperature range:	0 to 50°C
Maximum surface temperature:	80°C



Protect the instrument from influences by external heat sources (e.g. pipes or tanks).

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5.4 Measured media

Dry, neutral gas (filtered 10 µm)

The BlueEye™ Ex-D can measure gas compositions in a wide range, in the form of H-gas or L-gas, as well as biogas or other (natural and synthetic) gas compositions. However, to ensure accuracy and warranty period, the gas composition range should be within the following range:

Gas Composition Range					
CH_4	70-100 mol%	Higher Alkanes	0-1 mol%	O_2	≤ 3 mol%
C_2H_6	0-20 mol%	N_2	0-15 mol%	H_2O (Gaseous)	≤ 0.1 mol%
C_3H_8	0-5 mol%	**CO_2**	0-3 mol% (**20**/**100** mol%) [1]	Dust, Liquids	Without
C_4H_{10}	0-3 mol%	**H_2**	≤ 0.5 mol% (**30** mol%) [2]	H_2S	≤ 0.01 mol%
H_s addressable range	27.52 to 50.40 MJ/m³ (15°C/15°C)				
Environment temperature	0 to 50°C, 32 to 122°F				
Operating gas pressures	950 to 1100 mbar **absolute**, 13.9 to 15.95 psi **absolute**				
Flow rate	30 ml/min (+/- 10%), 0.001059 scf/min (+/- 10%) [4]				

[1] only for BlueEye™ Ex-D **Renewable** & **Ultragreen**
[2] only for BlueEye™ Ex-D **Hydrogen** & **Ultragreen**
[3] unfiltered 1 second cycle measurement
[4] flow rate range customizable on request

Please consult Bright Sensors SA or your local distributor if you are unsure whether your gas composition is within specification for your requirements. On request, tailored solutions for deviating composition ranges can be provided.

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6. APPENDIX

6.1 Appendix A: Modbus Communication Protocol

Please find the Modbus Communication Protocol here (bottom of the page):
https://www.bright-sensors.com/blueeye-ex-d/

6.2 Appendix B: Certificates

ATEX and IECEx certificates of conformity:

NOTICE

This is an example of the certificates, which depends on the inspection of an individual batch and is therefore not static.



IECEx Certificate of Conformity

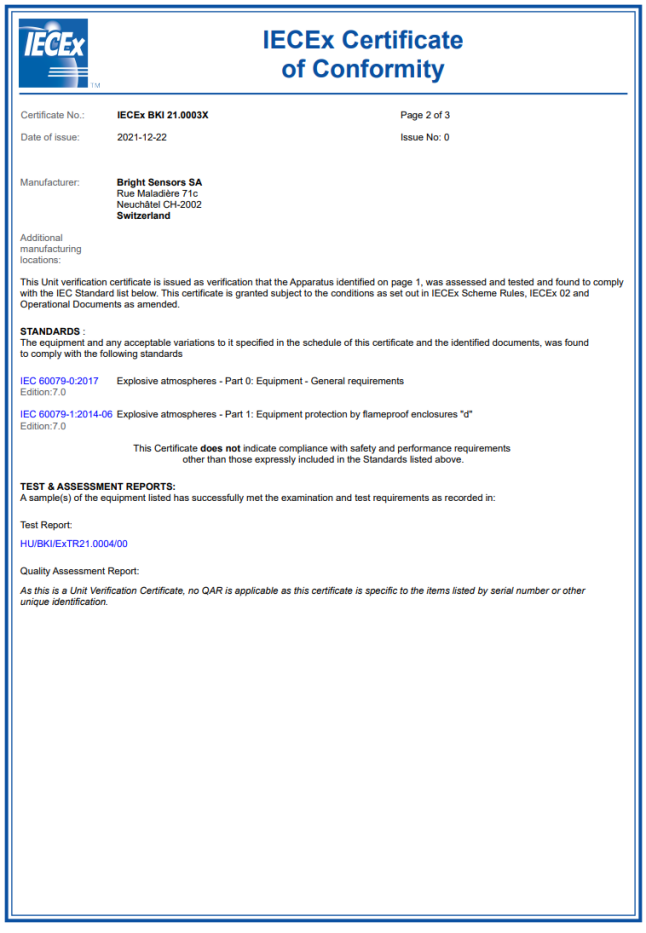
INTERNATIONAL ELECTROTECHNICAL COMMISSION
IEC Certification System for Explosive Atmospheres
for rules and details of the IECEx Scheme visit www.iecex.com
UNIT VERIFICATION

