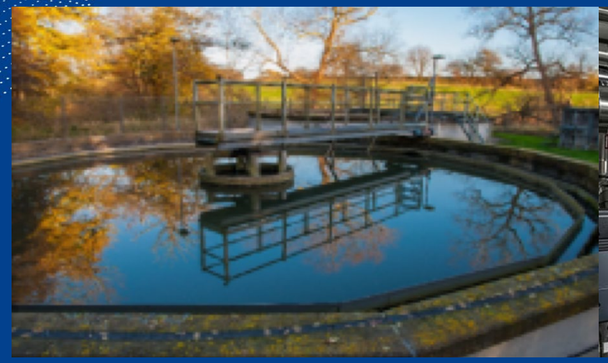


ATEX and Functional Safety

Ex Forum
17-11-2022

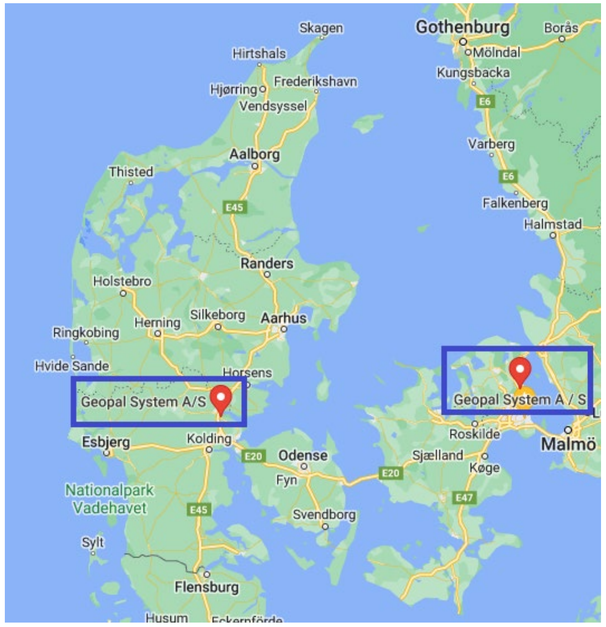
geopal®

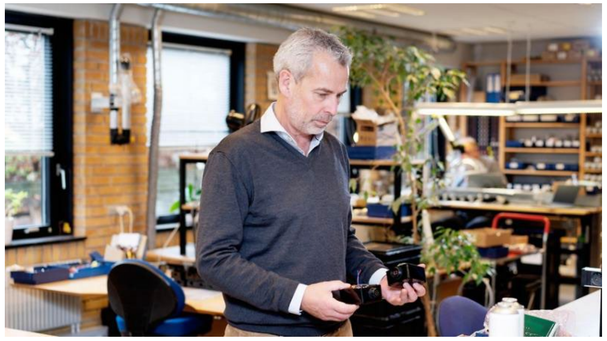
Agenda

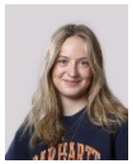
- **Introduction**
- **GP-NOVA**
- **ATEX and Functional Safety**
- **GP-NOVA ATEX and Functional Safety**
- **Thank You**

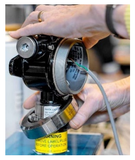
Introduction – Geopal System A/S, est.1985

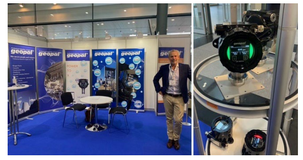
Geopal develop, manufacture and service professional alarm systems for detection of explosive and toxic gases.









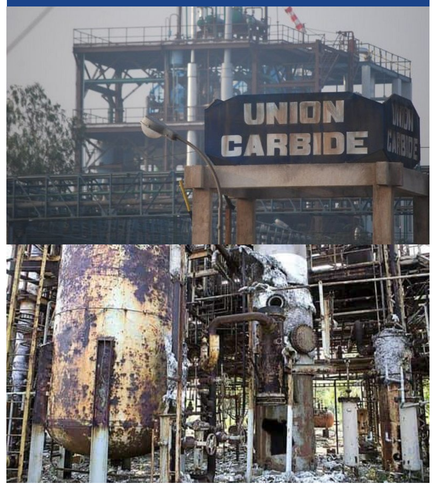


24/7 Customer Support Service Department

- Headquarter in Vedbæk
- Project management and service in Vejle

Introduction – Why Gas Detection

Bhopal, India
02-12-1984



Toxic gas leak (Methyl isocyanate)
16000 died, 560000 hospitalized

Imperial Sugar, USA
07-02-2008

Dust explosion
14 died, 40 hospitalized

Vejen, Denmark
26-09-2014

Toxic gas leak (Ammonia)
27 evacuated

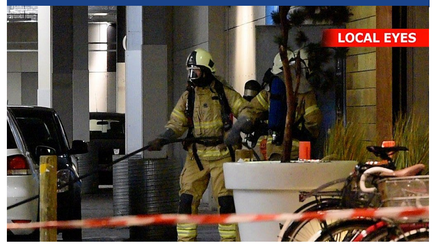
Kaohsiung, Taiwan
11-05-2017

Explosive gas leak (Propane)
20 died, 270 hospitalized

Dezful, Iran
13-08-2017

Toxic gas leak (Chlorine)
400 hospitalized

Fisketorvet, Denmark
12-11-2019



Toxic gas leak (Ammonia)
5 hospitalized

Hotel Saratoga, Cuba
07-05-2022

Explosive gas leak (Propane)
46 died, 53 hospitalized

Introduction – Typical Applications

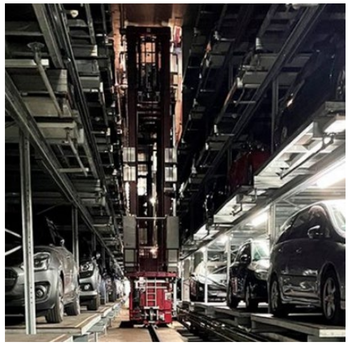
Power-to-X

Marine

Power Plants

Refrigerating systems

Research and education



Car Parks

Construction Sites

Biogas Plants

Battery Charging Stations

Medico

Introduction – Gas Detection

Principle of Operation

A gas detector is basically a gas sensor attached to a controller (electronic circuitry). The sensor outputs a signal that is proportional with the target gas concentration. A change in the sensor output is then processed by a controller; if the signal changes beyond a setpoint, the controller ensures to announce this change via its analog-, digital-, and/or relay- outputs.

Introduction – Geopal System A/S, est.1985

Visual Indication
Status LED bars offer clear visibility from distance of ≥ 10 m.

OLED Display
Clear and bright independent of viewing angle.

Analog output
Configurable galvanically isolated 4-20 mA loop.

Relay Output
Alarm 1, 2, and Fault

Digital Output
RS-485 Modbus RTU.

Electrical Ratings
Input voltage: 18-36 V_{DC}.
Input power: < 6.5 W.

Bluetooth Communication
Quick and easy way of configuring, monitoring and servicing via Geopal's mobile app.

Logger and BlackBox Function
Memory containing system settings and logs is battery driven, for quick startup after power cycling.

Calibration History
Overview of sensor performance by storing previous calibration data for better planning of maintenance and service routines.

Approvals
- ATEX/IECEx.
- Suitable for SIL 2.

