

Operating manual

Oxygen transmitter

FCX-TRxxyy-CH



EU DECLARATION OF CONFORMITY (CE Conformity Declaration)

Act No. 90/2016 Coll., Act No. 265/2017 Coll. and Act No. 91/2016 Coll. as amended

DIRECTIVES AND HARMONIZED STANDARDS OR DOCUMENTS:

- Act No. 90/2016 Coll., Act No. 265/2017 and Act No. 91/2016 Coll. as amended
- standards EN 61326-1, EN 61000-4-2 ed. 2, EN 61000-4-3 ed. 3, EN 61000-4-4 ed. 3, EN 61000-4-6 ed. 3 as amended,
- Directive 2014/30/EU (Government Regulation No. 117/2016 Coll.) – „EMC“, as amended
- Directive 2015/863/EU (Government Regulation No. 391/2016 Coll.) – „RoHS“. as amended

This manual contains information on how to operate the standard Angst+Pfister Sensors and Power OEM CE certified FCX-TRxxyy oxygen transmitter. The zirconia oxygen sensor is built into a stainless steel transmitter housing, where also the control electronics are integrated into. Power and output to and from the transmitter is provided via a cable. The cable is not part of the delivery. The oxygen sensor can be chosen from a selection of 4 sensors;

- 1) the FCX-ULL 0...1000 ppm (xxyy = 1000)
- 2) the FCX-UL 0...5% (xxyy = 0005)
- 3) the FCX-UC 0...25% (xxyy = 0025) and
- 4) the FCX-UWC 0.1...95% (xxyy = 0095)

As an example the sensor in the FCX-TR0005-7-5-Q08-113-000 transmitter is a 0-5% FCX-UL oxygen sensor integrated into the stainless steel housing with a G1/2" DIN 3852 process adapter for screw-in of the transmitter and with an M8, 4-pole cable connector for power (10-28 VDC) and output (4-20 mA, 3-wire). The 113 code means that the transmitter has a sinter bronze filter before the process opening and the 000 code means that the sensor is gas & leakage tight, but there is option for flow through (see later). Please refer to the product coding table on page 11 in this document for an accurate description of the product family.

Products mentioned in this manual may possibly be trademarks used only for the purposes of identification.

Revision protocol

Issue	Month / Year	Change management
1.1	May 2017	Original
1.5	June 2019	Changes to product code
1.6	June 2021	Changes to mechanical design – M5 process connection introduced

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Angst+Pfister Sensors and Power AG
Thurgauerstrasse 66
8050 Zürich
Switzerland

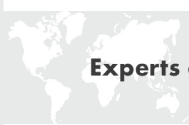
Tel: +41 (0)44 877 35 00

e-mail : sensorsandpower@angst-pfister.com
url : sensorsandpower.angst-pfister.com

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2 Customer Service

At Angst+Pfister Sensors and Power we want to offer you the best customer service possible. If you have any questions or comments about your FCX-TRxxy transmitter(s), we would be happy to hear from you. Should you have any problems with the transmitter(s), please contact us for advice and support. We recommend that all service and repair work on the unit be done exclusively by our customer service or specially trained personnel.

You can reach us at the following addresses:

Headquarter:

Angst+Pfister Sensors and Power AG

Thurgauerstrasse 66
8050 Zürich
Switzerland

Tel +41 (0)44-877 35 00

e-mail : sensorsandpower@angst-pfister.com
url : sensorsandpower.angst-pfister.com

Please send any returns to our Logistics Centre:

Before returning anything, please request an RMA number from us.

Angst+Pfister Sensors and Power AG

Logistics Centre
Hardhofstrasse 31
8424 Embrach/ZH
Switzerland

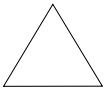
3 Safety instructions

Danger sources that could result in personal injury or damage to machinery are explicitly indicated in the appropriate places in the user documentation.

Before installing the machine, please read this operating manual carefully. Pay particular attention to the sections explaining possible hazards.