Certificate No.: IECEx BKI 21.0003X — Page 1 of 3 — Certificate history:
Status: Current — Issue No: 0
Date of Issue: 2021-12-22
Applicant: Bright Sensors SA, Rue Maladière 71c, Neuchâtel CH-2002, Switzerland
Equipment: MEMS based gas analyzer type BlueEye™ Ex-D Hydrogen
Serial number(s) or Unique Identification: 0001502; 0001503; 0001504; 0001505; 0001506; 0001507; 0001508; 0001509
Type of Protection: General requirement, Equipment protection by flameproof enclosures "d"
Marking: Ex db IIC T6 Gb
$T_{ambient}$ = -20°C ... +70°C

Approved for issue on behalf of the IECEx Certification Body: Nagy Botond
Position: Head of the Certification Body
Signature: (for printed version)
Date:

1. This certificate and schedule may only be reproduced in full.
2. This certificate is not transferable and remains the property of the issuing body.
3. The Status and authenticity of this certificate may be verified by visiting www.iecex.com or use of this QR Code.

Certificate issued by:
ExVA Ltd
MIKOVINY S.u. 2-4
BUDAPEST H 1037
Hungary



IECEx Certificate of Conformity

Certificate No.: IECEx BKI 21.0003X — Page 2 of 3
Date of issue: 2021-12-22 — Issue No: 0

Manufacturer: Bright Sensors SA, Rue Maladière 71c, Neuchâtel CH-2002, Switzerland
Additional manufacturing locations:

This Unit verification certificate is issued as verification that the Apparatus identified on page 1, was assessed and tested and found to comply with the IEC Standard list below. This certificate is granted subject to the conditions as set out in IECEx Scheme Rules, IECEx 02 and Operational Documents as amended.

STANDARDS :
The equipment and any acceptable variations to it specified in the schedule of this certificate and the identified documents, was found to comply with the following standards

IEC 60079-0:2017 Edition:7.0 Explosive atmospheres - Part 0: Equipment - General requirements
IEC 60079-1:2014-06 Edition:7.0 Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures "d"

This Certificate **does not** indicate compliance with safety and performance requirements other than those expressly included in the Standards listed above.

TEST & ASSESSMENT REPORTS:
A sample(s) of the equipment listed has successfully met the examination and test requirements as recorded in:

Test Report:
HU/BKI/ExTR21.0004/00

Quality Assessment Report:
As this is a Unit Verification Certificate, no QAR is applicable as this certificate is specific to the items listed by serial number or other unique identification.

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IECEx Certificate of Conformity

Certificate No.: **IECEx BKI 21.0003X** Page 3 of 3

Date of issue: 2021-12-22 Issue No: 0

EQUIPMENT:
Equipment and systems covered by this Certificate are as follows:

The BlueEye™ Ex-D is a low CAPEX (Capital Expenditure) gas analyzer, designed for the continuous measurement of combustible gases. Every second the device accurately reports the combustion properties (H_s, H_i, WI_s, WI_i, ρ, Z, s-AFR, MN, CO_2, H_2 mol%) of gas compositions. Gas is flowing at low flow rate (50 ml/min) in and out of the BlueEye™ Ex-D through 1/4 NPT connectors. Measurement output is interfaced through 4-20 mA current loop and Modbus RTU. The BlueEye™ Ex-D uses Bright Sensors' patented MEMS gas viscometer technology combined with other MEMS sensors. The analyzer is specifically developed for biomethane injection, hydrogen blending, combustion control, gas grid monitoring and other stationary applications.