Sensor Technologies

Semiconductor

Catalytic Bead

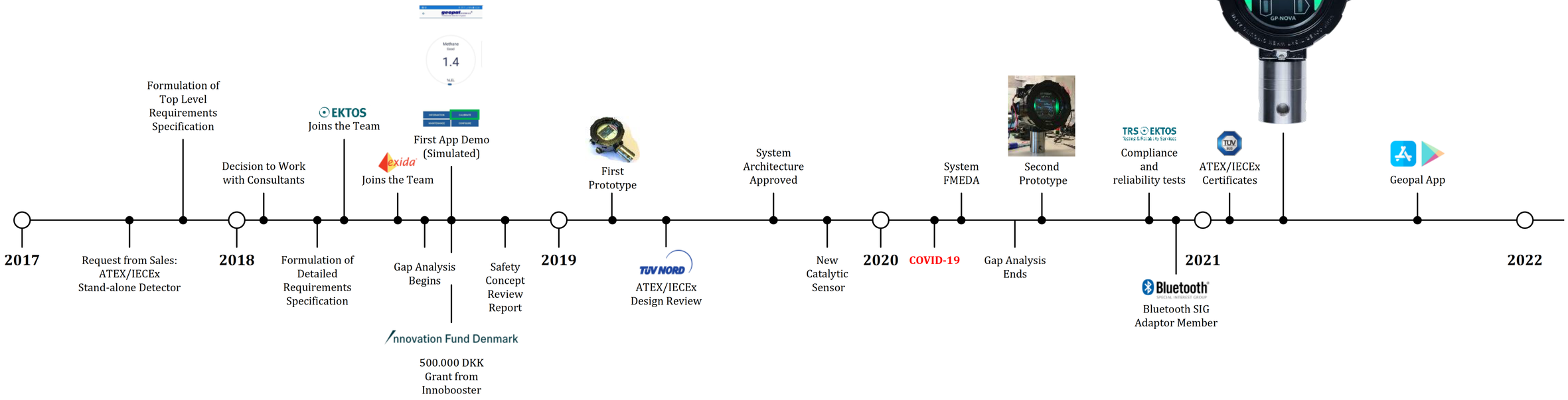
Photo Ionization Detector (PID)

Electrochemical

Infrared

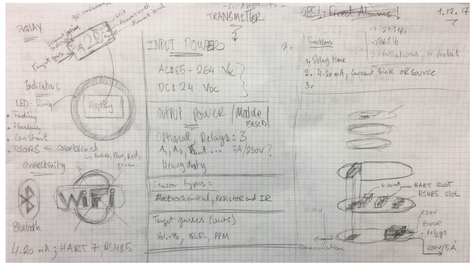
Molecular Property Spectrometer (MPS)

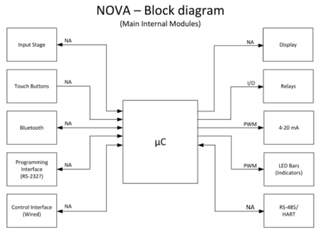
GP-NOVA – Timeline 2017-2022

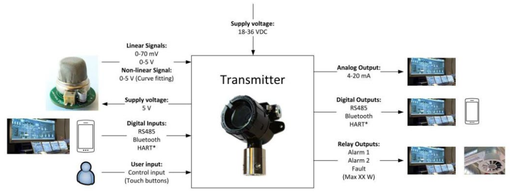


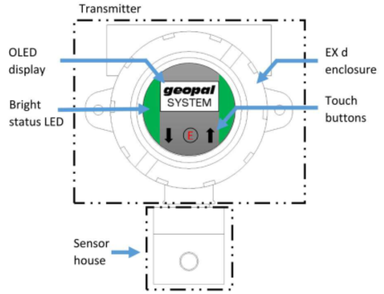
GP-NOVA – Timeline, 2017-2018

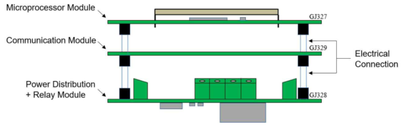
GP-NOVA Requirements Specification











EKTOS Joins the Team

EKTOS

Jesper Holst
Director

Oleksandr Liubimov
Project Director

Anders Fjordvald
Sales Manager

Sergii Gordiienko
Project Manager

Vadym Dovhopolyi
Technical Leader

Sergii Shavshyn
Quality Assurance

Konstantin Sirenko
Hardware architect

Sergii Vlasenko
Software architect

Oleksandr Chamara
Software engineer

Hennadii Plastun
Project Manager

Greetings from Ukraine

• CERTIFICATE • CERTIFICATE • CERTIFICATE • CERTIFICATE • CERTIFICATE •

SIL

Functional Safety Verification

Gratulations Abdallah with Elektroprisen.
We are proud of being part of development of your fantastic product.

EKTOS Team

EKTOS
PROVEN ELECTRONICS

• CERTIFICATE • CERTIFICATE • CERTIFICATE • CERTIFICATE • CERTIFICATE •

GP-NOVA – Timeline, 2018

exida Joins the Team

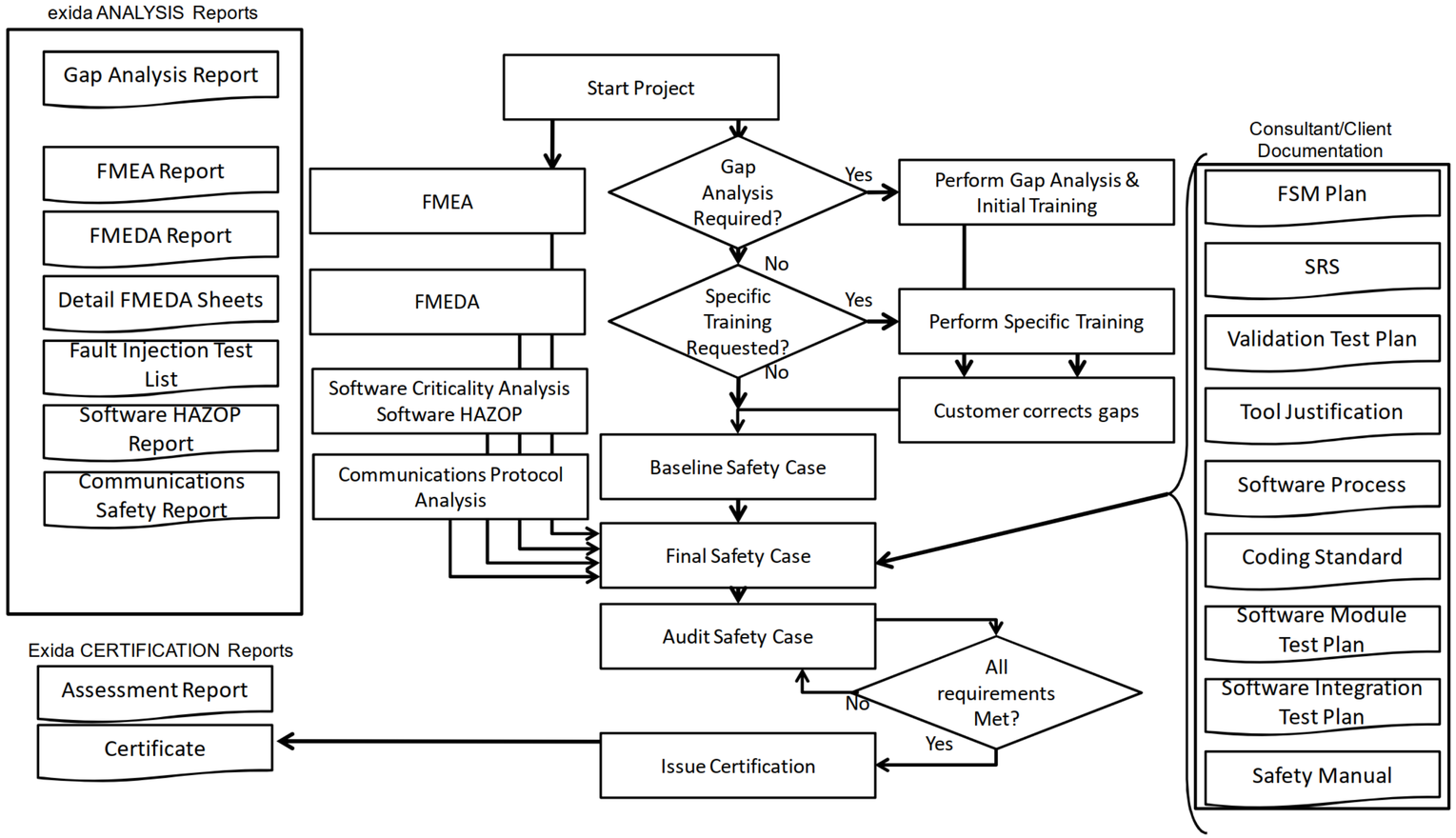
Dr. William Goble
Principal Partner, USA

Dave Butler
Safety Engineer, USA

John Grebe
Sr. Safety Engineer, USA

Rudolf Chalupa
Safety Engineer, USA

exida IEC 61508 Certification Process



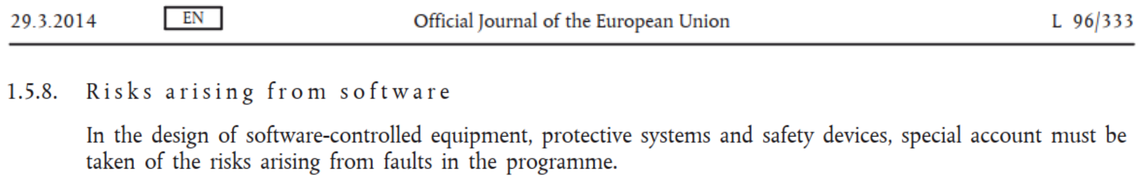
ATEX & Functional Safety

ATEX

ATEX directives are two EU directives dictates the minimum safety requirements for workplaces and equipment intended for use in explosive atmospheres.

