Dräger Pulsar 7000 Series
Safety Manual

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Content

1 Scope and purpose of the Safety Manual

The purpose of this Safety Manual is to document the necessary information and assumptions that are required for the integration of the assessed gas warning system Dräger Pulsar 7000 Series (including all OTR 00** variants) into a safety instrumented system (SIS) in compliance with the requirements of the IEC 61508 standard.

The Safety Manual specifies the safety functions. It shall be used to support the safety function of a SIS.

The Safety Manual provides the assumptions that have been made on the usage of the gas warning system. If those assumptions cannot be met by the application, the SIL capability must be evaluated considering the application-specific circumstances.Contact Dräger for assistance with application-specific configurations if they are not in line with these assumptions.

2 Relevant standards

EN 50402:2005 +A1:2008	Electrical apparatus for the detection and measurement of combustible or toxic gases or vapours or oxygen – requirements on the functional safety of fixed gas detection systems
IEC 61508:2010	Functional safety of electrical / electronic / programmable electronic safety-related systems

3 Field of application

The herein considered instruments Dräger Pulsar 7000 Series are explosion-proof open-path infrared gas warning systems for stationary, continuous monitoring of gases and vapours in a suitable atmosphere. A Dräger Pulsar 7000 Series gas warning system consists of a transmitter and a receiver.

The Dräger Pulsar 7000 Series monitors the concentration of combustible gases and vapours containing hydrocarbons.

The gas warning system uses microprocessor technology to convert the signal measured by the built-in detector components to a 4 to 20 mA analogue signal output.

The double-compensating and non-imaging optics effectively compensate for temperature and ageing effects.

The gas warning system is designed for one-man calibration and offers a variety of diagnostics and self-test features.

Various detectable gases are listed in an internal gas table. For these gases, an individual linearisation of the output signal corresponding to the measured gas concentration is provided.

Configuration and calibration are menu-guided and easy to perform, using a HART® handheld terminal, Dräger Pulsar handheld terminal or a PC software such as PolySoft.

The Safety Manual refers to the following models of Dräger Pulsar 7000 Series:

Model	Part no.
Pulsar 7000 Tx S Range JB Ex e	6851700
Pulsar 7700 Rx S Range JB Ex e	6851702
Pulsar 7900 Rx S Range JB Ex e	6851704
Pulsar 7000 Tx L Range JB Ex e	6851701
Pulsar 7700 Rx L Range JB Ex e	6851703
Pulsar 7000 Tx S Range JB Ex e Ho	6851706
Pulsar 7000 Tx L Range JB Ex e Ho	6851707
Pulsar 7700 Rx S Range JB Ex e Ho	6851708
Pulsar 7900 Rx S Range JB Ex e Ho	6851709
Pulsar 7900 Rx S Range JB Ex e SS	6851712
Pulsar 7000 Tx S Range JB Ex e SS	6851718
Pulsar 7000 Tx L Range JB Ex e SS	6851719
Pulsar 7700 Rx S Range JB Ex e SS	6851720
Pulsar 7700 Rx L Range JB Ex e SS	6851721
Pulsar 7700 Duct Mount JB Ex e, complete	6851716
Pulsar 7000 Tx Duct Mount JB Ex e	6851530
Pulsar 7700 Rx Duct Mount JB Ex e	6851531
Pulsar 7000 Tx S Range UL	6851728
Pulsar 7000 Tx L Range UL	6851729
Pulsar 7900 Rx S Range UL	6851732
Pulsar 7700 Rx S Range UL	6851733
Pulsar 7700 Rx L Range UL	6851734
Pulsar 7700 Duct Mount UL, complete	6851739
Pulsar 7000 Duct Mount Tx UL	6851730
Pulsar 7700 Duct Mount Rx UL	6851731
Pulsar 7000 Tx S Range SPPT	3700700
Pulsar 7000 Tx L Range SPPT	3700701
Pulsar 7700 Rx S Range SPPT	3700702
Pulsar 7700 Rx L Range SPPT	3700703
Pulsar 7900 Rx S Range SPPT	3700704
Pulsar 7000 Tx S Range Fi SPPT	3700705
Pulsar 7000 Tx L Range Fi SPPT	3700706
Pulsar 7700 Rx S Range Fi SPPT	3700707
Pulsar 7700 Rx L Range Fi SPPT	3700708

4 Assumptions and restrictions for usage of the gas warning system

4.1 General

For proper installation, operation, maintenance and calibration of the gas warning system and its accessories, strictly follow the instructions for use as well as the installation instructions for accessories.

