Requirements for the Safe Operation of Hydrogen Test Systems

Determination of Reliability Requirements

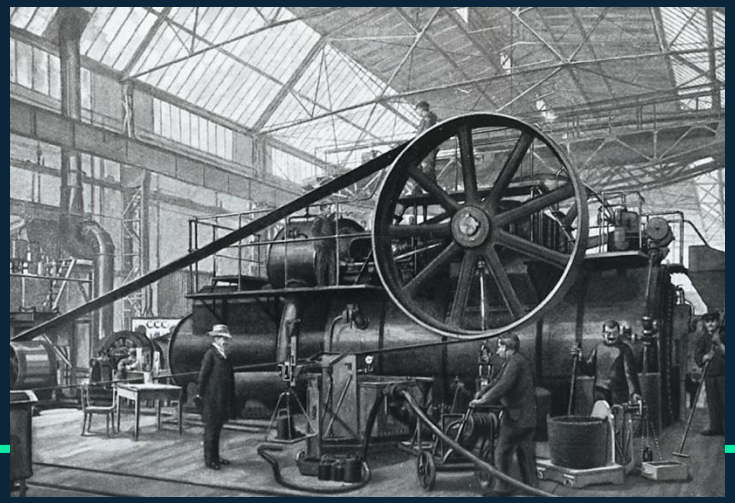
Ulm, 18-10-2023

Mehr Wert.
Mehr Vertrauen.

Agenda

01	**Introduction & Motivation** **Legal Requirements**
02	**Basic Principles Explosion Protection**
03	**Reliability Requirements** **Example: Gas Warning System**
04	**Summary**

Our legacy of sustainable business success



1866

Assuring trust in technology:
The Steam Boiler Inspection Association was established in Germany

Safer roads:
Expansion to electrical engineering and machinery with the first vehicle periodic technical inspection

1900s

1960s

Exporting expertise:
TÜV SÜD starts to provide quality assurance of goods across borders to facilitate global trade

Hydrogen
Physical Properties

- Gas
  - Colourless
  - Odourless
  - Non toxic

→ Flammable → Reacts with oxygen to H_2O → Use as Energy Carrier

Property	Value
Lower Explosion Level	4,0 Vol.-%
Upper Explosion Level	77 Vol.-%
Ignition Temperature	560 °C
Minimum Ignition Energy	0,017 mJ
Boiling Temperature	-253 °C

Comparison:
CH_4: 0,28 mJ
C_3H_8: 0,24 mJ

Safety Measures

- Flammable Gas

Hazard Evaluation
(Industrial Safety Regulations)

- Occurence of
  Hazardous Explosive Atmosphere
  Possible ?

- Explosion Protection Concept
  - Documentation in Explosion Protection Document
  - Regular Inspection of Explosion Safety Required

Responsibility:

EMPLOYER

- Explosion Protection Concept
- Performance of Inspection
- Extent of Inspections
- Qualification of Inspectors

Basic Requirements for an Explosion Protection Concept

Agenda

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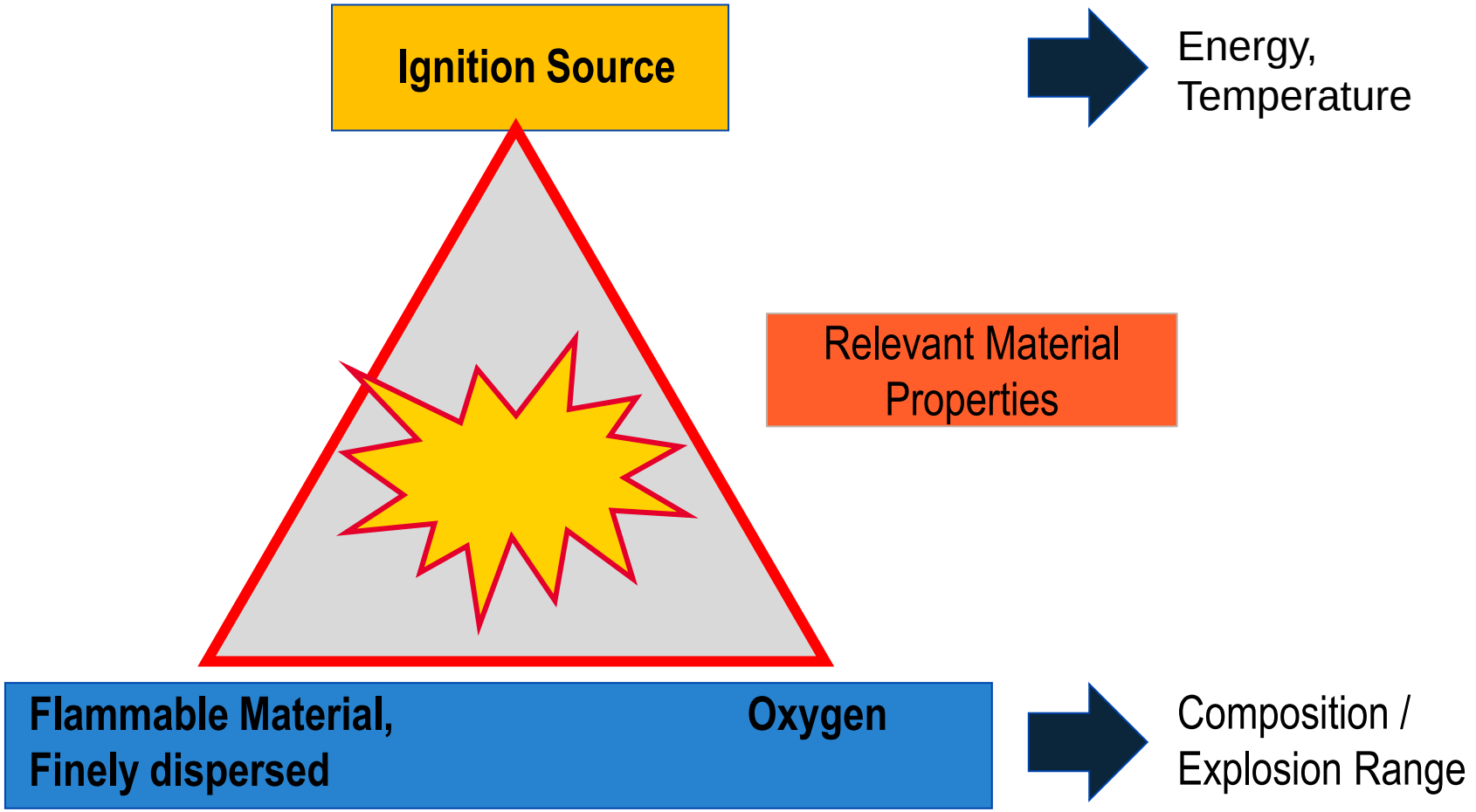
02 Basic Principles Explosion Protection