Sensor unit type:

BlueEye™ Ex-D Hydrogen Viscosity + TCD sensor + H_2 hardware

denomination	manufacturer, type		protection	certificate number
cable gland	RIBCO S.r.l	P...	II 2 G Ex db IIC Gb	INERIS 10 ATEX 0029 X
enclosure	International Metal Engineering Pte Ltd	8100PB	II 2 G Ex db IIC Gb	SIRA 08 ATEX 1325 U

See technical details in BlueEye™-Ex-D-Datasheet-12_2021.pdf

SPECIFIC CONDITIONS OF USE: YES as shown below:
The flameproof enclosure (8100PB) is epoxy coated, then it may generate an ignition-capable level of electrostatic charges under certain extreme conditions. The user should ensure that the equipment is not installed in a location where it may be subjected to external conditions (such as high-pressure steam) which might cause a build-up of electrostatic charges on non-conducting surfaces. Additionally, cleaning of the equipment should be done only with a damp cloth.

Warnings:
WARNING: POTENTIAL ELECTROSTATIC CHARGING HAZARD – SEE INSTRUCTIONS
WARNING: DO NOT OPEN WHEN AN EXPLOSIVE ATMOSPHERE IS PRESENT.

With regard to maintenance, the instructions in the "Operating Manual " must be strictly adhered to.

The BlueEye™ Ex-D has a multicore transparent cable (CY Copper Shield, PVC, 9x 0.75mm^2). Depending of the classification type of the ATEX zone where the outer end of the BlueEye™ Ex-D cable installed, the installation has to be fulfilled according to explosion-proof regulations.

Annex:

BlueEye™-Ex-D-Datasheet-12_2021.pdf

EXVA Vizsgáló és Tanúsító Kft.

A NAH által NAH-6-0027/2017/K számon akkreditált terméktanúsító szervezet. / Product certification organisation accredited by NAH under No. NAH-6-0027/2017/K

(1) *Megfelelőségi Tanúsítvány / Certificate of Conformity*
Egyedi Ellenőrzés / Unit Verification

(2) A potenciálisan robbanásveszélyes környezetben történő alkalmazásra szánt berendezések, védelmi rendszerek 2014/34/EU Direktíva /
Equipment or Protective Systems Intended for use in Potentially explosive atmospheres Directive 2014/34/EU

(3) Megfelelőségi Tanúsítvány Egyedi Ellenőrzés száma / Certificate of Conformity Unit Verification Number: **BKI21ATEX0015 X**

(4) A berendezés, vagy védelmi rendszer / Equipment or protective system:
MEMS alapú gáz analizátor /
MEMS based gas analyzer

Típusa / Type:
BlueEye™ Ex-D Hydrogen

Serial number:
0001502; 0001503; 0001504; 0001505; 0001506; 0001507; 0001508; 0001509

(5) Megrendelő / Applicant:
Bright Sensors SA

(6) Cím / Address:
Rue Maladière 71c, CH-2002 Neuchâtel, Switzerland

(7) A berendezés, vagy védelmi rendszer és annak változatai a jelen tanúsítvány vonatkozó pontjában vannak feltüntetve. /
This equipment or protective system and any acceptable variation thereto is specified in the schedule to this certificate and the documents therein referred to.

(8) A ExVA Vizsgáló és Tanúsító Kft., 1418 sz. kijelölt testület, a 2014. február 26-i Európai Parlament és Tanács 2014/34/EU Direktívájának 17. cikkelye szerint tanúsítja, hogy a gyártmány megfelel az Alapvető Egészségügyi és Biztonsági Követelményeknek a Direktíva II. számú Mellékletében a potenciálisan robbanásveszélyes térben alkalmazásra szánt egyedi gyártmányok tervezése és gyártása szerint. /
ExVA Testing and Certification Limited Liability Company, notified body number 1418 in accordance with Article 17 of Directive 2014/34/EU of the European Parliament and of the Council, dated 26 February 2014, certifies that this product has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of specific products intended for use in potentially explosive atmospheres given in Annex II to the Directive.