See instructions for use for information about assembly and functional description, operating conditions and interface specification.

4.2 Trainings

For available trainings contact the service of Dräger.

4.3 Installation

The parameterization of the gas warning system must be checked after installation by reading back the parameters (e.g. with the PC software PolySoft). Also a calibration and a proof test must be performed. The user has to ensure that the requirements regarding supply voltage and power consumption, as well as the 4 to 20 mA loop requirements are within the specified range.

The accuracy of gas measurement is depending on ambient parameters. See instructions for use for details and measuring performance. The ambient temperature range for SIL 2 operation is restricted to -40 °C to +60 °C. Dräger Pulsar 7000 Series supports HART® multidrop, however, in a SIS this option must be avoided, as the output current is fixed to 1 mA in this mode and does not change with gas concentrations.

4.4 Use of accessories

Use only original Dräger Pulsar 7000 Series accessories. Part nos. see instructions for use, descriptions see specific installation instructions.

4.5 Maintenance

The reason for repeated maintenance of the gas warning system is to ensure the safety function of the instrument. Therefore, functionality, calibration and parameterization of the gas warning system must be checked at regular intervals. The maintenance interval must not exceed one year.

4.6 Calibration

For calibration ensure that the alignment of transmitter and receiver is within the specified limits.

See instructions for use for calibration procedure.

4.7 Replacement

If a Pulsar open path system needs to be replaced (for repair or exchange), the parameterization of the replacing gas warning system must be checked. A calibration and a proof test must be performed. The time assumed for replacement is 24 hours.

⚠ CAUTION

Check if the replacing receiver is locked for unauthorised access to calibration and/or configuration (SIL lock), if not: lock it.

4.8 Configuration

The gas warning system is configurable over a wide range of settings. For configuration, first unlock the device from SIL lock. If any settings are changed, the parameters must be confirmed by authorized personnel. Check all parameters listed on the confirmation screen of the particular tool like PolySoft and/or HART® handheld terminal. To confirm the parameters, the gas warning system must be locked (SIL lock).

4.9 Access rights related to SIL lock

Three levels of access rights and related user groups of different qualification are distinguished to unlock the receiver and change parameters.

- Operator – does not receive the password to unlock for calibration or modification of safety-related parameters.
- Calibration personnel – has the password and a tool to unlock for calibration purposes and to lock it again after successful calibration.
- Parameterization personnel – has the password and a tool to unlock for modification and parameterization of safety-related parameters.

⚠ CAUTION

Locking of the receiver is required for SIL operation, i.e. an unlocked receiver may not be used in SIL applications.

4.10 Access restrictions

⚠ CAUTION

The plant operator must ensure that only personnel qualified for calibration may know the password to unlock the gas warning system for calibration.

The plant operator must ensure that only personnel qualified for parameterization know the password to unlock the device for parameterization.

5 Proof test

All safety-related data are based on repeated proof tests performed at regular intervals, provided that the proof tests were successful.

Proof testing is an essential part of functional safety because it is the only way to detect unrevealed dangerous failures. Compliance with these proof test intervals isthe responsibility of the user of the safety equipment.

During the proof test, functional safety is affected and must be ensured by other measures, also organizational measures, or the SIS must be forced and maintained in a safe state.

NOTICE
Not only the gas warning system must be tested, but the safety function of the whole SIS.

The proof test consists of the following steps:

Steps for proof test to be passed

Step	Action
1	To prevent unwanted alarms or actuation of devices such as extinguishing systems, these devices must be disabled prior to performing SIS proof tests or maintenance.
2	Check all the accessories in use for contamination or damage. Clean or replace these accessories if necessary.
3	Check the lenses of the gas warning system for contamination. If contaminated, clean and dry the lenses.
4	Check if alignment is ok. If not, realign the gas warning system.
5	Ensure that the optical path is free of hydrocarbons and check if the SIS displays the expected value.
6	Perform zero-point calibration.
7	Test proper fault condition indication of the SIS by ● either blocking the optical path, or ● sending a digital command to set the current output of the gas warning system to fault condition. Make sure the SIS recognizes the fault condition state.
8	Apply the test gas cell or an adequate number of test sheets to trigger the alarm thresholds being used in the SIS. Make sure the SIS recognizes the alarm condition.
9	Restore the standard operating mode. Unlock the alarm activation at the control device to put the SIS back to normal operating mode.