03 Reliability Requirements
Example: Gas Warning System

04 Summary

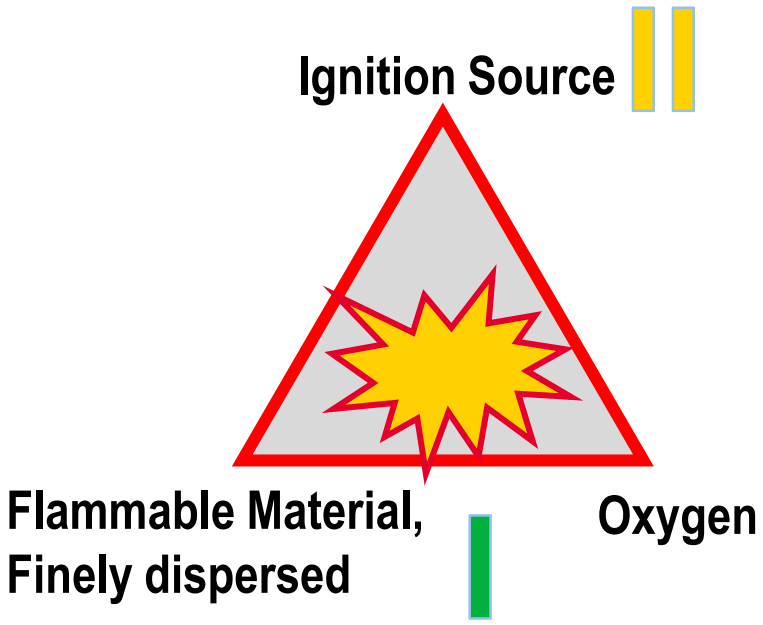
Explosion Protection

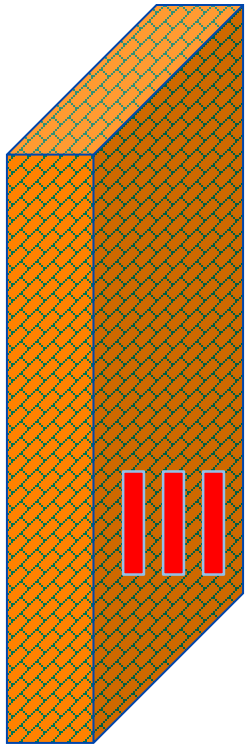


- 3 Contributing Items Required
  - Flammable Material
  - Oxygen
  - Ignition Source
- Elimination of 1 Item:
  - No Explosion Possible

Explosion Protection Measures

- I Primary Protection — Preventing the Generation of Hazardous Explosive Atmosphere
- II Secondary Protection — Preventing the Ignition of Hazardous Explosive Atmosphere
- III Tertiary Protection — Preventing the Impact of Igniting Hazardous Explosive Atmosphere