A vizsgálat eredményeit az alábbi nyilvántartási számú bizalmas vizsgálati dokumentáció tartalmazza: / The examination and test results are recorded in confidential report number: **VA-0183-21-A**

Ez a tanúsítvány csak a maga egészében és változatlan formában használható fel, mellékleteivel együtt. / This certificate may only be reproduced in its entirety and without any changes, schedule included.

---

(9) Az alapvető egészségügyi és biztonsági követelményeknek való megfelelést a következők biztosítják: / Compliance with the Essential Health and Safety Requirements has been assured by compliance with:

EN IEC 60079-0: 2017 **(= MSZ EN IEC 60079-0: 2018)**
EN 60079-1: 2014 **(= MSZ EN 60079-1: 2015)**

kivéve a 18. pontban felsorolt követelményekre vonatkozóan.
except in respect of those requirements listed at item 18 of the Schedule.

(10) A tanúsítvány száma után álló „X" jel azt mutatja, hogy a gyártmány speciális feltételek megtartása mellett felel meg a jelen tanúsítvány vonatkozó pontjában feltüntetett biztonságos alkalmazás feltételeinek. /
If the sign „X" is placed after the certificate number, it indicates that the product is subject to Specific Conditions of Use specified in the schedule to this certificate.

(11) A berendezés, vagy védelmi rendszer jele a következő /
The marking of the equipment or protective system shall include the following:

Ex II 2 G Ex db IIC T6 Gb **$T_{környezeti\ /\ ambient}$ = -20°C ... +70°C**

(12) A tanúsított gyártmány gyártója felelős, hogy az megfeleljen a jelen tanúsítványban megadott jellemzőknek. Gyártó a megvizsgált darabon rögzíti az ExVA Vizsgáló és Tanúsító Kft. Tanúsító Szervezet azonosító számát. /
The manufacturer of the apparatus referred to in this certificate, has the responsibility to ensure that the apparatus conforms to the specification laid down in the Schedule to this certification and has satisfied routine verifications and tests specified therein. The manufacturer affixes the identification number of the ExVA Testing and Certification Limited Liability Company Certification Body to the tested piece of apparatus.

ExVA Vizsgáló és Tanúsító Kft.
ExVA Testing and Certification Ltd.
Hungary, 1037 Budapest, Mikoviny u. 2-4.
Tel.: 36 1 408 2213
E-mail: office@exva.hu

ExVA Vizsgáló és Tanúsító Kft.
1037 Budapest, Mikoviny S. u. 2-4
10928505-2-41

Nagy Botond
Tanúsító Szervezet Vezető /
Head of Certification Body

Budapest, 2021. december / December 22.

Ez a tanúsítvány csak a maga egészében és változatlan formában használható fel, mellékleteivel együtt. / This certificate may only be reproduced in its entirety and without any change, schedule included.