6 Safety-relevant parameters

Parameter	Description
Measured gas	Selected measured gas (e.g. “Methane”).
CAS number	CAS Number of the selected measured gas
Custom gas name	User specific gas name
Gas table number	Index of the selected gas
LEL category	Three categories available: 1: “NIOSH”, 2: “IEC”, 3: “PTB”
LEL of measured gas	Gas concentration corresponding to 100% of the Lower Explosion Limit (LEL) in ppm, depending on national or regional regulations
Measuring range	Gas concentration of the configured measured gas unit which will lead to an output signal of 20 mA on the 4 to 20 mA interface
Channel	Number of the selected channel
Capture value and limits	Clamping of the signal output to the capture value for measurement readings within the capture value limits
Auto zero tracking state	Indicates if auto zero tracking is active or not
Auto zero tracking rate	Selected rate to compensate for drift effects by automatically correcting the zero-point
Time to beam block	Duration before the system indicates beam block error in case of an obstructed beam path
Beam block to fault state	Indicates if the beam block to fault feature is active or not
Beam block to fault time	Duration before a beam block error becomes a general fault
HART® polling address	Selected polling address of the device
Path length	Path length between transmitter and receiver
Zero-point parameters	See instructions for use, calibration

NOTICE
Refer to the instructions for use for further information.

7 Functional specifications of the safety functions

The safety function comprises the measurement of the concentration of flammable hydrocarbons in the atmosphere by absorbing infrared radiation and setting the 4 to 20 mA output accordingly.

Definition Fail Dangerous: Failure that does not respond to a demand from the process (i.e. being unable to go to the defined fail-safe state) or results in an output measurement value which is:

- 10 % below the measured gas concentration or
- 3 % of full scale below the measured gas concentration whichever is the greater.

The deviation between measured value and true concentration can exceed above errors.

NOTICE
For detailed information see chapter “Technical data” in the instructions for use.

7.1 Assumptions

The following assumptions have been made during the Failure Modes, Effects, and Diagnostic Analysis (FMEDA) of the infrared gas warning system Dräger Pulsar 7000 Series.

- Failure rates are constant, wear-out mechanisms are not included.
- Propagation of failures is not relevant.
- The device is installed per manufacturer’s instructions.
- Sufficient tests are performed prior to shipment to verify the absence of vendor and/or manufacturing defects that prevent proper operation of specified functionality to product specifications or cause operation different from the design analyzed.
- External power supply failure rates are not included.
- The Meantime To Restoration (MTTR) after a safe failure is 24 hours.
- For safety applications only the described versions and configurations are considered.
- The 4 to 20 mA output signal is fed to a SIL 2 compliant analogue input board of a SIS.
- Only the 4 to 20 mA output signal is evaluated in separate FMEDA estimations.
- For soft errors, a worst case failure rate of 1.2 FIT/kBit was assumed. Soft errors are part of the FMEDA.
- When using the 4 to 20 mA output signal, the application programme in the safety logic solver is configured according to NAMUR NE43 to detect under-range and over-range failures and does not automatically trip on these failures; therefore these failures have been classified as dangerous detected failures.
- General necessary gas detection tests have been passed successfully.
- Faulty too high output value is classified as safe failure.
- The flash light transmitter is not part of the safety function since no measurement or diagnostic function depends on the transmitter.
- Sink and source current output operation is evaluated together. The result is the worst case assumption and valid for both configurations.