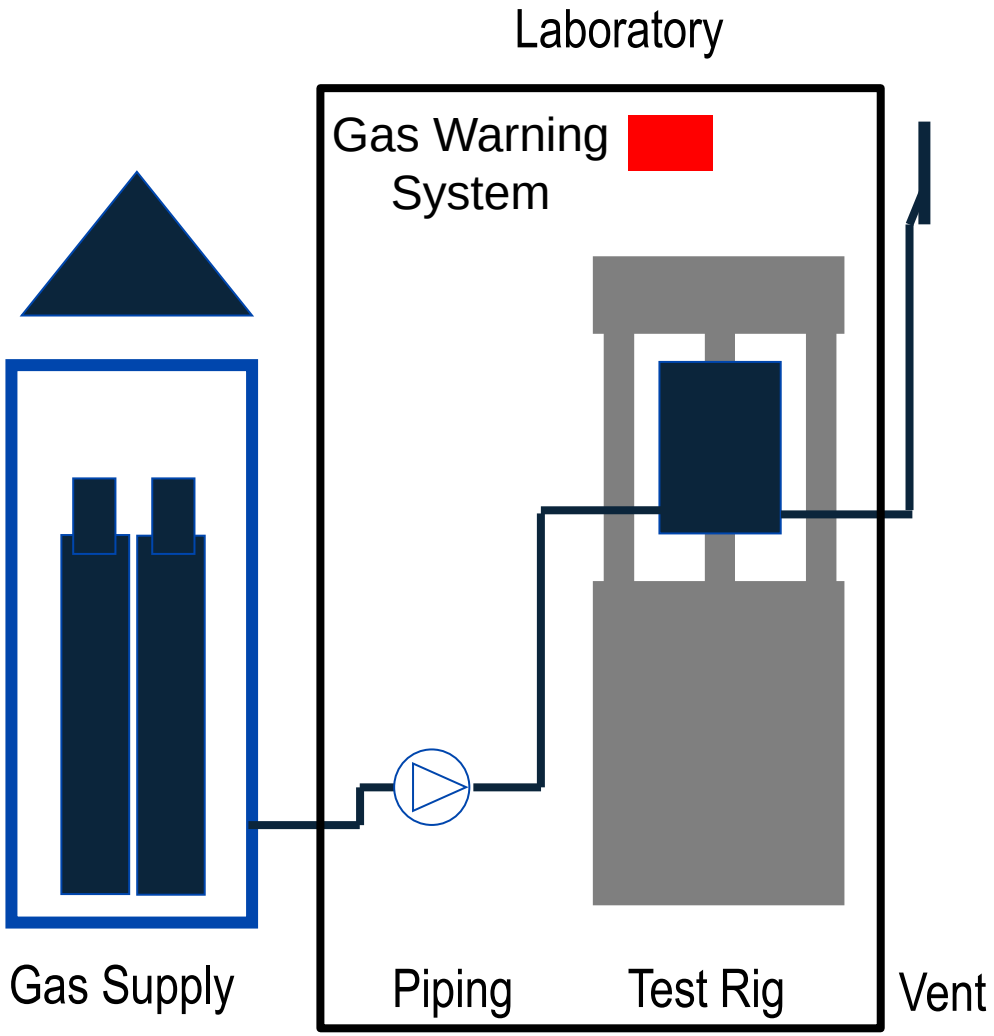




Frequency of Occurrence of Explosive Atmosphere	
Longterm, Frequently	Zone 0
Sometimes	Zone 1
Shortterm and Rarely	Zone 2

No Simultaneous Occurrence of
- Explosive Atmosphere and
- Ignition Source allowed!

Basic Setup of Explosion Protection Concept



Primary Protection:

- Leak-tightness of all components (connections)
- Regular Maintenance / Inspection
  -> small leakages will not become big leakages
- Ventilation / Flushing will dispense small amounts of flammable gases

Secondary Protection:

- Wherever explosive atmosphere might occur: No Ignition Sources!

Protection Concept supported by **Control Devices**, e.g.:

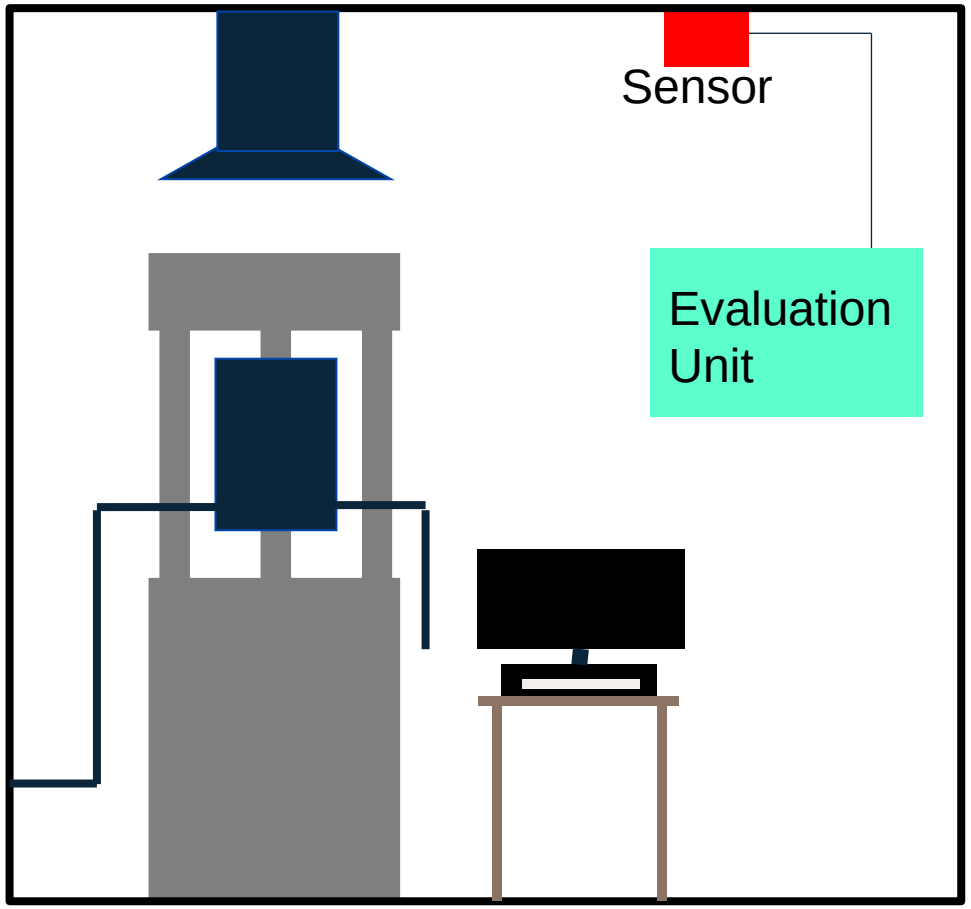
- Pressure Transducers
- Gas Warning Systems
- Level Sensors
- …

