



ACCELERATING
INNOVATION

**3-1210 Are your SIS Performance
Assumptions Realistic? Let's find out!**

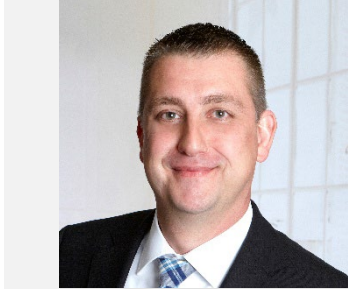
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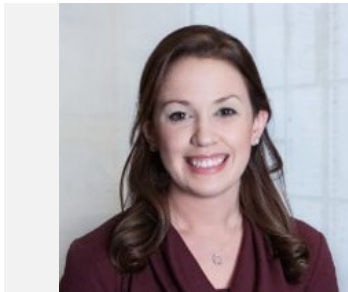
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exida

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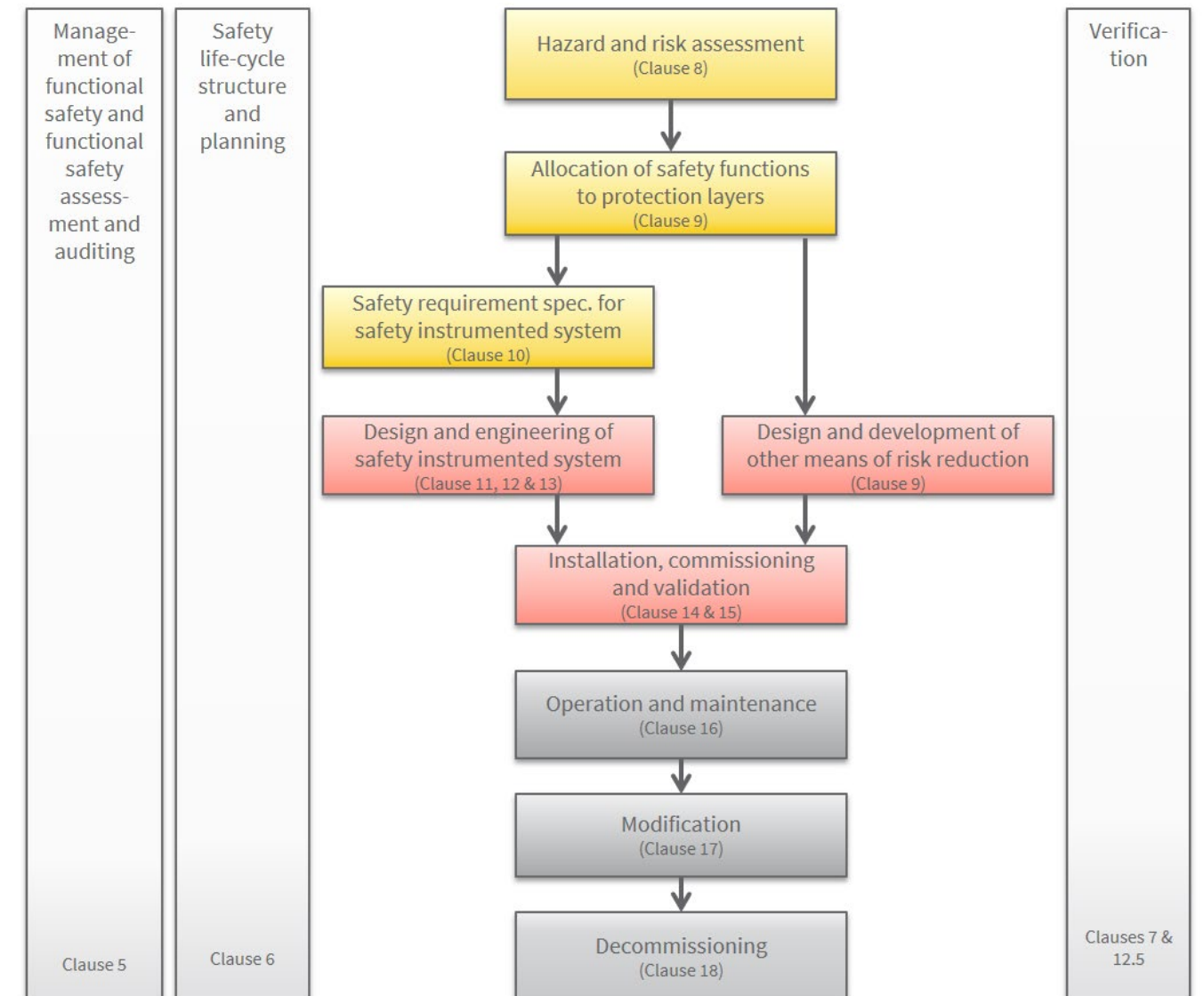
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IEC 61511 Standard