DIRECTIVE 1999/92/EC on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres

DIRECTIVE 2014/34/EU on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (recast)



29.3.2014 EN Official Journal of the European Union L 96/333

1.5.8. Risks arising from software

In the design of software-controlled equipment, protective systems and safety devices, special account must be taken of the risks arising from faults in the programme.

Functional Safety

Functional safety ensures that an automatic safety function will perform the intended function correctly or the system will fail in a predictable safe manner.

The automatic safety function should be designed to properly handle likely human errors, systematic errors, hardware failures and operational/environmental stress.

Basically:

- Perform its function correctly – Reliability Engineering
- Fail in predictable manner – Safety Engineering

ATEX & Functional Safety

ATEX

- **EN 60079 Series**

EN IEC 60079-0:2018: Explosive atmospheres - Part 0: Equipment - General requirements
EN 60079-1:2014: Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures "d“
EN 60079-14:2014: Explosive atmospheres. Electrical installations design, selection and erection

- **Gas detectors**

EN 60079-29-1:2016: Explosive atmospheres - Part 29-1: Gas detectors - Performance requirements of detectors for flammable gases
EN 60079-29-2:2015: Explosive atmospheres - Part 29-2: Gas detectors - Selection, installation, use and maintenance of detectors for flammable gases and oxygen

- **Others**

EN 50270:2015: Electromagnetic compatibility. Electrical apparatus for the detection and measurement of combustible gases, toxic gases or oxygen
EN 50271:2018: Electrical apparatus for the detection and measurement of combustible gases, toxic gases or oxygen. Requirements and tests for apparatus using software and/or digital technologies

Regarding the requirements for the software development process, this European Standard specifies a practical approach to comply with the requirements of EN 61508-3 for SIL 1 without using this generic standard.

It is recommended to apply this European Standard for apparatus used for safety applications with SIL-requirement 1 instead of EN 50402 because EN 50402 is designed for the assessment of more complex gas detection systems with SIL-requirements greater than 1. However, the technical requirements of EN 50271 and EN 50402 are the same for SIL 1.

Functional Safety

- **IEC (EN) 61508 Series**

IEC/TR 61508-0:2005: Functional Safety Of Electrical/Electronic/Programmable Electronic Safety-Related Systems - Part 0: Functional Safety And IEC 61508
IEC 61508-1:2010: Functional Safety Of Electrical/Electronic/Programmable Electronic Safety-Related Systems - Part 1: General Requirements
IEC 61508-2:2010: Functional Safety Of Electrical/Electronic/Programmable Electronic Safety-Related Systems - Part 2: Requirements For Electrical/Electronic/Programmable Electronic Safety-Related Systems
→ **IEC 61508-3:2010:** Functional Safety Of Electrical/Electronic/Programmable Electronic Safety-Related Systems - Part 3: Software Requirements
IEC 61508-4:2010: Functional Safety Of Electrical/Electronic/Programmable Electronic Safety-Related Systems - Part 4: Definitions And Abbreviations
IEC 61508-5:2010: Functional Safety Of Electrical/Electronic/Programmable Electronic Safety-Related Systems - Part 5: Examples Of Methods For The Determination Of Safety Integrity Levels
IEC 61508-6:2010: Functional Safety Of Electrical/Electronic/Programmable Electronic Safety-Related Systems - Part 6: Guidelines On The Application Of IEC 61508-2 And IEC 61508-3
IEC 61508-7:2010: Functional Safety Of Electrical/Electronic/Programmable Electronic Safety-Related Systems - Part 7: Overview Of Techniques And Measures

→ **EN 50402:2017:** Electrical apparatus for the detection and measurement of combustible or toxic gases or vapours or of oxygen - Requirements on the functional safety of gas detection systems

In the event of conflict between the requirements of this European Standard and those of EN 61508, EN 50402 will take precedence.

Functional Safety

The purpose of functional safety is to ensure that the automatic system, that performs a safety function, will operate correctly as intended or the system will fail in a predictable and safe manner.

What is a Safety Instrumented System (SIS)?
An Implementation of one or more Safety Instrumented Functions.

What is a Safety Instrumented Function (SIF)?
A safety function is performed by a set of equipment to implement automatic protection function. Its ability to detect, decide and act is rated by the safety integrity level (SIL 1, 2, 3 or 4) of the specific function.

What is a Safety Integrity Level (SIL)?
Discrete rating level, SIL 1-4, specifying the safety integrity requirements of the safety instrumented functions (SIF) to be allocated to the safety instrumented systems (SIS). SIL 4 has the highest safety integrity and SIL 1 has the lowest safety integrity.

Safety Integrity Level	Probability of Failure on Demand	Risk Reduction Factor
SIL 4	>= 10^{-5} to < 10^{-4}	100,000 to 10,000
SIL 3	>= 10^{-4} to < 10^{-3}	10,000 to 1,000
SIL 2	>= 10^{-3} to < 10^{-2}	1,000 to 100
SIL 1	>= 10^{-2} to < 10^{-1}	100 to 10

Functional Safety

The purpose of functional safety is to ensure that the automatic system, that performs a safety function, will operate correctly as intended or the system will fail in a predictable and safe manner.