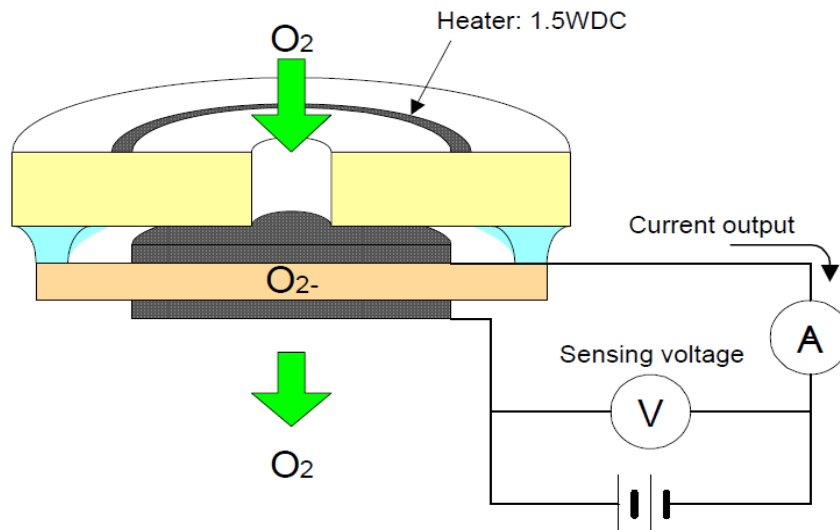
Warnings and instructions are shown as follows:

	Means that failure to follow the instruction indicated can lead to personal injury.
Warning	

	Means that the instruction indicated must be followed exactly to prevent damage to the machine.
Caution	

4 Measuring Principle

The FCX-TRxxy transmitter is a complete solution for fast and accurate oxygen concentration measurements within the range 0...1000 ppm (TR1000), 0...5% (TR0005), 0...25% (TR0025) or 0.1...95% (TR0095). The sensor and the measurement electronics are integrated into a stainless steel transmitter housing. The electronic amplifies the raw sensor signal and the output is a logarithmic current output signal 4...20mA (according to IEC 60381) as a function of oxygen partial pressure (see Appendix)



Zirconium oxide, heated to about 450 °C, is penetrable for oxygen ions. A voltage applied to the sensor therefore pumps the oxygen out of the inner chamber. At a constant gas pressure, the quantity of oxygen pumped out is equal to the quantity of oxygen molecules diffusing in through the capillary, and within a certain range it is independent of the voltage applied between the electrodes. The measurement current is proportional to the quantity of oxygen molecules pumped away. The relationship between the oxygen partial pressure and sensor current is governed by the formula

$$I_s = c \ln (1 - p_{O_2} / p_t)$$

where:

I_s : Sensor current
 c : Constant (sensor-specific)
 p_{O_2} : Oxygen partial pressure
 p_t : Gas pressure (total)

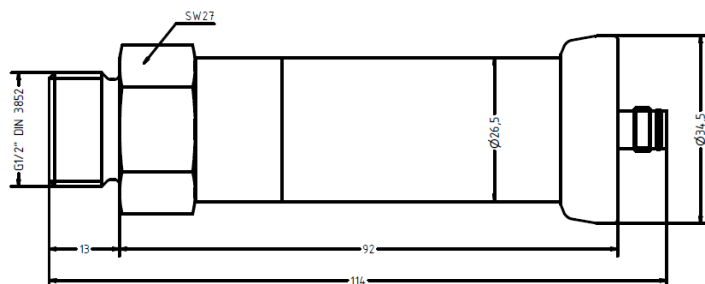
The transmitter performs three tasks:

- Regulation of the heating power of the sensor
- Amplification of the microampere signal from the sensor
- Conversion of the amplified signal into a standardised current output signal

The transmitter is calibrated as one unit at the factory. The heating voltage must be correctly adjusted for each sensor to bring the temperature to exactly 450 °C. The sensor is not directly replaceable, and cannot be used with other transmitters. All transmitters have a label on the transmitter housing with the transmitter serial number (SN).