- IEC 61511 addresses Functional Safety for Safety Instrumented Systems in the Process Industry Sector
- Two main concepts
 - Engineering **lifecycle** to minimize systematic errors in the evaluation of risk and the design and operation of the protection against that risk
 - **Performance** based approach to match the design of risk reduction measures to the actual risk



IEC 61511 Performance Based Design

Performance Assumptions

- During the design several assumptions are made, incl.
 - SIF equipment failure rates
 - SIF demand rates
 - Proof test frequencies
 - Proof test effectiveness (coverage and correctness)
 - Mission time
 - Useful lifetime

$$PFD_{AVG} = \frac{C_{PT} \cdot \lambda^{DU} \cdot PTI}{2} + \frac{(1 - C_{PT}) \cdot \lambda^{DU} \cdot MT}{2}$$

Verifying Design Basis Assumptions

Compare Actual to Assumed

- IEC 61511 expects users to periodically compare actual with assumed performance.
- Part of Functional Safety Assessment (FSA) after gaining experience in operating and maintenance (FSA 4)

5.2.5.3 Procedures shall be implemented to evaluate the performance of the SIS against its safety requirements to:

- identify and prevent systematic failures which could jeopardize safety;
- monitor and assess whether reliability parameters of the SIS are in accordance with those assumed during the design;
- define the necessary corrective action to be taken if the failure rates are greater than what was assumed during design;
- compare the demand rate on the SIF during actual operation with the assumptions made during risk assessment when the SIL requirements were determined.

IEC 61511-1:2016+AMD1:2017 CSV
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Questions to Answer

- Are the Performance Assumptions during design realistic?
- Is the SIF operating as assumed?
- How do we compare actual with assumed performance?
- What data do we need to collect?
- How do we get statistically viable results from that data?
- How does the data apply?