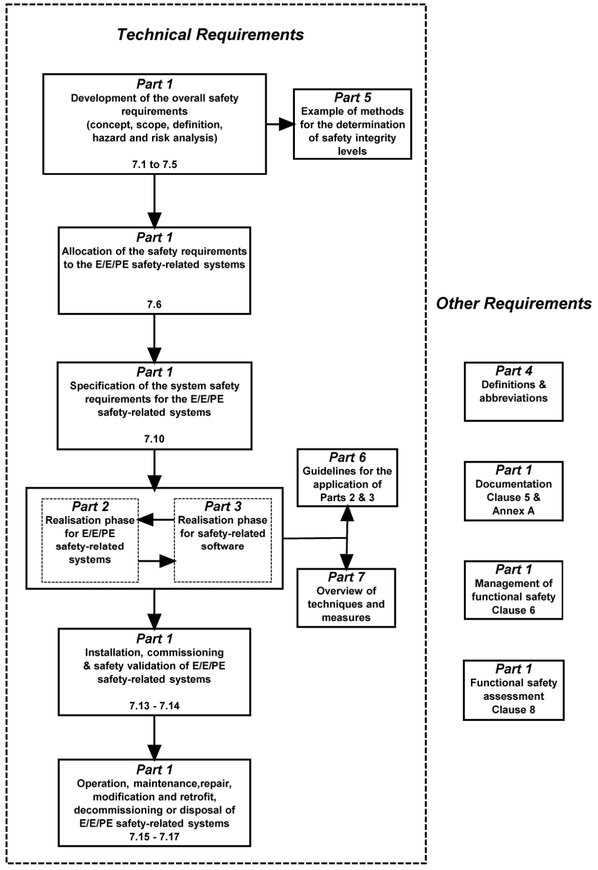


Figure 1 – Overall framework of the IEC 61508 series

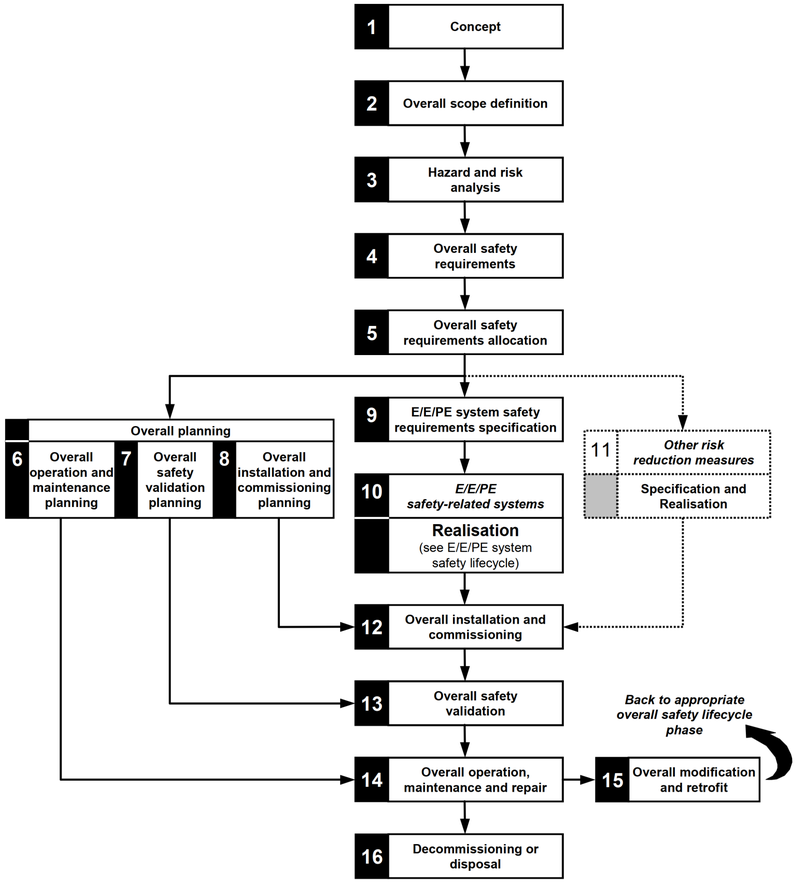
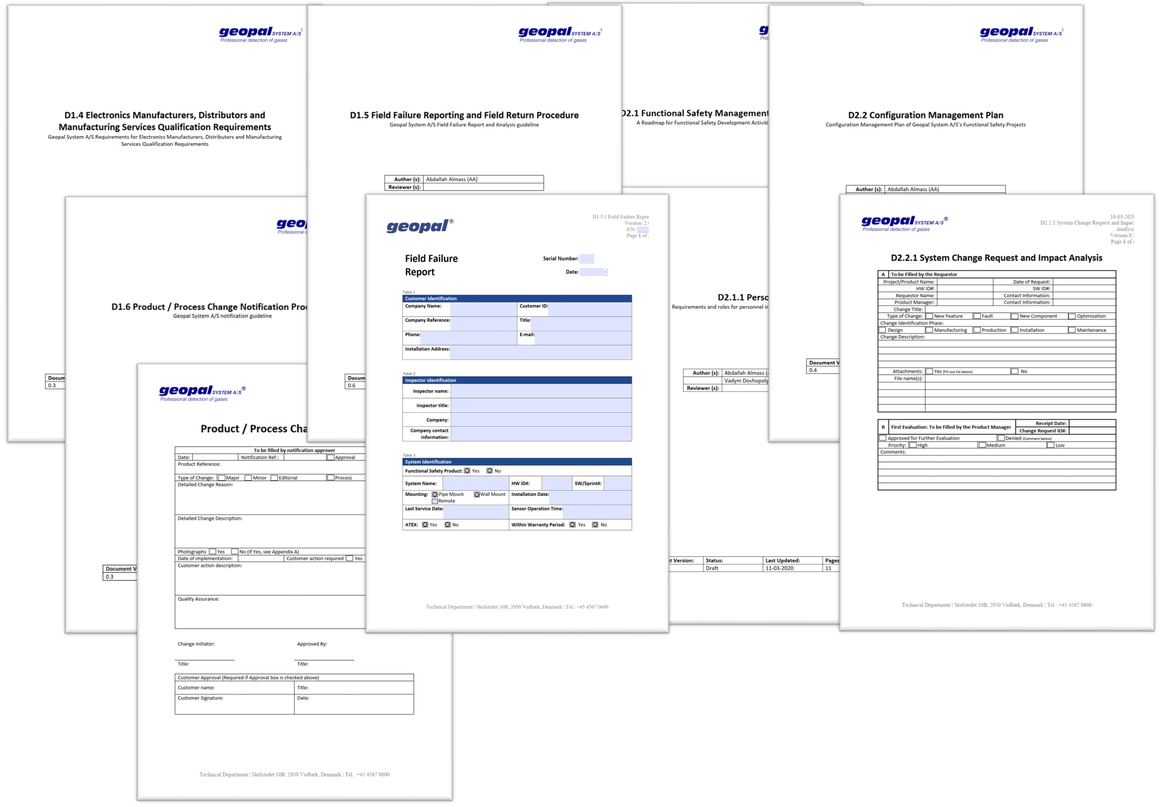
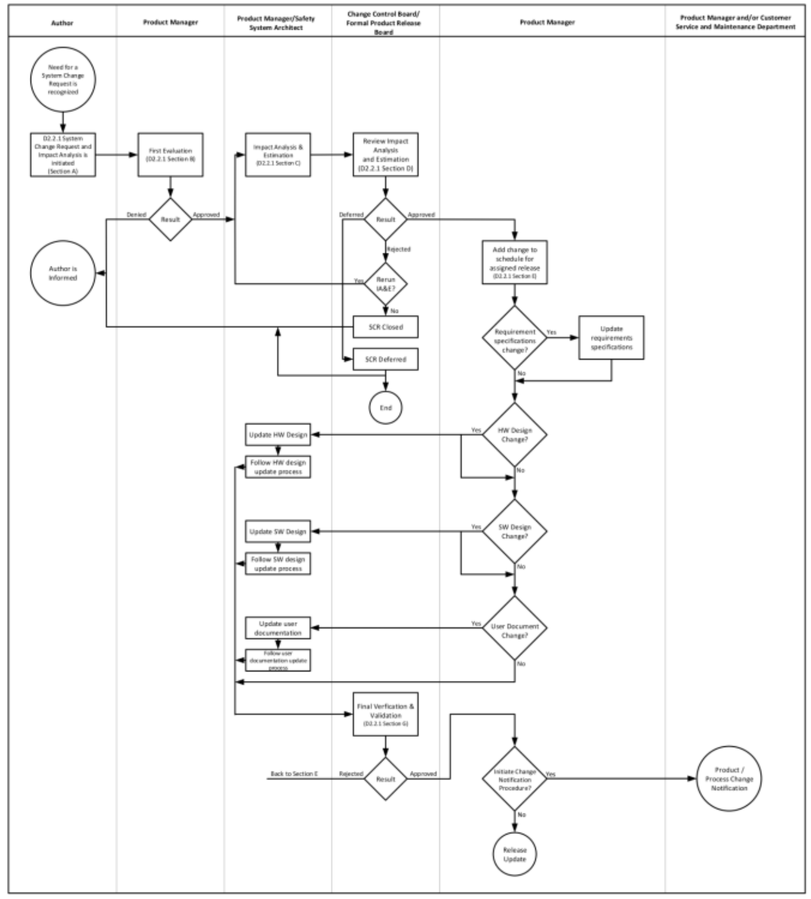


