Special Documentation
ZIRKOR200, ZIRKOR200 Ex

ZIRKOR Series
SIL Safety Manual

Endress+Hauser
People for Process Automation

About this Manual

This Manual contains additional important information concerning the design, installation, commissioning, operation, maintenance and troubleshooting of the ZIRKOR200 (Ex) with SIL2 option. Safe work with the ZIRKOR200 (Ex) requires the users to become familiar with all warnings, safety instructions and maintenance aspects of this Manual.

Symbols used in this Manual

Important information as well as safety instructions are emphasized by symbols below. Make sure that all safety advice and warnings are observed at all times.

	**Warning** Follow all instructions in this Manual
	**Warning of hot surface** Warns of danger of burns which could occur from hot system parts
	Caution Warns of risks which can severely damage the system or its components or functionality

	**Consider following information** Draws attention to important information which must be noted before execution
	**Info** Contains further detailed information
	Protective grounding

Safety instructions

This system is operated with line voltage. An electric shock hazard will occur when covers are removed while line voltage is still connected,.

Only well trained and authorized personnel are allowed to conduct work on this system. Personnel have to understand all precautions, safety instructions, installation and maintenance instructions in this Manual. The trouble free and safe operation of this system requires safe transportation, professional storage, installation, operation and maintenance. Furthermore, all local safety requirements have to be considered.

This system may not be used in the vicinity of combustible gases as parts of the system may cause a risk of explosion.

Manufacturer

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1 System description

1.1 Purpose of this manual

This Manual contains information and instructions which are required when using ZIRKOR200 and ZIRKOR200 Ex analyzers (later jointly referred to as ZIRKOR200 (Ex)) in a SIL configuration and must be used by all relevant personnel. The Operating Instructions document for ZIRKOR200 (Ex) has to be fully considered.

1.2 Scope

This Addendum to Operating Instructions applies to ZIRKOR200 (Ex) devices with software version 4.10 or higher, which are delivered with a SIL 2 certificate and a SIL 2 manufacturer declaration.

The SIL 2 certification covers the ZIRKOR200 (Ex) with the capability of automatic calibration.

The SIL 2 variants of ZIRKOR200 use the following product keys:

- Z200-0XXXXX2XXXXX1 (complete)
- Z200-2XXXXX2000000 (probe only)
- Z200-10ZZZ000XXXXX1 (evaluation unit only)

The SIL 2 variants of ZIRKOR200 Ex use the following product keys:

- Z200EXG-x2XXXXX2XXXXXXXXXX (probe)
- Z200EXG-x1XXXXXXXXXXXXXCXX (evaluation unit)
- Z200EXD-72XX2XXXXXXXXXXX (probe)
- Z200EXD-71XXXXXXXXXXCXXX (evaluation unit)

1.3 Intended use

Info

ZIRKOR200 (Ex) analyzer systems are for measurement of the oxygen concentration in flue gases and other non-combustible gases. Typical applications include combustion plants, drying plants, cement processing, Heat and power plants, refineries, paper and cellulose production. For reasons of safety and the possibility of accidents, unauthorized conversions and modifications of the device are prohibited.

Warning

The systems cannot be used to determine the oxygen concentration of combustible gases or in a location where combustible gases are present as the measuring cell temperature of 800 °C could present an explosion hazard!

Combustible gases distort the measurement result and can cancel the safety function.

Info

The minimum concentration of O_2 in flue gas should not be less than 0.5% under normal process conditions.
If the O_2 concentration is regularly below 0.5%, we recommend the option of LL^2 (**Long Life²**) to protect the O_2 sensor.

Caution

Under no circumstance should the measuring probe be directly connected to the 230 V main power supply, as this will immediately severely damage the probe heater element!

1.4 Safety hazards

Warning of hot surface

During operation, the temperature of the probe filter head and of other parts exposed to flue gas is 150 °C ... 800 °C (302 °F ... 1472 °F). Direct contact with the hot parts when dismantling or maintenance will cause severe burns!

The probe may only be removed with heat-insulated gloves. Before removing the probe, always switch off the supply voltage of the electronic system. After removal, store the probe in a safe, protected place and wait until it has cooled down below 35 °C (95 °F).

1.5 Disruption of the process

The analyzer system has to be kept in operation also in the event of the process being disrupted or if the plant is powered off temporarily (e.g. at night or during the weekend). Frequently cooling down and heating up of the probe results in thermal stress of the hot probe parts (heater, thermocouple and sensor) and shortens their service life. Responsibility will not be accepted for resultant damage.