Challenges Interpreting Operational Data

Install Date vs. Surveillance Start Date

- Failure Rate Point Estimate

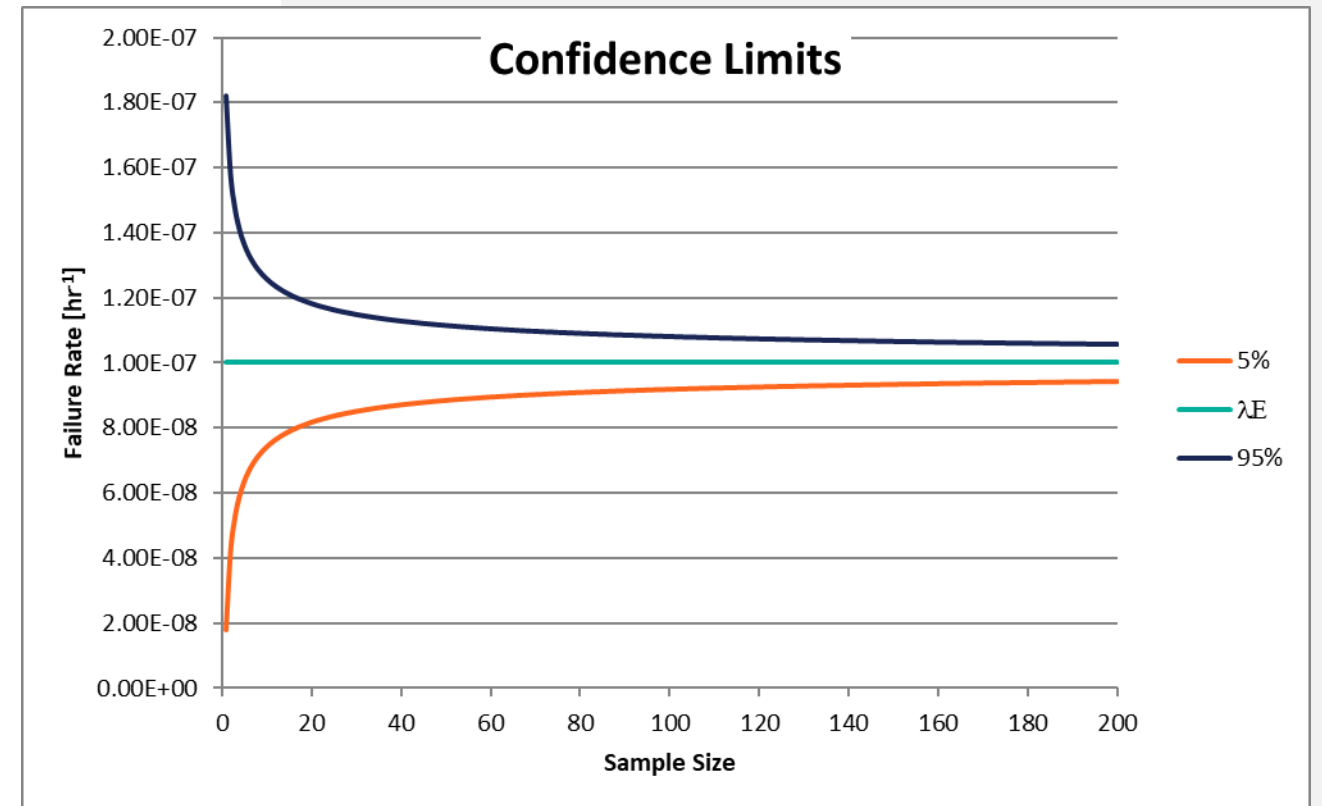
$$\lambda = \frac{\# \text{ Failures}}{\# \text{ Operating Hours}}$$

- The adaptation of IEC 61511 within the process industry is significant but data collection maturity is low.
- If failures have not been recorded / a program to record failures was not in place, the number of operating hours can not start at the installation date, it must start at the surveillance start date.
- With 1,000,000 operating hours, failure rate estimates start to become statistically viable.



Confidence Intervals

- Field failure rates are expected to be calculated at a 70% upper confidence limit.
- The larger the number of data points (samples)
 - The narrower the confidence intervals are
 - The more certain we are of the estimated failure rate
- Unfortunately, the sample sizes are small
 - Relatively low number of installed items per site
 - Not many equipment failures in the process industries



Homogeneous Data

- To calculate a 70% upper confidence limit for the failure rate a Chi-squared distribution is used
- This assumes that data is homogeneous (from the same distribution), i.e., data represents the same (type of) device under the same environmental and application stresses
- Combining data from different sites/locations should be done very carefully
- Data for different devices should never be combined