Figure 2 – Overall safety lifecycle

GP-NOVA – ATEX & Functional Safety

Internal Procedures



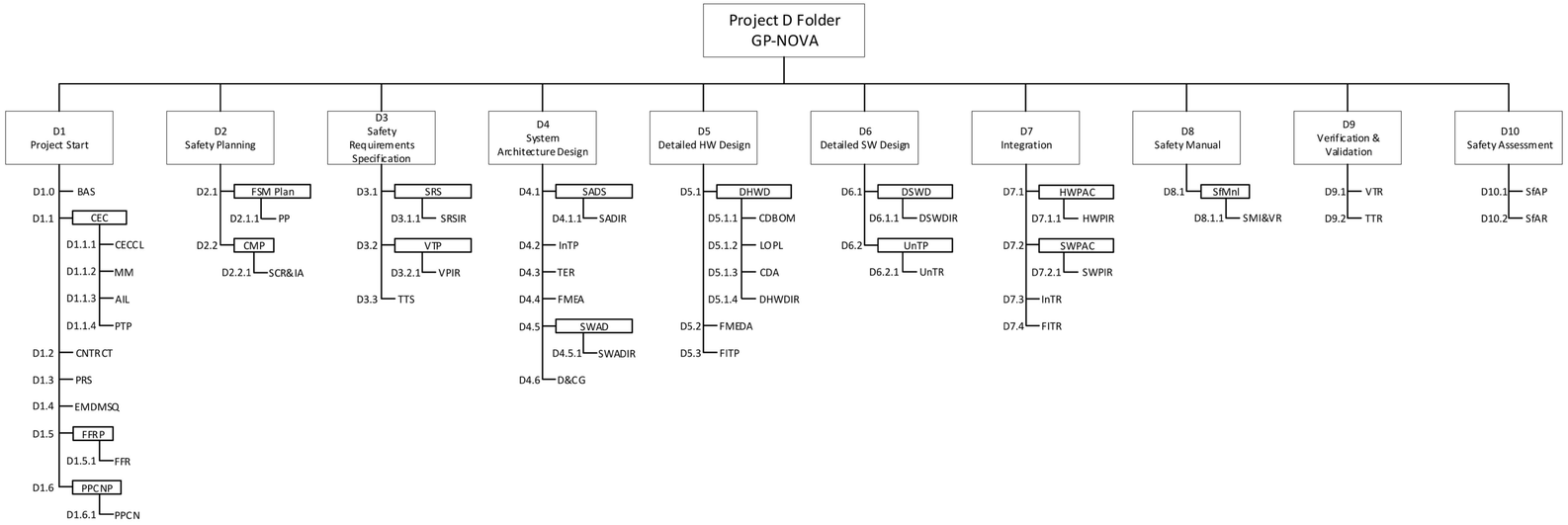


GP-NOVA – ATEX & Functional Safety

Requirements and Documentation

IEC 61508 General Requirements:

- **Management of Functional Safety**
- Safety Cycle Process
- Functional Safety Management Planning
- Configuration Management
- Documentation
- Training
- Functional Safety Assessment
- **Requirements Management**
- **Architecture Design**
- **Design and Implementation**
- **Verification and Validation – Testing**
- Integration Testing
- Safety Validation Testing
- **Modification and Change Management**
- **Safety Manual**



Architecture

There are 3 MCUs in the system:

1. Safety MCU
2. Application MCU
3. Bluetooth MCU

Safety MCU
System Power Circuitry
Sensor Input stage
Analog Output
Relays

Application MCU
Optical Buttons
Display
LED
Communication with RS-485 Modbus RTU module
Communication with Bluetooth Module
Micro SD Card (Logger)

Bluetooth MCU
Wireless communication (App)

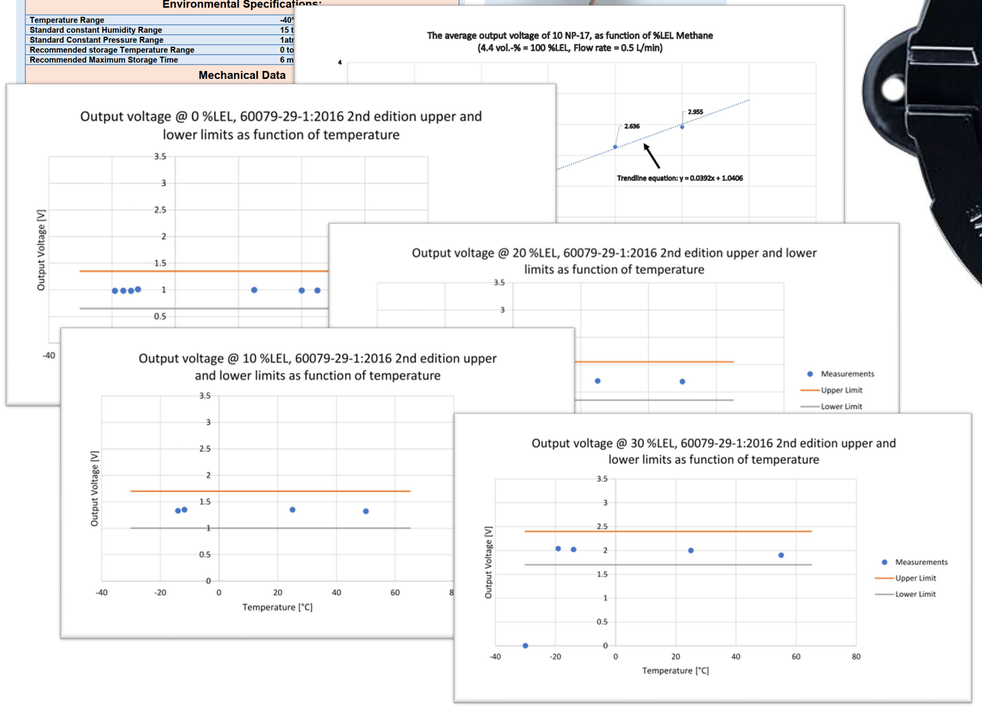
GP-NOVA – ATEX & Functional Safety

Design

The purpose of functional safety is to ensure that the automatic system, that performs a safety function, will operate correctly as intended or the system will fail in a predictable and safe manner.

General Specifications:

Operating Specifications:	
Detected Gases	Flammable Gases (Specifications are based on the detection of Methane/Natural Gas)
Standard Concentration Range	0-60% LEL
Recommended Bridge Voltage	2.0V +/- 0.1V
Current Consumption (at Recommended Bridge Voltage)	175mA +/- 15mA
Bridge zero offset	0 +/- 30mV
Minimum Output Sensitivity	50 mV for 1% CH_4
Linearity	Effectively Linear to 60% LEL
Response Time (Measured as T90)	<8secs
Accuracy (Measured as Repeatability)	± 0.5mV for Zero ± 1% LEL for Gas Sensitivity
Long Term Stability Drift	Sensitivity: Less than +/- 1% signal / month Zero: Less than +/- 1mV / month
Expected Lifetime in the field	> 3 Years.
Warranty Period	24 Months
Environmental Specifications:	
Temperature Range	-40
Standard constant Humidity Range	15 t
Standard Constant Pressure Range	1atr
Recommended storage Temperature Range	0 to
Recommended Maximum Storage Time	6 m
Mechanical Data	



5.2. How to Use Assumptions

The following assumption is taken when the sensor is incorporated in a safety-related system or integrated into a gas detector:

- the sensor is intended to be used in SIL 2 for low demand applications
- sensor diagnostics shall include
  - monitoring of the max allowed difference between channels *|tgsVCh1-tgsVCh2| < 0.3V*
  - output voltage of the sensor is inside the valid range *0.3V > tgsVCh1 > 2.68V*
  - sensing element supply voltage is inside the valid range *1.9V > seVcc > 2.1V*
  - input supply voltage is inside the valid range *4.0V > 5VDC > 5.5V*
  - Gas concentration level low limit monitoring *GCL >-10%LEL*
- periodical service shall include
  - periodical proof test is performed. The test includes target gas applying
  - periodical calibration (offset and/or span) is performed. The maximum expected offset drifting during the lifetime is ±0.2V. This drift is already included in the output voltage valid range diagnostics
- periodical service steps shall be taken after each exposure to high gas or low oxygen
- sensor replacing before the its lifetime has been gone. The lifetime of the sensor is 2 years
- Set point in a transmitter or similar equipment shall be less or equal to 60%LEL
- for safe operation 60 minutes warm-up timer shall be implemented into a transmitter or similar equipment in which the sensor is incorporated. The equipment shall provide the safe state during the warm-up time

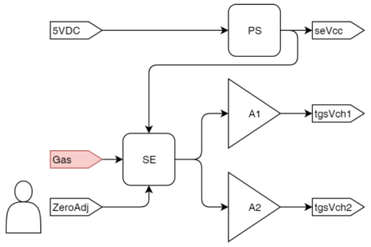
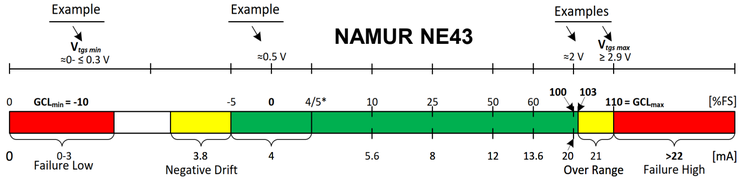


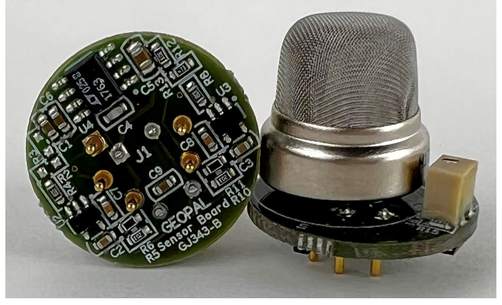
Table 6 Useful lifetime of components contributing to dangerous undetected failure rate

Component	Useful Life
Catalytic Bead Sensor	2 years

It is the responsibility of the end user to maintain and operate the GP-NOVA per manufacturer's instructions. Furthermore, regular inspection should show that all components are clean and free from damage.