The SIS must fulfil all requirements according to SIL 2 or higher of Standard IEC 61508:2010 or parameters related to the safety function above (see table below):

Parameter	value
Diagnostic test interval (w/o memory test)	≤ 2 seconds
Diagnostic test interval (memory test)	≤ 8 hours
Hardware Fault Tolerance (HFT)	0
Component type	Type B
SIL capability	SIL 2, systematic capability SIL 3
Safe state	I_{out} ≤ 3.6 mA
Architecture	1oo1
MTBF	105 years
Useful lifetime (maximum)	12 years
Measured value response time	See instructions for use

7.2 4 to 20 mA current output

The entire valid measurement range for the output signal is between min. 3.8 mA and max. 20.5 mA.

All special signals are configurable between 0.5 mA and 3.2 mA except WARNING.

Default configuration of “fault, maintenance and beam block signals” are as follows:

Default current [mA]	Meaning	Configurable range [mA]
1.0	Fault (including memory error and runtime error)	0.5 ... 3.2
2.0	Beam block error	0.5 ... 3.2
3.0	Maintenance	0.5 ... 3.2
3.5	Warning For SIL locked devices	0.5 ... 3.5
3.5	Warning For NOT SIL locked devices NO SIL use possible > 3.5 mA	0.5 ... 5.0

⚠ CAUTION
The user must ensure the configuration of different current levels for the signals listed above.

NOTICE
For detailed information see instructions for use.

7.2.1 Useful lifetime

Although a constant failure rate is assumed by the probabilistic estimation method, this only applies if the useful lifetime of components is not exceeded. Beyond their useful lifetime the result of the probabilistic calculation method is therefore meaningless, as the probability of failure significantly increases with time. The useful lifetime is highly dependent on the component itself and its operating conditions, especially its temperature.

This assumption of a constant failure rate is based on the bathtub curve, which shows the typical behaviour of electronic components. Therefore it is obvious that the PFD_{AVG} calculation is only valid for components which have this constant domain and that the validity of the calculation is limited to the useful lifetime of each component. The experience-based useful lifetime is usually between 8 and 12 years. (IEC 61508-2, 7.4.9.5, Remark 3)

7.2.2 Operation in current source/sink mode

Failure category	Failure rates (in FIT)
λ_{SD} Fail safe detected	0
λ_{SU} Fail safe undetected	37
λ_{DD} Fail dangerous detected	1409
λ_{DU} Fail dangerous undetected	48
Safe failure fraction (SFF)	96.79 %
DC_D	96.71 %
PFD_{AVG} (T[Proof] = 1 year)	8.34E-04
PFD_{AVG} (T[Proof] = 2 years)	9.75E-04
PFD_{AVG} (T[Proof] = 5 years)	1.40E-03
PFH	4.8E-08 1/h

8 Reference documents

Document	Part no.
Instructions for use (Dräger Pulsar 7000 Series, ATEX version)	9033451
Instructions for use (Dräger Pulsar 7000 Series, UL version)	9100114

9 List of abbreviations

DC_D	Diagnostic Coverage of Dangerous failures ($DC_D = \lambda_{DD} / (\lambda_{DD} + \lambda_{DU})$)
DU	Dangerous Undetected (failure)
FMEDA	Failure Modes, Effects, and Diagnostic Analysis
HART®	Highway Addressable Remote Transducer
HFT	Hardware Fault Tolerance
IR	Infrared
Low demand mode	Mode, where the frequency of demands for operation made on a SIS is no greater than one per year and no greater than twice the proof test frequency.
MTBF	Meantime Between Failure
MTTR	Meantime To Restoration
PFD	Probability of Failure on Demand
PFD_{AVG}	Probability of Failure on Demand Average
PFH	Probability of dangerous Failure per Hour The term “Probability” is misleading, as IEC 61508 defines a Rate.
PLC	Programmable Logic Controller
SFF	Safe Failure Fraction; summarises the fraction of failures, which lead to a safe state and the fraction of failures which will be detected by diagnostic measures and lead to a defined safety action. $SFF = (\lambda_S + \lambda_{DD}) / (\lambda_S + \lambda_D)$ $\lambda_S = \lambda_{SD} + \lambda_{SU}$ $\lambda_D = \lambda_{DD} + \lambda_{DU}$
SIL	Safety Integrity Level
SIS	Safety Instrumented System
Type B component	“Complex” component (using micro controllers or programmable logic); for details see 7.4.3.1.3 of IEC 61508-2
T[Proof]	Proof test interval

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