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(13) Melléklet / Schedule

(14) MEGFELELŐSÉGI TANÚSÍTVÁNY EGYEDI ELLENŐRZÉS szám / CERTIFICATE OF CONFORMITY UNIT VERIFICATION № BKI21ATEX0015 X

(15) Gyártmány leírása / Description of Product

15.1 Leírás / Description

A BlueEye™ Ex-D egy alacsony CAPEX (Tőkeberuházású) gázelemző, amelyet éghető gázok folyamatos mérésére terveztek. A készülék másodpercenként pontosan jelzi a gázösszetételek égési tulajdonságait (H_s, H_i, WI_s, WI_i, ρ, Z, s-AFR, MN, CO_2, H_2 mol%). A gáz alacsony áramlási sebességgel (50 ml/perc) áramlik be és ki a BlueEye™ Ex-D-ből 1/4 NPT csatlakozókon keresztül. A mérési kimenet 4-20 mA -es áramhurkon és RTU Modbuson keresztül csatlakozik. A BlueEye™ Ex-D a Bright Sensors szabadalmaztatott MEMS gázviszkoziméter technológiáját használja fel más MEMS érzékelőkkel kombinálva. Az analizátort kifejezetten biometán befecskendezéshez, hidrogén keveréshez, égésszabályozáshoz, gázhálózat-felügyelethez és egyéb helyhez kötött alkalmazásokhoz fejlesztették ki.
/
The BlueEye™ Ex-D is a low CAPEX (Capital Expenditure) gas analyzer, designed for the continuous measurement of combustible gases. Every second the device accurately reports the combustion properties (H_s, H_i, WI_s, WI_i, ρ, Z, s-AFR, MN, CO_2, H_2 mol%) of gas compositions. Gas is flowing at low flow rate (50 ml/min) in and out of the BlueEye™ Ex-D through 1/4 NPT connectors. Measurement output is interfaced through 4-20 mA current loop and Modbus RTU. The BlueEye™ Ex-D uses Bright Sensors' patented MEMS gas viscometer technology combined with other MEMS sensors. The analyzer is specifically developed for biomethane injection, hydrogen blending, combustion control, gas grid monitoring and other stationary applications.

15.2 Szenzor egység típusa / Sensor unit type

BlueEye™ Ex-D Hydrogen	Viszkozitás + TCD szenzor + H_2 hardver / Viscosity + TCD sensor + H_2 hardware

15.3 Beépített tanúsított gyártmányok / Built-in certified products

megnevezés / denomination	gyártó, típus / manufacturer, type		védelmi jel / protection	tanúsítvány száma / certificate number
kábelvezető / cable gland	RIBCO S.r.l	P...	Ex II 2 G Ex db IIC Gb	INERIS 10 ATEX 0029 X
tokozat / encloseur	International Metal Engineering Pte Ltd	8100PB	Ex II 2 G Ex db IIC Gb	SIRA 08 ATEX 1325 U

Ez a tanúsítvány csak a maga egészében és változatlan formában használható fel, mellékleteivel együtt. / This certificate may only be reproduced in its entirety and without any change, schedule included.

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6.3 Appendix C: Calibration Report

Calibration report example:

NOTICE

This is an example of the calibration report. Actual report can vary depending on BlueEye™ Ex-D model.

Calibration Report

Manufacturer:	Bright Sensors SA
Device type:	BlueEye™ Ex-D Renewable
Serial number:	2003494
Certificate number:	2003494/7383-2383
Certificate date:	30.09.2026
Customer:	
Distributor:	

Bright Sensors' BlueEye™ Ex-D Extended and Hydrogen measure Dynamic Viscosity and Thermal Conductivity. These measuring principles are based on Micro-electromechanical systems (MEMS). When operating the BlueEye™ Ex-D within the specified operating conditions (gas pressure, composition, temperature, and humidity) sensor drift is proven to be having no material impact. However, the BlueEye™ Ex-D sensor cell, depending on the operation conditions, experiencing wear from temperature cycles, electronic component tolerance shifts, and contamination build up over time on the sensor chip. This calibration report allows the user to verify over time if the sensor cell accuracy is within the by the user required limits.
The BlueEye™ Ex-D Renewable and Ultragreen have in addition to the Dynamic Viscosity and Thermal Conductivity Micro-electromechanical systems (MEMS) sensors also an Integrated IR CO_2 sensor build in. IR CO_2 sensors are more prone to drift and therefore require so called "zeroing" to reset the baseline.
Bright Sensors recommends checking the deviation from the reported values in this calibration report on a yearly basis. For devices that include a CO_2 sensor it is recommended to perform a zeroing of the CO_2 sensor on a 6-month basis.
The Calibration values are determined under the following conditions:

- **Gas medium used: pure Methane (CH4) N45 (CH4 ≥ 99,995 %)**
- **A temperature between 20 °C and 35 °C of both the device and the pure Methane (CH4) N45**
- **Pressure: stable in the range of 995 and 1085 mbar absolute**
- **1 time boosting directly after starting to flow pure Methane (CH4) N45**
- **Minimum operating time before measurement: 60 mins**
- **Measurement time: 10 mins**

To validate if the drift is within the required accuracy the BlueEye™ Ex-D should be tested as close as possible under the same conditions when the calibration values were established. By comparing the calibrated values with the validation values the possible drift can be quantified. Bright Sensors recommends recalibrating or replacing the sensor unit if the mean values are deviating more than 0.5% of the in this report stated Correlative Theoretical Higher Heating Value over the 10 minutes validation measurement.
The Higher Heating Value can be assessed in the Modbus input registers 2-3. Alternatively, the Modbus Interface program can be used to record the Higher Heating Value over the recommended period of time. For more information, please refer to the user manual of your product.
Should you require support with the validation or if you require a recalibration, please contact Bright Sensors or your distributor.

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Serial number: 2003494 Page: 2/3
Certificate number: 2003494/7383-2383

Calibration Reported Values:

Below are reported 1000 Higher Heating Value (Measured Hs) measurements by the BlueEye™ Ex-D of in pure methane (CH4) N45, at the reference conditions of 25°C/0°C, 1013.25 mBar (blue line).
The Theoretical Higher Heating Value (Theoretical Hs) of pure methane is equal to 11.063 kWh/m3 at the reference conditions of 25°C/0°C, 1013.25 mBar (red dotted line).

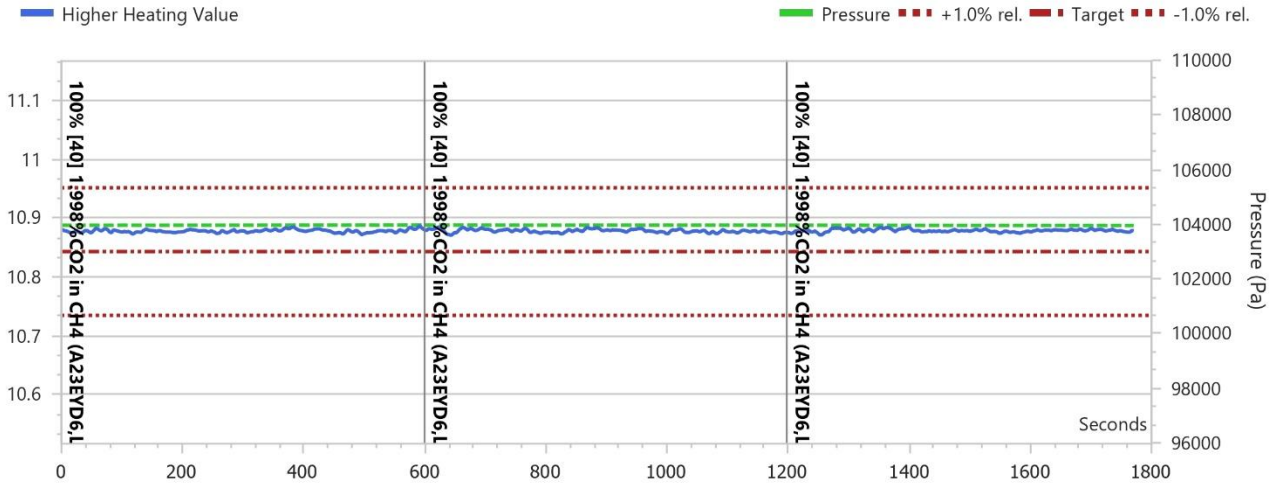
Here, the Measured Higher Heating Value (Hs) is within the advised +/- 1% from the Theoretical Higher Heating Value. Bright Sensors recommends recalibrating or replacing the sensor unit if the values are deviating more than 1% from the Theoretical Higher Heating Value over a 10 minutes validation measurement.