The limiting factor with regard to the useful lifetime of the system is the Catalytic bead sensor. Therefore, the useful is predicted to be 2 years. The remainder of the transmitter is expected to have a useful life of 20 years.





Installation, Commissioning, Operation, and Maintenance

EN 60079-29-2:2015: Explosive atmospheres - Part 29-2: Gas detectors - Selection, installation, use and maintenance of detectors for flammable gases and oxygen

8.10 Timing of installation during construction operations

8.11 Commissioning

8.12 Operating instructions, plans and records

10 Training of operational personnel

11 Maintenance, routine procedures and general administrative control

11.2 Operational checks

11.2.2 Fixed systems

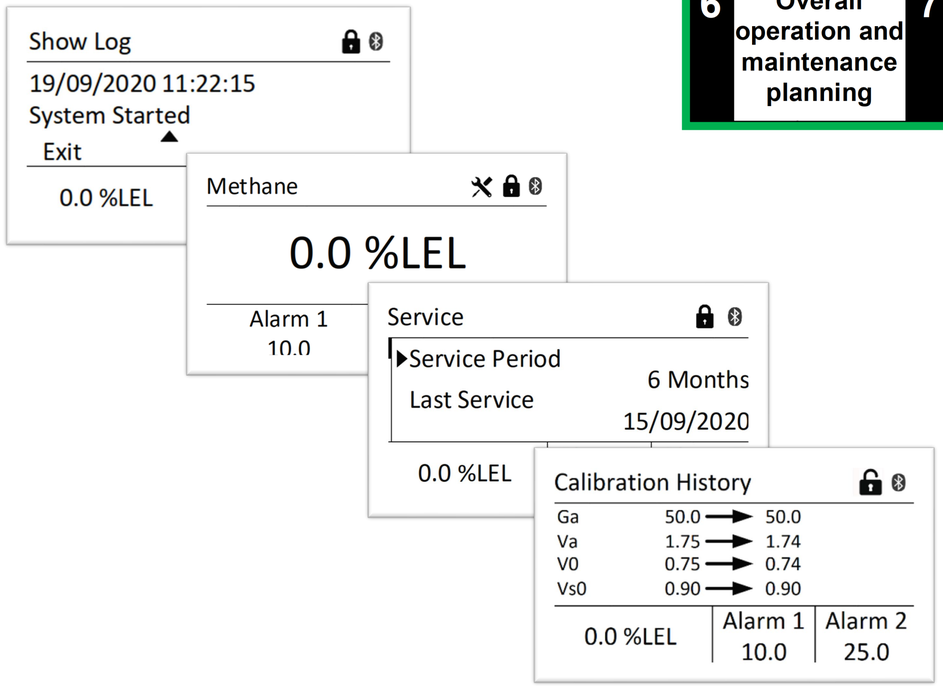
a) Regular visual inspection.

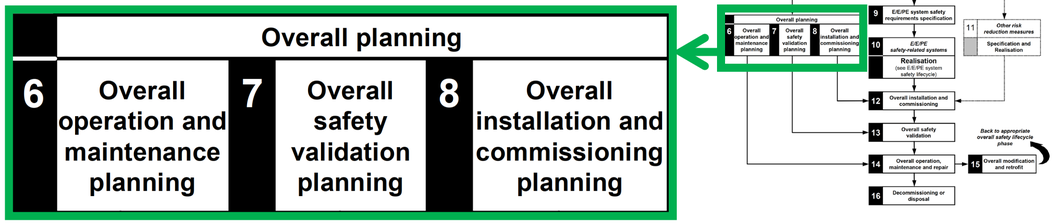
b) Regular functional verification.

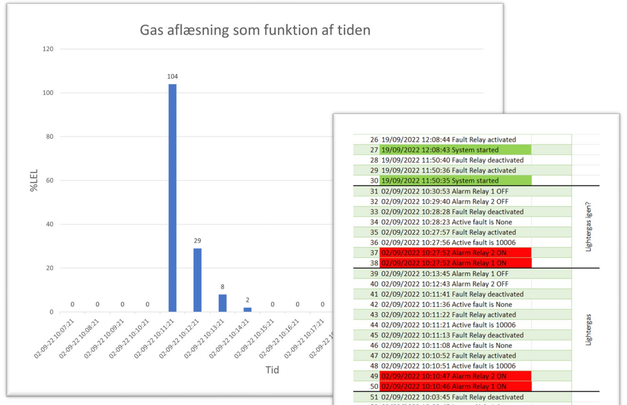
c) Regular re-calibration

d) System operation test

11.8.2.7 Maintenance record







GP-NOVA – ATEX & Functional Safety

Installation, Commissioning, Operation, and Maintenance

1 Safety

PAY ATTENTION
Please read, understand, and follow the instruction below.

SPECIFIC INFORMATION FOR EXPLOSION PROTECTION

- Do not open when an explosive gas is present
- Blanking elements shipped with the enclosure are included as part of the certificate for the complete equipment. Only use ATEX/IECEx certified blanking elements, in case of replacement.
- For information about the dimensions of the flameproof joints, the manufacturer must be contacted.

GENERAL

- Only trained personnel can assemble, install, and conduct maintenance of the system, include but not limited to training in ATEX/IECEx and functional safety.
- Before any interaction with the system, please read and understand all warnings, instructions, and descriptions presented in this manual.
- Use only genuine Geopal replacement parts and accessories when performing any maintenance procedure. Failure to comply will invalidate the certifications and warranty.
- Do not install, mount, disassemble the system within a hazardous working environment.
- Do not subject the system to silicone lubricants and/or vapors. Silicone can inhibit and/or permanently damage catalytic/pellistor type sensors.
- Do not paint near the system.
- Do not place the detector under direct sunlight.
- To reduce the risk of unauthorized access, enable and frequently change system passwords.
- For optimum utilization of the detector's visual features, avoid placing and/or subject the detector to direct light.
- Calibration must be conducted in a gas-free environment. If in doubt, conduct zero-calibration using clean canned atmospheric air.
- Overrange gas concentration reading and/or failure high of the system may indicate the presence of high explosive and/or toxic gas concentration.
- Any flameproof parts, joints, and plugs shall not be repaired.
- Conduct regularly visual inspection and bump tests to ensure that the gas can reach the sensor and the system is reacting to the gas concentration as intended
- Beware of electrostatic charge. When cleaning, use only a damp black/dark cloth.
- Use of alcohol near the system may result in a gas reading and thereby trigger an alarm.
- Always refer to system certifications, safety manual, and this user manual.

FAILURE TO COMPLY WITH THE ABOVE CAN RESULT IN SERIOUS PERSONAL INJURY AND/OR DEATH!

PENDING · SP14ATEX7159 · DBI reg.no 233.301 · Intertek DIC444QMS

EM92100E 2.2 4

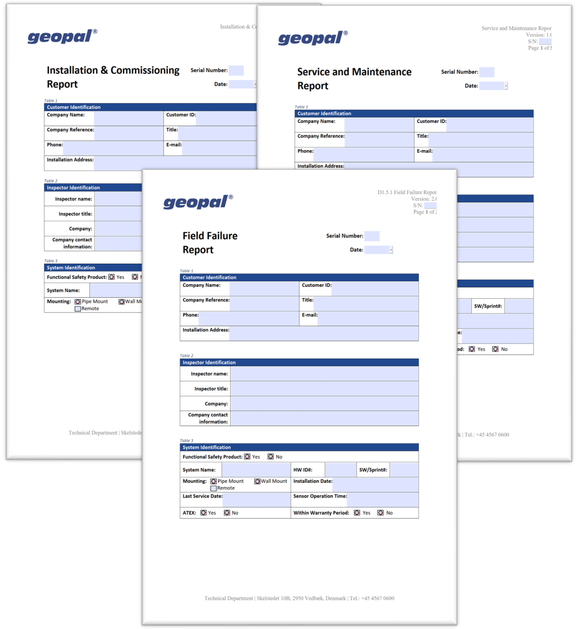
4 Installation

PAY ATTENTION
After reading and understanding Section 1. Safety, ensure the following:

- Product, documents, and mounting parts identification
- Placement and mounting of detector
- Power ratings available for the system
- System start-up, calibration, functional verification, and documentation on-site

FAILURE TO COMPLY WITH THE ABOVE CAN RESULT IN SERIOUS PERSONAL INJUI AND/OR DEATH!