5 Commissioning

5.1 Mechanical Installation



The transmitter has a dimension of 114 mm x Ø34.5 mm (see drawing above). In Fig. 1 a principal drawing of the transmitter is shown. The oxygen sensor is protected by a process connection thread G1/2", which also makes installation of the transmitter easy. The electronics is integrated in the bulk of the transmitter and consists of conditioning electronics for the heating voltage and amplifying electronics in order to deliver a standardized output of 4-20 mA (3-wire).



Warning

The oxygen sensor has a surface temperature in operation of ~55-60°C. When the transmitter is connected to power, but is not mounted into the application, the surface temperature of the transmitter can be as high as ~50°C. By applying the transmitter to the application, i.e. screw-mounting the transmitter in a metal wall or tube, the metal wall or tube acts as a cooling media and the temperature increase on the transmitter surface is kept below 10°C above the surrounding temperature

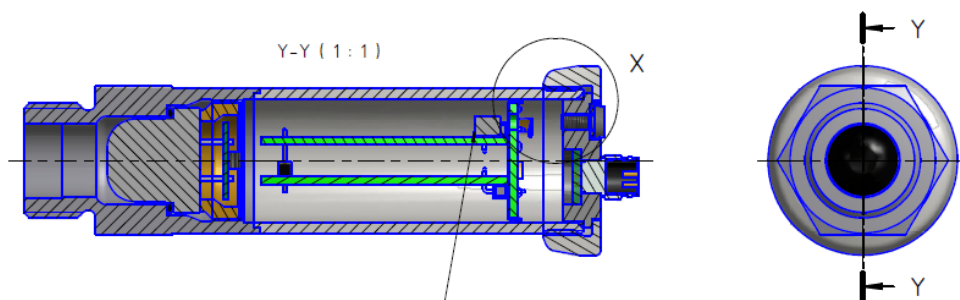


Fig. 1 FCX-TR principal drawing

On the back of the transmitter is the male M8 4-pole electrical connection (input and output) and a M3x6 PA6.6 plastic screw that serve as a protection of the potentiometer on the amplifying circuit that can be used to calibrate the transmitter (Fig. 1). In Fig. 2 is shown a close up of the construction with the plastic protection screw and the potentiometer, which is integrated on the amplifying electronics.

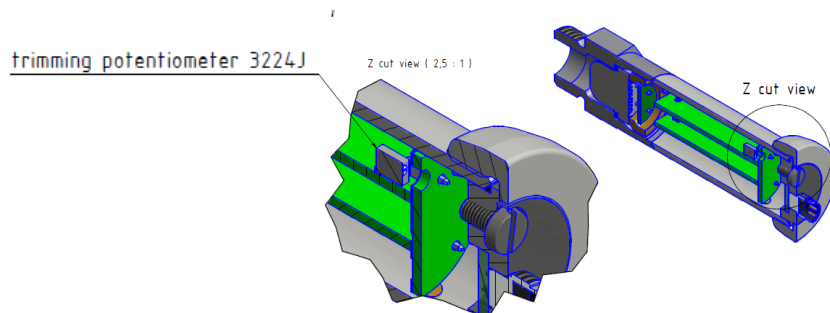


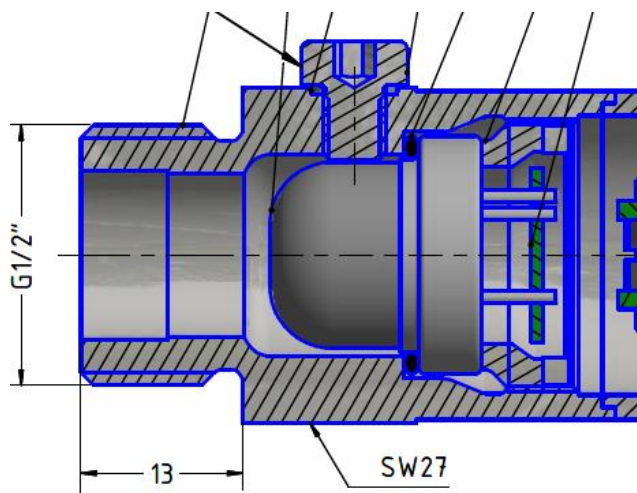
Fig. 2. Close-up on the backside of the transmitter

5.2 Pneumatic connections

The transmitter has no pneumatic connections for forced flow. The transmitter has a G1/2" thread for a reliable process connection. The oxygen reaches the sensor via diffusion. The diffusion can be "forced" by opening the valve/removing the M5x6 DIN 7984 screw (see Photo below), thereby creating a driving force for the gas exchange oxygen from the small volume in front of the sensor. The driving force or leakage can be controlled by inserting the small hex wrench screw into the hole and turning the screw until the requested leak size has been reached (see drawings below).