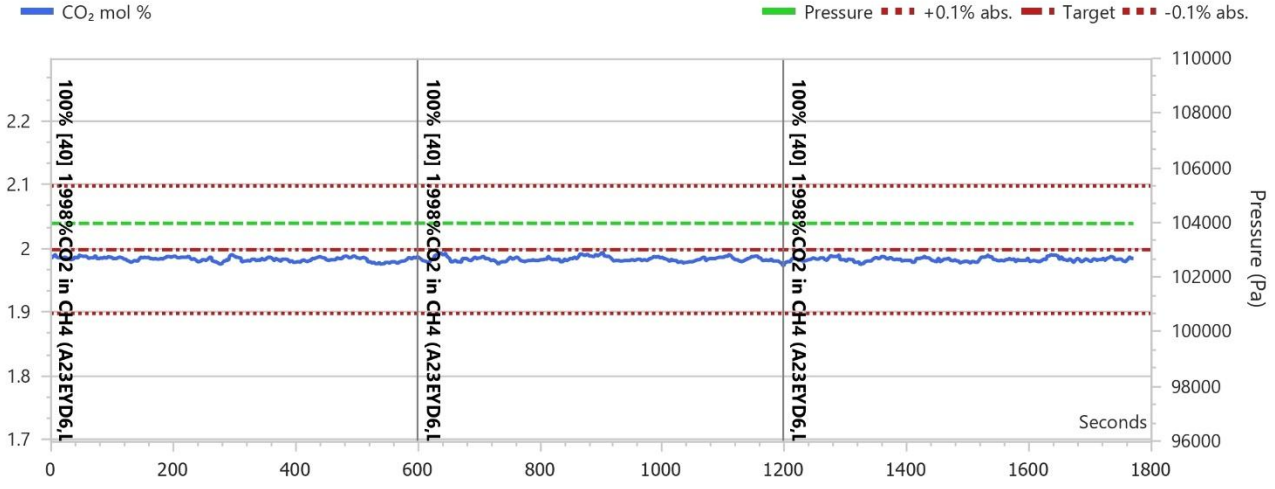
For the BlueEye™ Ex-D Renewable and Ultragreen, this calibration report also shows 1000 measurements in 1.991 mol% CO2 in methane (CH4). The typical maximum error of the CO2 IR sensor is around 0.1-0.15 mol% absolute from the certified CO2 content of the gas measured.

1.998%CO2 in CH4

ISO 6976, 25°C/0°C / 101325 Pa Model CO2 HHV 10.84 kWh/m³ WIS 14.31 kWh/m³ Rho 1 g/m³ Z 0.998

CH4	C2H6	C3H8	n-C4H10	i-C4H10	C5H12	i-C5H12	n-C5H12	n-C6H14	H2	N2	O2	CO2
98.002%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	1.998%