Reliability Requirements

Agenda

01	Introduction & Motivation Legal Requirements
02	Basic Principles of Explosion Protection
03	**Reliability Requirements** **Example: Gas Warning System**
04	Summary

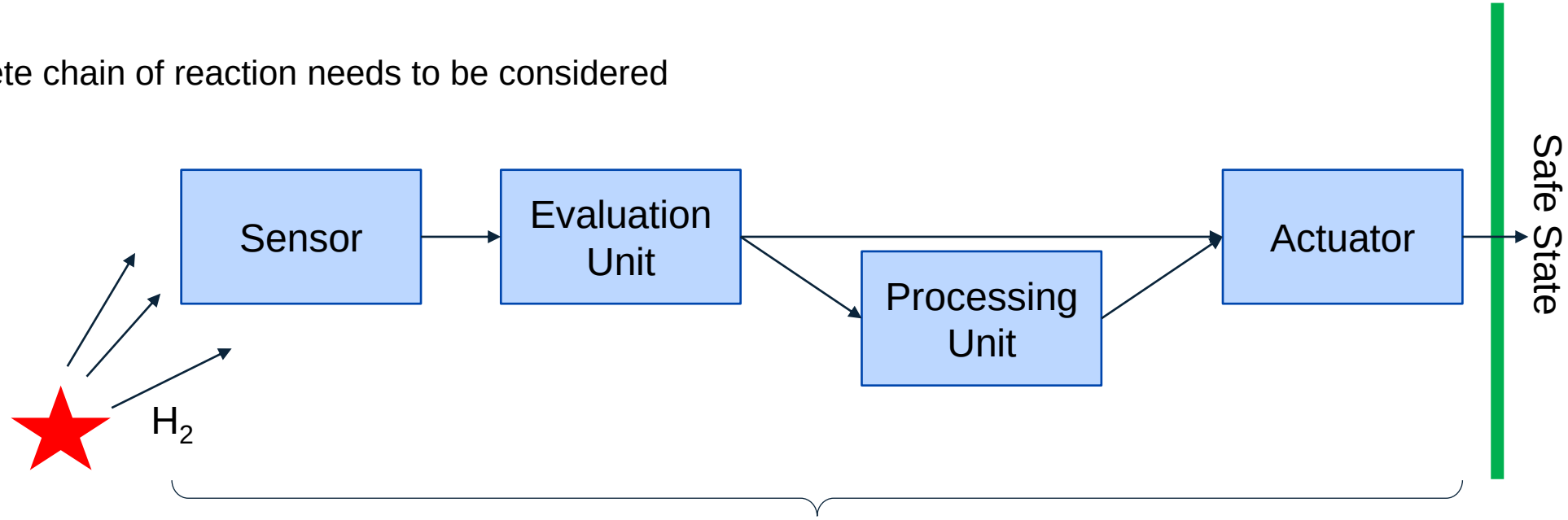
Reliability Requirements
Example: Gas Warning System



- Gas Warning System
  - Sensor
  - Evaluation Unit
  - Primary Questions:
    - Is the sensor capable of detecting the leaking gas
    - Is the sensor located in a suitable place
  - Additional Question:
    - What is the damage scenario that needs to be considered (e.g. reaction time)
  - Similarly Important:
    - What is the Gas Warning System supposed to do?