NOTE
Geopal Installation and Commissioning Report template is available upon request.



7 Maintenance

Many factors dictate how and how often a maintenance procedure should be conducted. Site routines, environmental factors, and other operating conditions will have a direct effect on the frequency of routine maintenance and tests. However, Geopal recommends conducting a servicing routine every six months and a test routine every three months as a minimum.

7.1 Service Routine

A service routine must at least include the following:

- Visual inspection: Check all ATEX parts including cable glands for defect and/or damage.
- Clean the system with a damped black cloth.
- Check the system time and date. If incorrect, update them.
- Check and record the last service date.
- Check and record sensor operation time.
- Check the system logs.
- Check and record sensor signal values from the last calibration.
- Conduct system calibration.
- Conduct bump test.
- Reset service timer.
- Reset sensor operation time (if the is replaced).

7.2 Bump Test

The purpose of a bump test is to check if the system is operating as intended or not. During this test, the system is subjected to a well-known gas concentration, enough to trigger alarm 2. The system will pass based on the following criteria:

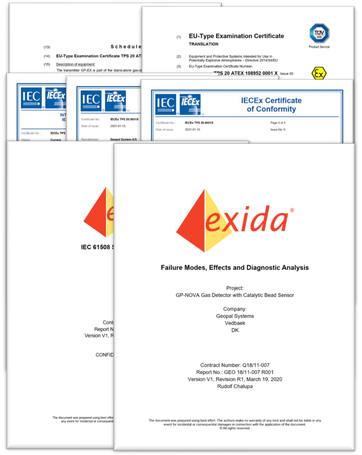
- System display and visual indication, LED bars, are operating as intended during Normal operation and Alarm state.
- The analog output has a value corresponding to the applied gas.
- The alarm relays get activated at on and off setpoints.
- The Modbus RTU is sending a value corresponding to the applied gas and events.

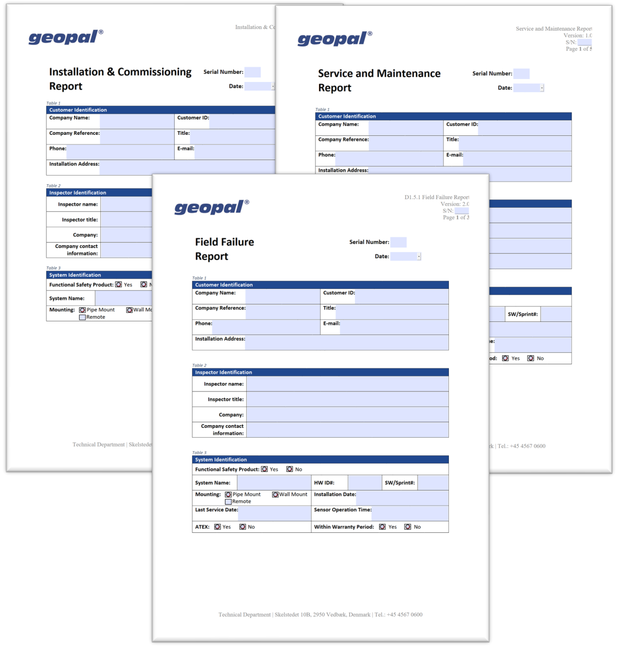
NOTE
Geopal Maintenance Report template is available upon request.

GP-NOVA – ATEX & Functional Safety

Document Management System

- Project D Folder GP-NOVA
  - D1 Project Start
    - D1.0 BAS
    - D1.1 CEC
      - D1.1.1 CECCL
      - D1.1.2 MM
      - D1.1.3 AIL
      - D1.1.4 PTP
    - D1.2 CNTRCT
    - D1.3 PRS
    - D1.4 EMDMSQ
    - D1.5 FFRP
      - D1.5.1 FFR
    - D1.6 PPCNP
      - D1.6.1 PPCN
  - D2 Safety Planning
    - D2.1 FSM Plan
      - D2.1.1 PP
    - D2.2 CMP
      - D2.2.1 SCR&IA
  - D3 Safety Requirements Specification
    - D3.1 SRS
      - D3.1.1 SRSIR
    - D3.2 VTP
      - D3.2.1 VPIR
    - D3.3 TTS
  - D4 System Architecture Design
    - D4.1 SADS
      - D4.1.1 SADIR
    - D4.2 InTP
    - D4.3 TER
    - D4.4 FMEA
    - D4.5 SWAD
      - D4.5.1 SWADIR
    - D4.6 D&CG
  - D5 Detailed HW Design
    - D5.1 DHWD
      - D5.1.1 CDBOM
      - D5.1.2 LOPL
      - D5.1.3 CDA
      - D5.1.4 DHWDIR
    - D5.2 FMEDA
    - D5.3 FITP
  - D6 Detailed SW Design
    - D6.1 DSWD
      - D6.1.1 DSWDIR
    - D6.2 UnTP
      - D6.2.1 UnTR
  - D7 Integration
    - D7.1 HWPAC
      - D7.1.1 HWPIR
    - D7.2 SWPAC
      - D7.2.1 SWPIR
    - D7.3 InTR
    - D7.4 FITR
  - D8 Safety Manual
    - D8.1 SfMnl
      - D8.1.1 SMI&VR
  - D9 Verification & Validation
    - D9.1 VTR
    - D9.2 TTR
  - D10 Safety Assessment
    - D10.1 SfAP
    - D10.2 SfAR





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Quality Management System

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6 Management of functional safety

6.1 Objectives

6.1.1 The first objective of the requirements of this clause is to specify the responsibilities in the management of functional safety of those who have responsibility for an E/E/PE safety-related system, or for one or more phases of the overall E/E/PE system and software safety lifecycles.

6.1.2 The second objective of the requirements of this clause is to specify the activities to be carried out by those with responsibilities in the management of functional safety.