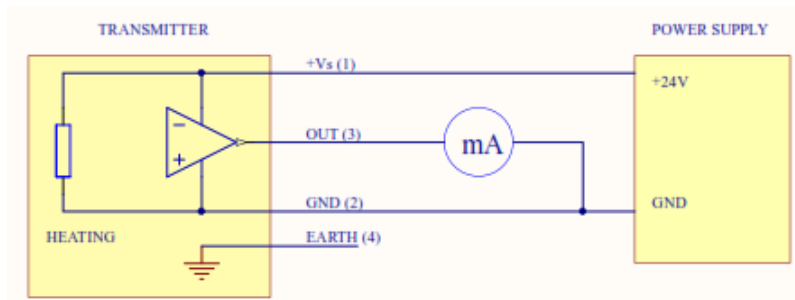


For applications, where forced flow is needed, please contact Angst+Pfister Sensors and Power. Special flow connections are possible.



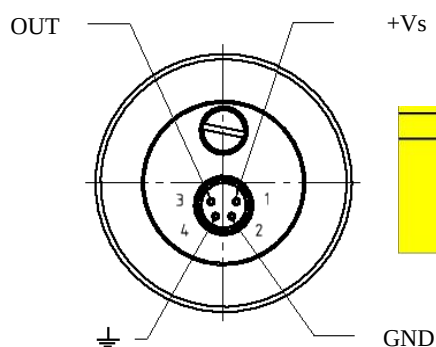
The M5 process connection can be used to mount a male process connector – for instance a one-touch fitting (SMC KGH04-M5 & KGH06-M5). This allows hoses with a diameter of 4 mm or 6 mm to be connected to the transmitter.

5.3 Electrical connections



5.3.1 Supply voltage

Angst+Pfister Sensors and Power can deliver a standard 5 m cable with the transmitter (type 79-3382-55-04); the cable has a female M8 connector on one end of the cable that matches the male M8 connector on the transmitter and 4 wires on the other end of the cable. With reference to the electrical pin-out (numbers) shown below, the colour coding of this cable/wires are: 1) brown, 2) white, 3) blue and 4) black. The order number for the cable is 1620214919.



FCX-TR	Code: FCX-TR0095-7-5-Q08-113-000	SN: 2002878
Range: 0...25% O ₂	Connector Pinout:	
Signal: 4...20 mA	Pin 1: +Vs	Pin 3: OUT
Supply: 9...28 V DC	Pin 2: GND	Pin 4: EARTH



The 10–28 VDC power for the transmitter is supplied through terminals 1 (+Vs) and 2 (GND), at about 250 mA (24 VDC). For the lower limit of the power supply voltage, please take into account the resistance between the current output terminals. As an example; using a 500 Ohm resistance between the output terminals will cause of 10 V voltage drop at an output current of 20 mA. If the supply voltage is only slightly above this voltage drop, the required current for operating the transmitter may be too low, which will then cause erroneous measurement output values.

5.3.2 Analog Output (4-20 mA; 3-wire)

For the output signal the clamps 3 (Signal) and 2 (GND) is to be used.

6 Environment Condition

See also under 11. Specifications, in particular for the temperature, pressure and humidity ranges.

- Protect from water

The sensor temperature is about 450 °C. Please note in any case the resulting hazards for applications with reactive gas mixtures.

 Warning	Potentially explosive atmospheres The unit may under no circumstances be operated in or with potentially explosive atmospheres.
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7 Warm Up Time

The transmitter need a warm up time of approx. 3 minutes. After 3 minutes the sensor delivers an output signal which is within the accuracy limits of the transmitter.