Reliability Requirements
Example: Gas Warning System

- Complete chain of reaction needs to be considered



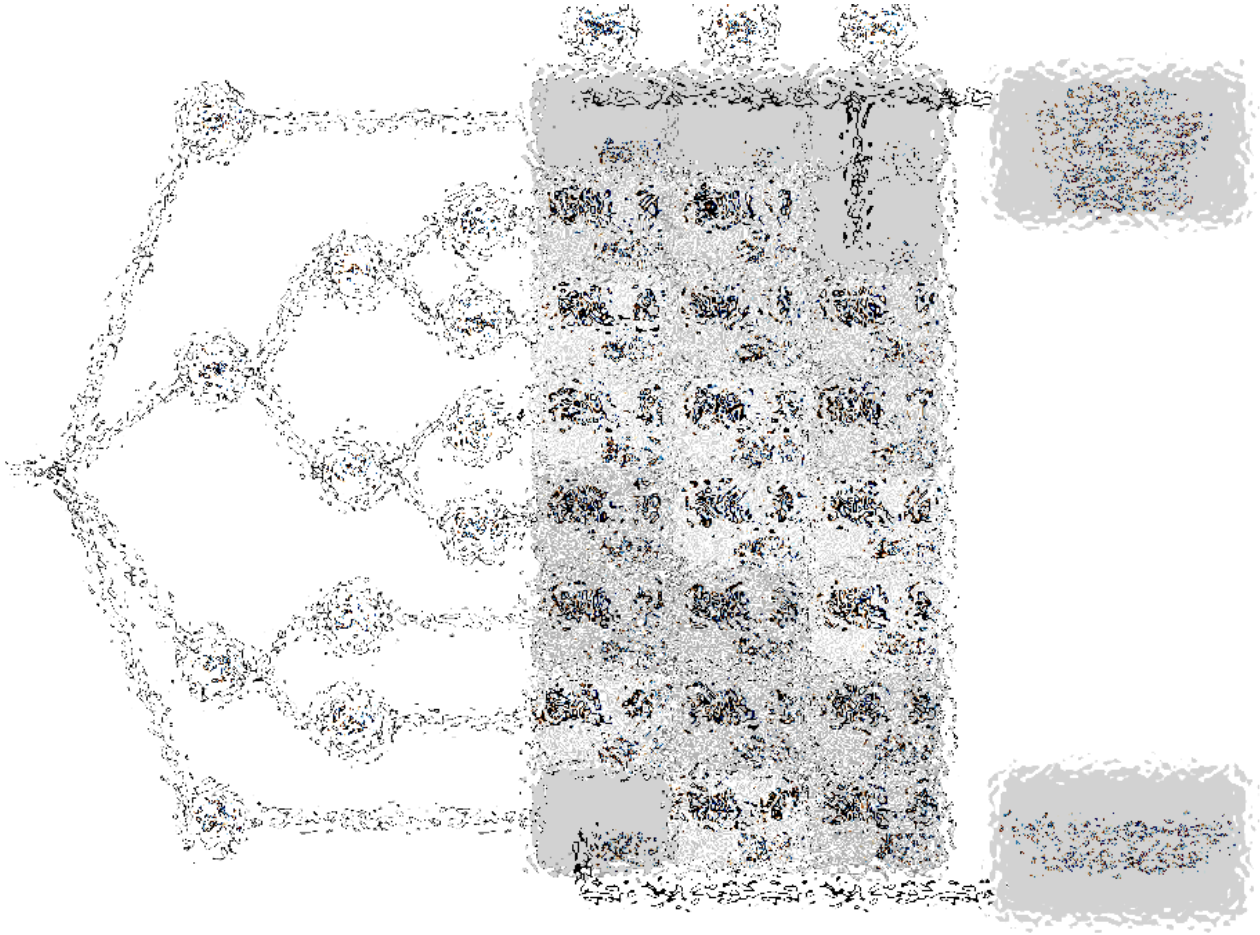
Reliability Requirements according to TRGS 725
(technical guideline for the handling of hazardous materials)

Alternative Path: Evaluation according to VDI/VDE 2180 Blatt 1

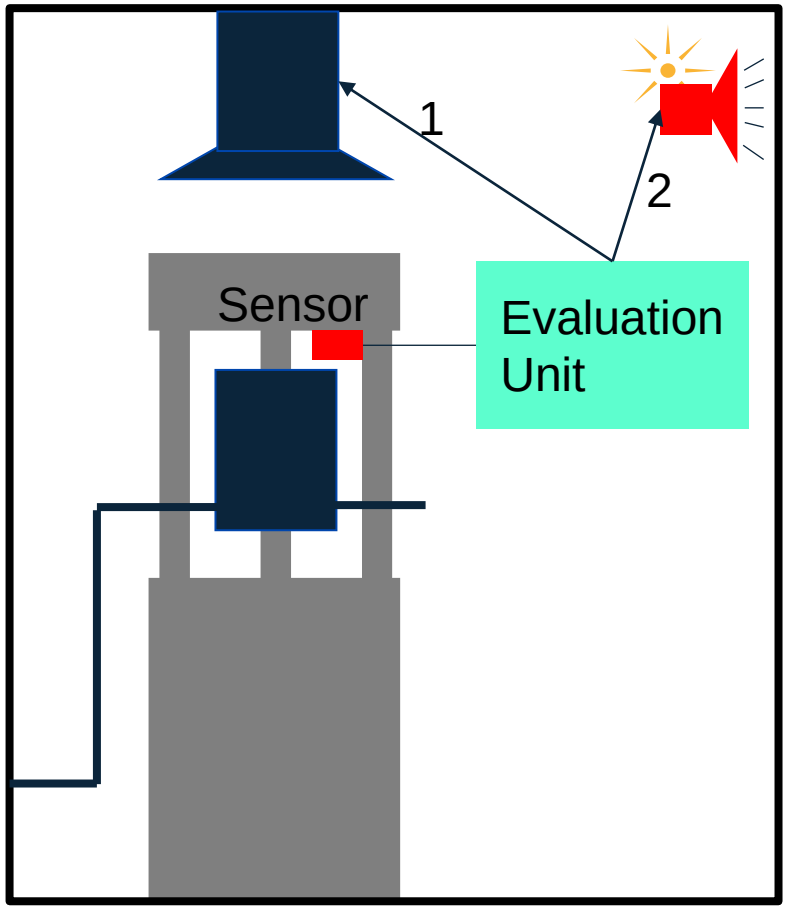
Reliability Requirements
Risk Graph VDI/VDE 2180