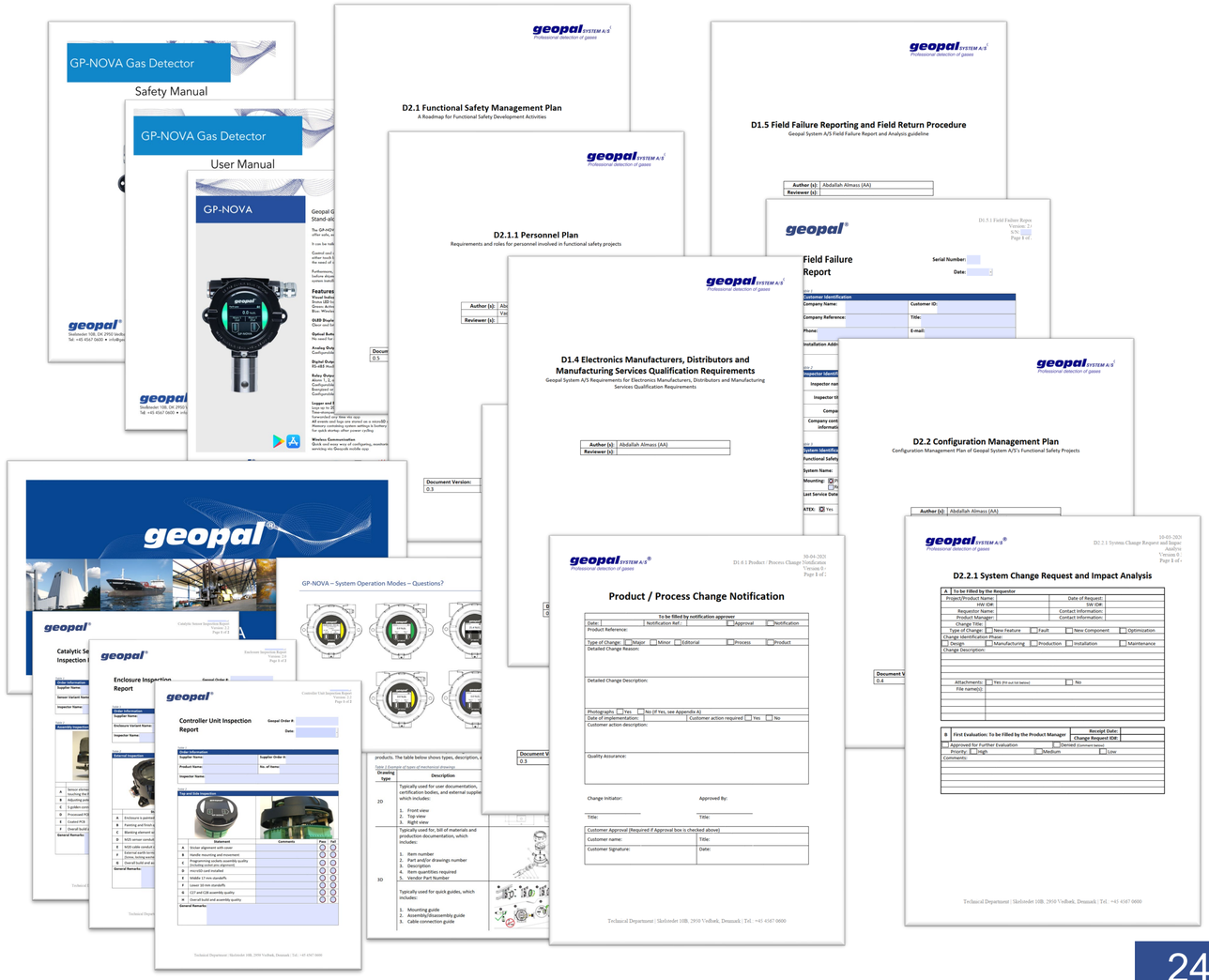
6.2 Requirements

6.2.1 An organisation with responsibility for an E/E/PE safety-related system, or for one or more phases of the overall, E/E/PE system or software safety lifecycle, shall appoint one or more persons to take overall responsibility for:

- the system and for its lifecycle phases;
- coordinating the safety-related activities carried out in those phases;
- the interfaces between those phases and other phases carried out by other organisations;
- carrying out the requirements of 6.2.2 to 6.2.11 and 6.2.13;
- coordinating functional safety assessments (see 6.2.12 b) and Clause 8) – particularly where those carrying out the functional safety assessment differ between phases – including communication, planning, and integrating the documentation, judgements and recommendations;
- ensuring that functional safety is achieved and demonstrated in accordance with the objectives and requirements of this standard.

NOTE Responsibility for safety-related activities, or for safety lifecycle phases, may be delegated to other persons, particularly those with relevant expertise, and different persons could be responsible for different activities and requirements. However, the responsibility for coordination, and for overall functional safety, should reside in one or a small number of persons with sufficient management authority.

6.2.2 The policy and strategy for achieving functional safety shall be specified, together with the means for evaluating their achievement, and the means by which they are communicated within the organization.



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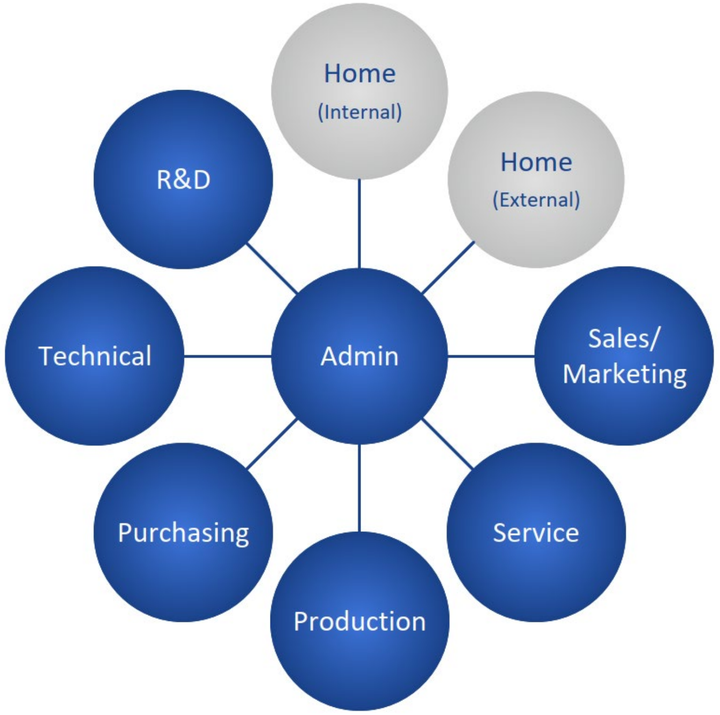
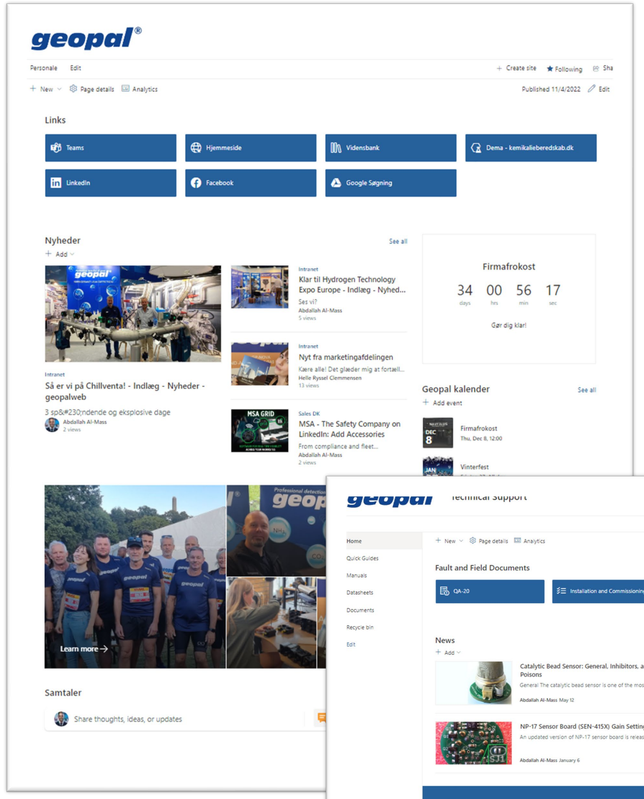
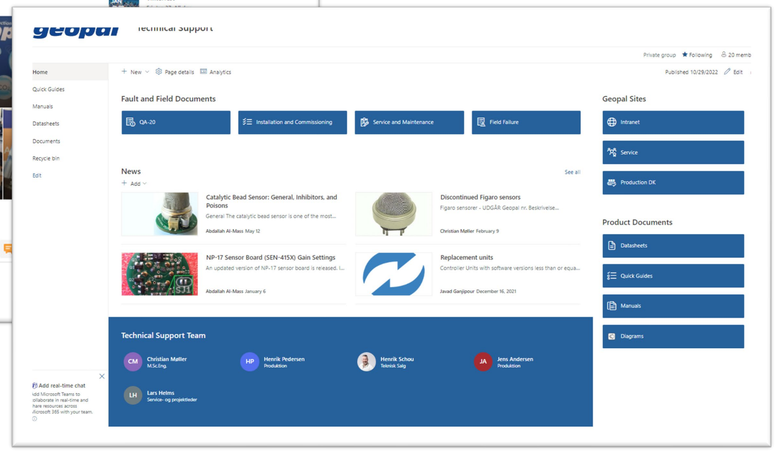
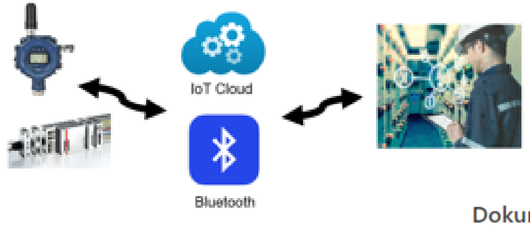
Modern IT-Infrastructure: Data Collection, Information Sharing, and Archiving









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