8 Calibration

All compensations and calibrations needed for operation have been carried out at the factory. The output signal should be interpreted as follows:

FCX-TR1000, 0...1000ppm:

$$I_{out} (mA) = 16 [mA] * (pO_2 [ppm] / 1000 [ppm]) + 4 [mA]$$

FCX-TR0005, 0...5%:

$$I_{out} (mA) = 16 [mA] * (pO_2 [\%] / 5 [\%]) + 4 [mA]$$

FCX-TR0025, 0...25%:

$$I_{out} (mA) = -57 [mA] * \ln(1 - (pO_2 [\%] / 100 [\%])) + 4 [mA]$$

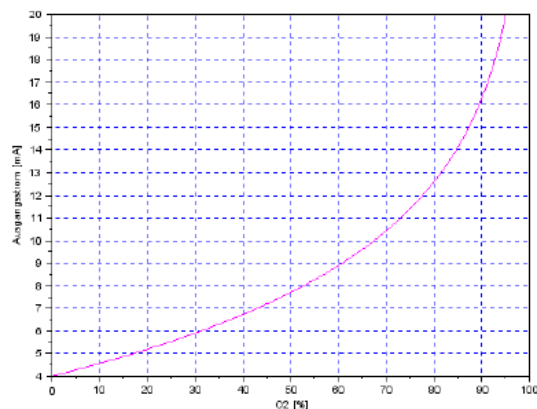
FCX-TR0095, 0...95%:

$$I_{out} (mA) = -5.34 [mA] * \ln(1 - (pO_2 [\%] / 100 [\%])) + 4 [mA]$$

pO₂: oxygen partial pressure in % of the total pressure

I_{out}: output current in mA

In the figure below is shown the relationship between output current and partial oxygen concentration for a 95% oxygen transmitter. The output from a 25% transmitter can be considered quasi-linear.



8.1 Calibration Adjustments

It is recommended to check the transmitter output periodically by running it under regular lab conditions and flushing the transmitter with regular dry air (20.95% O₂). This procedure only apply to the FCX-TR0025 and FCX-TR0095 versions. For the FCX-TR1000 & FCX-TR0005 versions the period check must be done with a dry gas having a maximum of 1000 ppm and 5% O₂, respectively (balance N₂).

8.2 Adjustment Span

The result of the measuring at an environmental temperature of 25°C should be 20.95 %O₂ ±0.5% O₂ (FCX-TR0095) and 20.95 %O₂ +0.2/-0.5% O₂ (FCX-TR0025). For the FCX-TR0005 and FCX-TR1000 transmitter types the expected accuracy in full-scale is +/-5 %FS.

Should there be higher differences as expected try following procedure:

- 1 Attach the transmitter to the supply
- 2 Use the transmitter in regular dry air (20.95% O₂). For the 0...5% transmitter please use for example a N₂-O₂ gas with an oxygen concentration of 5 %O₂ +/-2% rel. For the 0...1000 ppm transmitter please use a N₂-O₂ gas with an oxygen concentration of 1000 ppmO₂ +/-2% rel.
- 3 After 10 minutes adjust the output signal using the potentiometer (Span). In a dry and clean environment the amplifier should have an output signal of 17.44 mA (±0.05 mA) for the FCX-TR0025 transmitter and 5.26 mA (±0.05 mA) for the FCX-TR0095 transmitter. The FCX-TR0005 transmitter with the 5% oxygen sensor should be adjusted to 20 mA using a full-scale gas and the FCX-TR1000 transmitter with 1000 ppm oxygen sensor should be adjusted to 20 mA also using a full-scale gas.

This completes the recalibration.