- Risk Graph acc. to VDI/VDE 2180

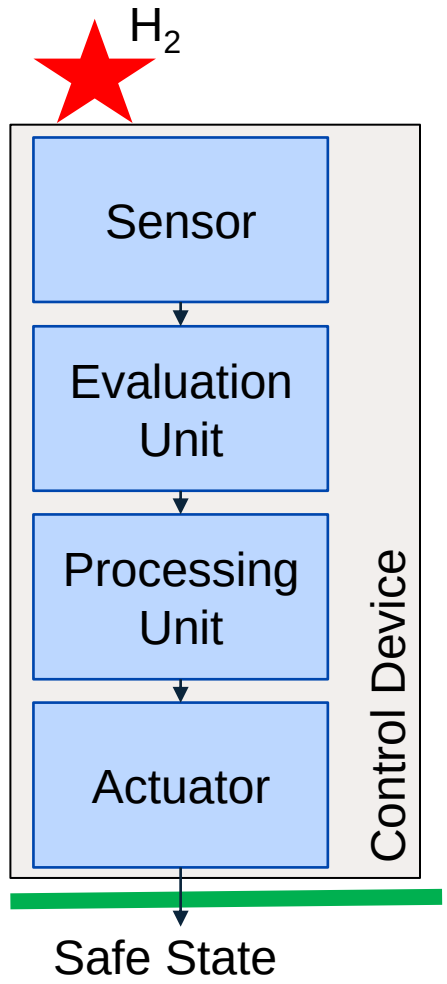
- S: Extent of Damage
  - S1 - Minor Injury
  - S2 – Major Injury / Fatality of single Person
  - S3 – Fatalities of several People
  - S4 - Catastrophic, many Fatalities
- A: Duration of Stay
  - A1 - Rarely
  - A2 - Frequently
- G: Countermeasures
  - G1 - Possible under certain circumstances
  - G2 - Basically impossible
- W: Probabilty of Occurrence
  - W1 - Very low
  - W2 - low
  - W3 - relatively high



Reliability Requirements
2 Scenarios of Required Raction by GWS



- **Basic Safety Strategy:**
  - Sensor is located in proper position
  - System is designed, manufactured and installed according to state of the technique
  - No major leak to be expected, only minor leakages
  - **Scenario 1:**
    - Ventilation is not running
    - Intended Reaction of GWS: Activation of Ventilation
  - **Scenario 2:**
    - Ventilation is continuously running
    - Intended Reaction of GWS: Alert of the Operator of existing gas leak



Reliability Requirements
Scenario 1: Activation of Ventilation Required

- **Evaluation according to Risk Graph**

- S: Extent of Damage
  - S1 - Minor Injury
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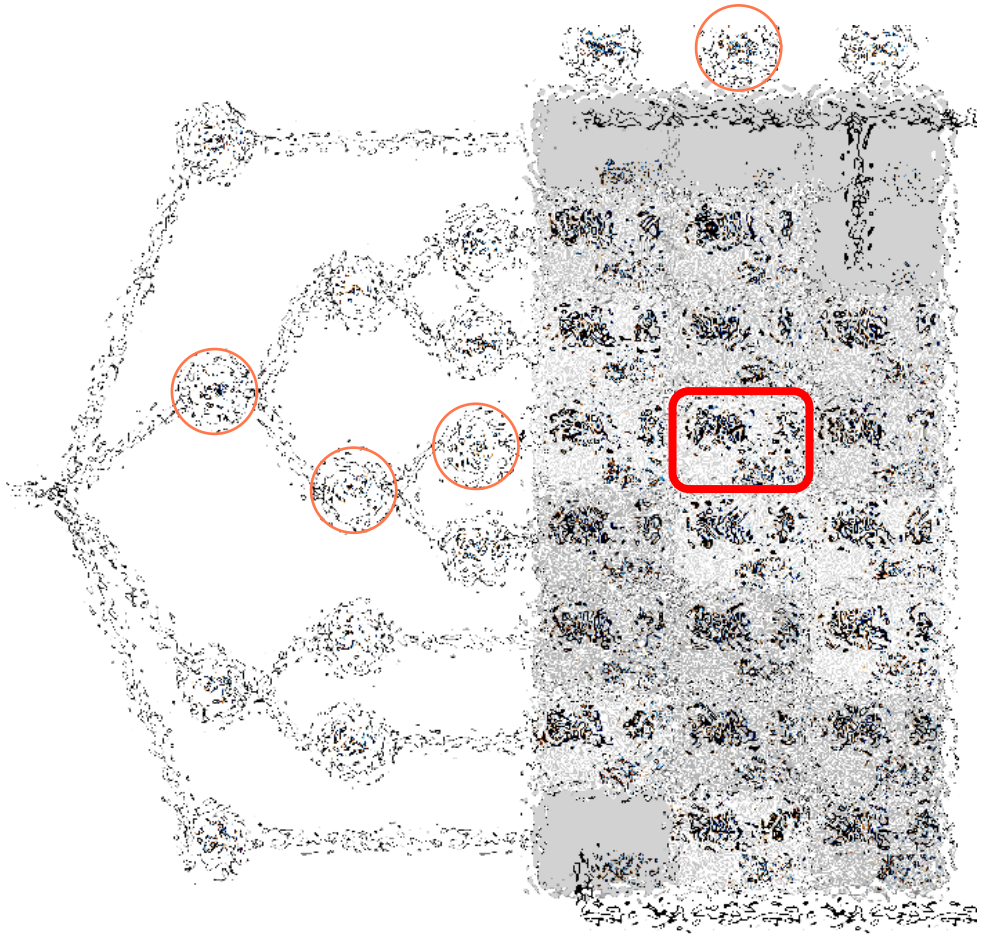