1.6 Storage instructions

Equipment and spares are to be stored in a dry and ventilated environment. Paint fumes, silicone sprays, etc. must be avoided in the storage environment.

1.7 Installation, maintenance and decommissioning

For installation, maintenance and decommissioning, refer to the Operating Instructions of the ZIRKOR200.

Abbreviations

Abbreviation	Full form	Definition
SIL	Safety integrity level	Safety integrity level (SIL) is a relative level of risk-reduction provided by a safety function, or to specify a target level of risk. Based on the IEC 61508 standard, four discrete Safety Integrity Levels (SIL 1 to SIL 4) are defined with SIL 4 the most dependable and SIL 1 the least dependable
PFD	Probability of Failure on Demand	Probability of dangerous safety function failures occurring on demand.
PFD_{avg}	Probability of Failure on Demand average	Average probability that a system will fail dangerously, and is not able to perform its safety function when required
SFF	Safe Failure Fraction	Ratio of safe and dangerous detected failures to the total failure rate
HFT	Hardware Fault Tolerance	Hardware fault tolerance: Capability of a functional unit to continue the execution of the demanded function in case of faults or deviations

1.8 Related documentation

This manual covers the ZIRKOR200 (Ex) analyzers as part of a safety function and must be used in in conjunction with the relevant Operating Instructions of the respective analyzers.

Instructions in this Safety Manual take precedence over instructions in the Operating Instructions.

2 General safety instructions

2.1 Safety-instrumented system

	Note The ZIRKOR200 (Ex) O_2 analyzer system acts as part of a safety function.

2.2 Measuring principle

ZIRKOR200 (Ex) O_2 analyzer systems consists of an in-situ probe installed in a duct to measure non-combustible process gases and of an electronic unit for voltage and gas supply, as well as for signal processing.

The oxygen sensor is at the tip of the probe and is regulated to 800 °C, and works on the zirconium oxide principle of measurement. Here, an mV signal between the reference gas side of the sensor (inside, instrument air 20.95% O_2) and the measured gas side is measured, which depends logarithmically on the ratio of oxygen partial pressures on both sides of the sensor.

The mV signal is converted according to the Nernst equation into oxygen partial pressure within the process gas, whereby the O_2 concentration is determined in the process gas. Gas-tight separation of reference air and process gas is of particular importance.

The measured O_2 value is converted to the isolated 4 ... 20 mA analog output (NAMUR).

2.3 Definition: SIL

Four SIL levels are defined based on the IEC 61508 standard, SIL 4 being the most dependable and SIL 1 the least dependable. A SIL is determined based on a number of quantitative factors in combination with qualitative factors such as development process and safety life cycle management.

The achievable SIL is determined by the following safety characteristics:

- Average probability of dangerous failure of a safety function in case of demand (PFD_{AVG})
- Hardware fault tolerance (HFT)
- Safe failure fraction (SFF)

Description

The following Table shows the dependency of the SIL on the average probability of dangerous failures of a safety function of the entire safety-instrumented system (PFD_{avg}) as well as on the safe failure fraction (SFF) and the hardware fault tolerance (HFT) of the system. The Table covers “Low demand mode”, i.e. the safety function is required a maximum of once per year on average. For the safety figures of the ZIRKOR200, please refer to the SIL certificate delivered with the device.

SIL	**PFD_{avg}**
1	0.1 – 0.01
2	**0.01 – 0.001**
3	0.001 – 0.0001
4	0.0001 – 0.00001

Table 2-1: Safety Integrity Level vs. PFD_{avg} (ZIRKOR200 (Ex) SIL printed bold)

SFF	**HFT**		
	0	1 **(0)***	2 (1)*
< 60%	Not allowed	SIL 1	SIL 2
60...< 90%	SIL 1	**SIL 2**	SIL 3
90...<99%	SIL 2	SIL 3	SIL 4
>99	SIL 3	SIL 4	SIL 4

Table 2-2: Safety Integrity Level vs. SFF and HFT (ZIRKOR200 (Ex) SIL printed bold)

*Values in brackets apply to „proven in use“ according to Route $2_H/2_S$ in IEC 61508-2

2.4 Systematic capability

The systematic capability (SC) of the ZIRKOR200 (Ex) is 2. Therefore, it can be used in safety-related systems up to SIL 2.

3 Device-specific safety instructions

3.1 Safety function

ZIRKOR200 (Ex) analyzers are mainly used for user defined threshold monitoring. Only the output current at the analog output 4...20 mA (NAMUR) is considered as the safety function. The dangerous failure is a deviation of the output current of ±2% full span. In this case, the analog output will go into the safety-related state.