9 Important notes

9.1 Restrictions

1. Do not remove the oxygen sensor from the transmitter.
2. Use regulated DC power source with current capacity over 1 A or more. If current capacity is not sufficient, the transmitter will not operate correctly.
3. The transmitter was adjusted for O₂-N₂ systems. Output characteristics may change if there are other gases present in the gas mixture to be measured.
4. Don't use in a gas that contains halogen atoms (F, Cl, Br). The transmitter can be damaged by decomposition of a gas containing halogen atoms.
5. SO_x, NO_x and H₂S will damage the performance of the transmitter. Therefore, please do not use the transmitter in an atmosphere that contain any of these gases.
6. Silicone gases damage immediately the transmitter beyond repair

10 Specifications

Measurement range(s)	: 0...1000 ppm, 0...5 %, 0...25 % or 0.1...95 % O ₂
Supply voltage	: 24 VDC nominal (10...28 VDC)
Power current	: type 250 mA (24 VDC). Power-on peak about 0.7 A
Power consumption	: < 2 W
Output signal	: 4...20 mA logarithmic (FCX-TR0025 & FCX-TR0095) 4...20 mA linear (FCX-TR0005 & FCX-TR1000)
Accuracy*	: ±0.5-1.0 % absolute FCX-TR0095 ±2 % FS FCX-TR0025 (> 10% O ₂) +/-0.2% absolute FCX-TR0025 (< 10% O ₂) ±5 % FS FCX-TR0005 (< 5% O ₂) ±50 ppm absolute FCX-TR1000 ±5 ppm absolute FCX-TR1000 (< 100 ppm) *Accuracy is very dependent on the application and the quality of the gas measurement system. Contact us for support in obtaining the maximum achievable accuracy for your system.
Stability	: ±0.5 % FS/Year (FCX-TR0025)
Repeatability	: ±1% of the value displayed (also achievable for the FCX-TR1000 with great care)
Temperature influence**	: Measurement error [in % pO ₂] ~ pO ₂ [%] x (T _e [°C] – 25 °C) / 500 T _e = Environmental temperature of the sensor **FCX-TR0025
Gas temperature***	: -10...+50 °C ***calibration interval for the sensor. Gas temperature up to 125°C is possible under certain conditions (please contact Angst+Pfister Sensors and Power for more information)
Pressure influence****	: No static pressure influence between 200 mbar and 10 bar absolute Sudden pressure changes causes the signal to strongly oscillate. The oscillations are damped over time, but the relaxation time is long (> 300 seconds). ****the upper limit for the FCX-TR is recommended/set at 10 bar overpressure. Successful tests have been made up to 20 bar.
Response time (diffusion)	: < 30 s T ₉₀
Response time (flow)	: < 8 s T ₉₀
Environmental temperature	: -20...+70 °C
Rel. humidity	: 98% RH, not condensing
Dimensions Length/diameter	: 114 mm/Ø34.5 mm
Weight	: 250 g

FCX-TR product code															
FCX-TR															
Measurement range - ppm/vol%															
0...1000ppm	1	0	0	0											
0...5vol%	0	0	0	5											
0...25vol%	0	0	2	5											
0...95vol%	0	0	9	5											
customer	9	9	9	9											
Output signal															
4...20mA/3-wire					7										
customer					9										
Accuracy															
+/-0,5FS0						5									
customer						9									
Electrical connection															
Male plug M8 x 1 (4-pin)/metal PW							Q	0	8						
customer							9	9	9						
Mechanical connection															
G 1/2" PW										1	1	2			
G 1/2" PW with Sinter										1	1	3			
customer										9	9	9			
Customer specific															
standard													0	0	0
customer													9	9	9

We are here for you. Addresses and Contacts.

Headquarter Switzerland:

Angst+Pfister Sensors and Power AG
Thurgauerstrasse 66
CH-8050 Zurich
Phone +41 44 877 35 00
sensorsandpower@angst-pfister.com

Office Germany:

Angst+Pfister Sensors and Power Deutschland GmbH
Edisonstraße 16
D-85716 Unterschleißheim
Phone +49 89 374 288 87 00
sensorsandpower.de@angst-pfister.com

Office North America:

Angst+Pfister North America Inc.
10391 Brecksville Rd.
US-Brecksville, OH 44141
Phone +1 440 375-5212
info.apus@angst-pfister.com

Scan here and get an overview of personal contacts!



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