Present Scenario:

High Hardware Requirements (SIL 2)

-> Redundancy required

-> System must function even if a possible failure occurs (e.g. loss of electricity)

Reliability Requirements
Scenario 2: Notification of Operator Required

- **Evaluation according to Risk Graph**

- S: Extent of Damage
  - S1 - Minor Injury
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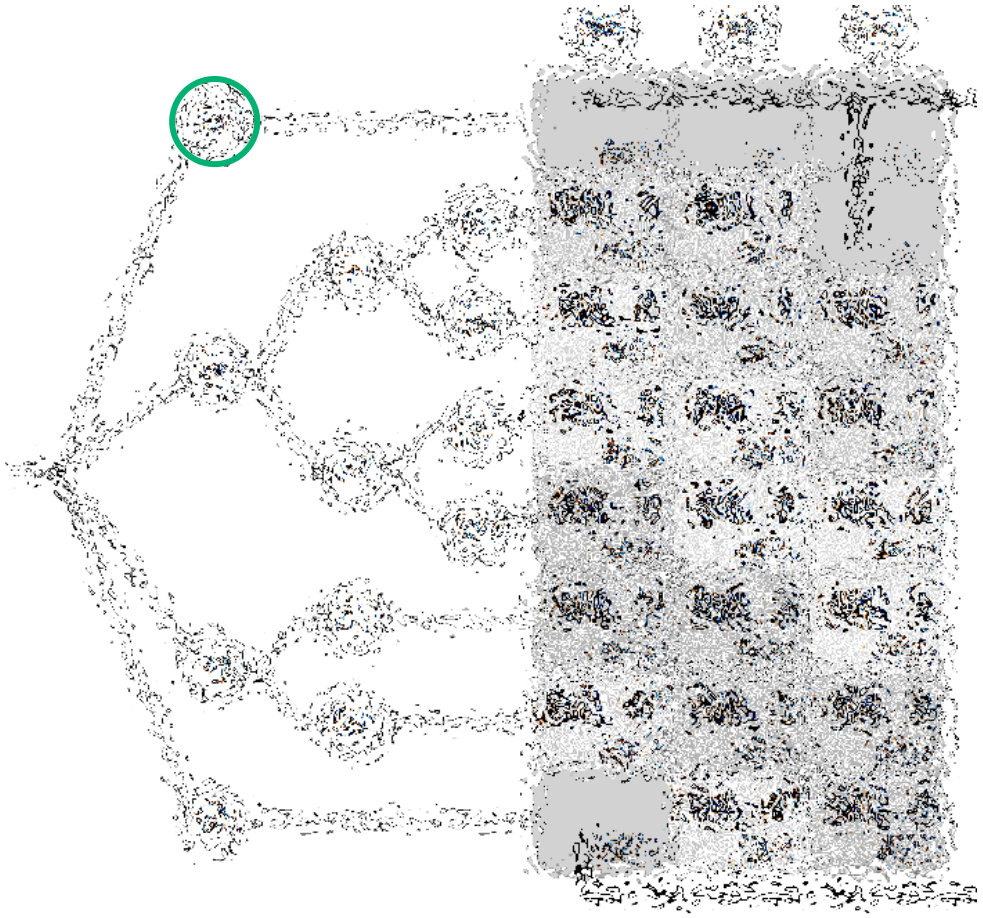


Present Scenario:

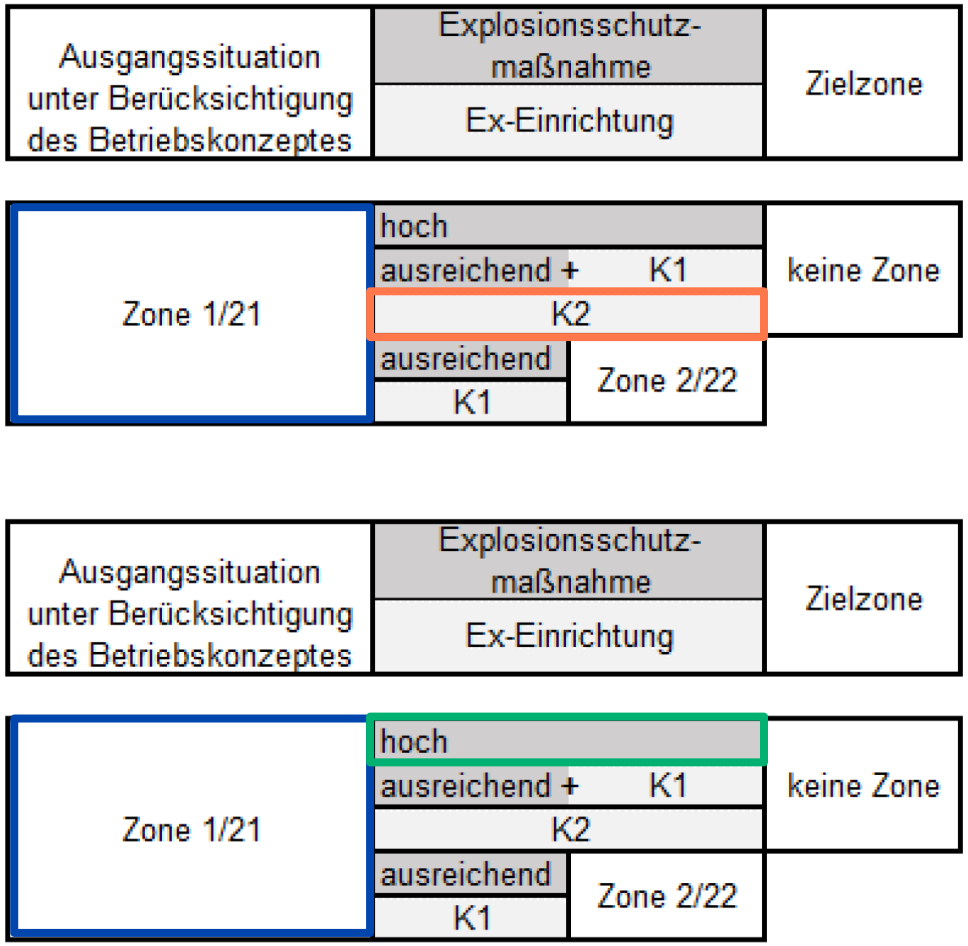
No Safety Integrity Level required

No redundancy of System Components or Failure Tolerance necessary.

Reliability Requirements TRGS 725

- **Scenario 1:**
  - Ventilation is not running
  - Intended Reaction of GWS: Activation of Ventilation

- **Scenario 2:**
  - Ventilation is continuously running
  - Intended Reaction of GWS: Alerting the Operator of existing gas leak



Source: TRGS 725

Comparison:

Different Approach
-> Same Result!

Scenario 1:
High Hardware Requirements (SIL 2), redundancy + failure tolerance required

Scenario 1:
No Safety Integrity Level required

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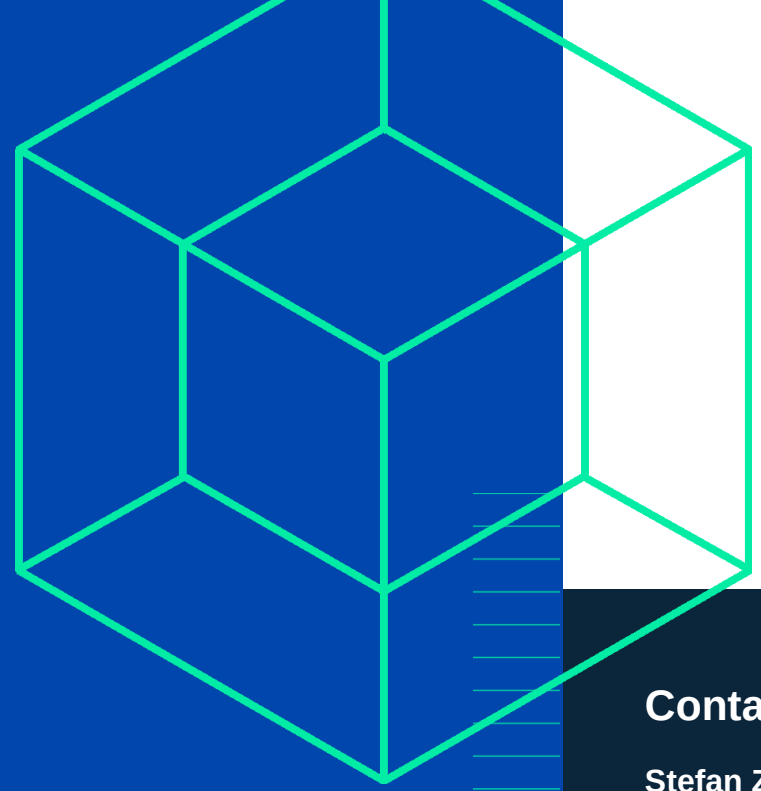
Summary

- Possible Existence of Hazardous Atmosphere Requires Explosion Protection Measures
- Ranking of Explosion Measures is
  - Preventing the Generation of Hazardous Explosive Atmosphere
  - Preventing the Ignition of Hazardous Explosive Atmosphere
  - Preventing the Impact of Igniting Hazardous Explosive Atmosphere
- Requirements regarding the Availability of Control Devices can be derived from the TRGS based on the probability approaches

- Requirements to the availability of Control Devices depend on the possible hazard in case of a failure

Thank You for your Attention



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