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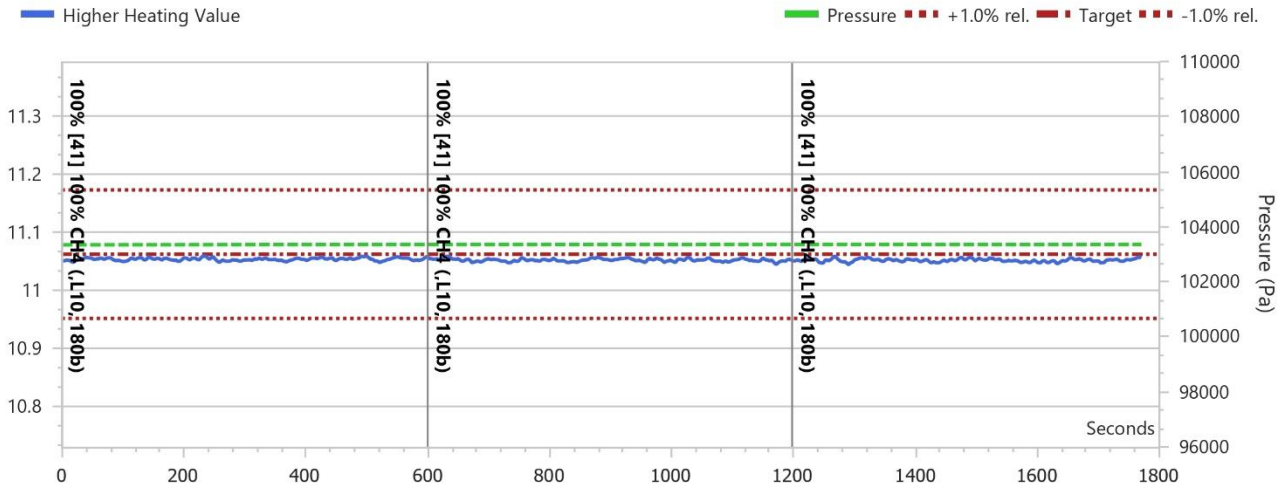
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Certificate number: 2003494/7383-2383

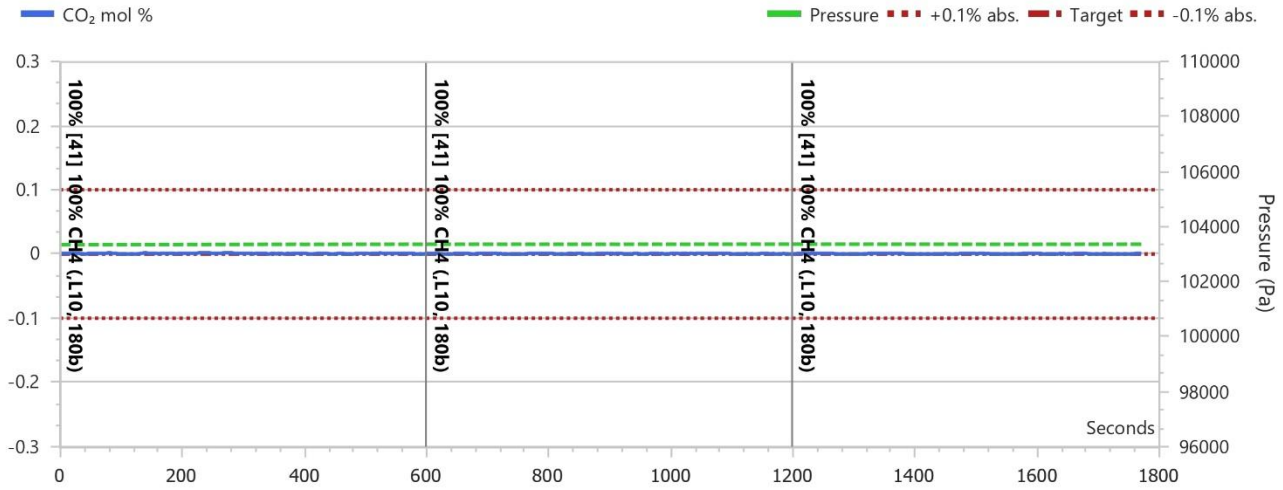
Calibration Reported Values:

100% CH4

ISO 6976, 25°C/0°C / 101325 Pa Model CO2 HHV 11.06 kWh/m³ WIS 14.85 kWh/m³ Rho 1 g/m³ Z 0.998

CH4	C2H6	C3H8	n-C4H10	i-C4H10	C5H12	i-C5H12	n-C5H12	n-C6H14	H2	N2	O2	CO2
100.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%





Status: Passed
Date: 30.09.2026
Operator: Jocelyn Roldan

Signature:

BRIGHT SENSORS SA
MALADIERE 71a CP 672
CH-2002 NEUCHATEL

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