The safety related state of the analog output is represented by an output current of 2 mA ± 0,05 mA. In the event of an interruption, the absence of an output current from the PLC is also to be regarded as a safety-related condition.

3.2 Initial setup

After installation and commissioning in accordance with the Operating Instructions, make sure that the following are set within the software menu:

Set the mA output type to 4 – 20 mA

SYS-MENU -> System configuration -> O_2 measuring ranges -> mA output type -> **4 - 20 mA**

Set automatic calibration at an interval of 3 days

SYS-MENU -> System configuration -> Calibration settings - > Auto.calibration -> **ON**
-> Calibration method -> **O_2 1-point**
-> Start by -> **Time**
-> Interval (days) -> **3**

Prevent changes to the settings

After commissioning the system, set a customized system code to prevent unauthorized changes to the settings.

Initial calibration after installation

Wait for the system to reach its operating temperature. Carry out an O_2 two point calibration after 24 hours of operation in accordance with the Operating Instructions.

CAL-MENU -> 2-point calibration, O_2

3.3 Checking the safety function

To check whether the analyzer enters a safe state in the event of a failure, carry out the following steps:

1. Take action to prevent a false trip e.g. Bypass the safety PLC.
2. Access the connection terminal of the electronic unit according to the Operating Instructions.
3. Disconnect the wire X4:12 (O_2 sensor signal **+**) at the terminal.
4. The error LED should be on after a short while and an error message should be present.
5. Measure the mA output at terminal X5:17 A/B with a suitable ampere meter, the output should be 2 mA ± 0,05 mA.
6. Reconnect the wires and confirm the error message.
7. Measure the mA output, while it is adjusted to the values 4 mA, 12 mA and 20 mA in the software menu SYS-MENU -> System checks -> Check mA output. The measured value and setpoint should be in the range of ± 0,05 mA.
8. Undo the PLC bypass or other measures taken in point 1.

3.4 Maintenance intervals

In general, maintenance as well as the maintenance intervals always depend on the flue or process gas conditions in which the probe is installed. Maintenance intervals may therefore vary between a few months up to a few years.

The biggest influencing factors are the presence of corrosive ingredients such as SO_2 or HCl, a continuous reducing atmosphere (reduced oxygen concentration, increased levels of combustibles) and the characteristics of the solid components in the flue gas.
These may have the following effects: Severe chemical or mechanical damage to the probe, clogging of the filter element or accelerated aging of the sensor. This may lead to a distortion of the measured values as well as an increase in the response time, which can in turn lead to false process operation afterwards.

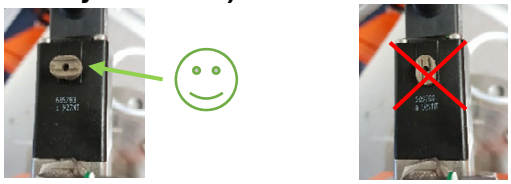
For this reason, a sensor check is recommended with test gas and test air every six months. If a significant deviation between the values obtained and those presently anticipated, a 2-point calibration should be carried out. A visual inspection of the probe, which includes cleaning of the filter element if necessary, should be conducted at least annually.

Notwithstanding these recommendations, the operator must define an appropriate maintenance interval which reflects the criticality of the measurement and the process.

3.5 Prooftest requirements and maintenance recommendation

IMPORTANT: **The tests marked bold are part of the proof test and are mandatory to establish the required prooftest interval of 1 year. Not following these intervals will result in loss of the safety function!**

It is strongly recommended to perform all maintenance steps in below table.

	Monthly	1/2 year	Yearly
Visual examination			
Check for plausible measured values	X	X	X
Visual check electronic unit, sensor, cables and hoses for external damage.			X
Check position of magnet valve push button at the probe head. It has to be in the horizontal position and unlocked (SIL safety relevance). 		**X**	**X**
Electronic unit			
Check sensor values with test air and test gas (SIL safety relevance)		**X**	**X**
Sensor calibration (if required)		X	X
Check mA and relay outputs (SIL safety relevance)			**X**
Check for next required calibration of the HCU (ATEX only)			X
Probe			
Check, and if necessary clean the probe and filter head			X
Check the probe for corrosion (flange process side)			X
System			
Check safety function (SIL safety relevance)		**X**	**X**
Log all work carried out incl. measurement values		X	X
Complete Service Report and Log Sheet		X	X

3.6 Troubleshooting

In case of failed tests of the safety function, refer to the Troubleshooting Section of the Operating Instructions. Contact the manufacturer for support or repairs if necessary.

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