*1 FIT = 1 failure per 10⁹ hours
 Confidence level 90%
 Example data*

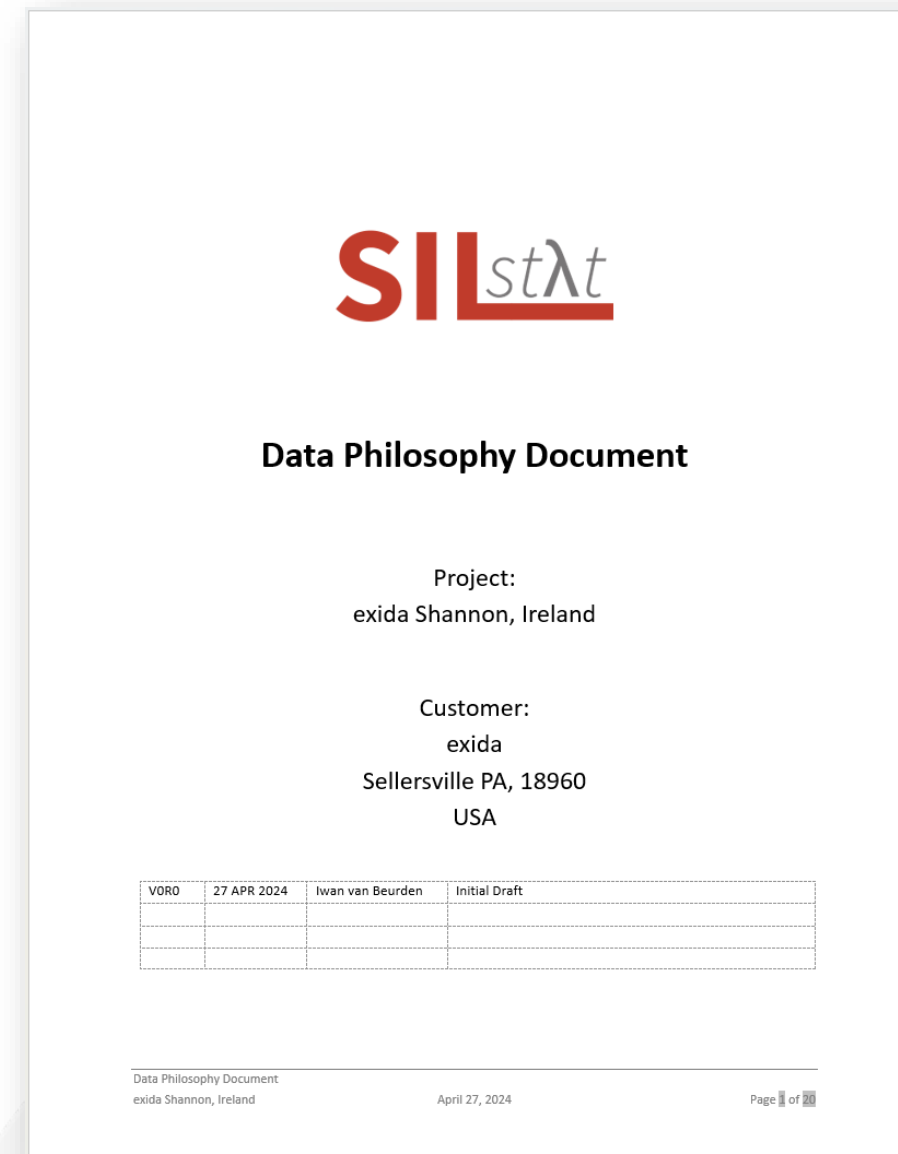
Source	Type of Device	# Valves	# DU Failures	Operating Hours	λ [FITs]
Site A	Identical Valves (Ball)	500	0	50,000,000	46
Site B	Identical Valves (Butterfly)	50	2	3,000,000	1774
Combined		550	2	53,000,000	100



Establishing a Data Philosophy Document

Data Philosophy Document

- A data philosophy establishes basic definitions, principles, and processes for the design, implementation, and management of a data collection system.
- It describes the data that is to be collected, the purpose of that data, includes any mapping of data fields between various recording systems, and describes roles and responsibilities related to the collection system.
- The Data Philosophy Document (DPD) provides guidance for a consistent approach to data collection in the operation and maintenance phase of a plant.



Benefits of a DPD

- A written philosophy on data collection is critical to creating and maintaining an effective data collection system over time. A documented data philosophy promotes:
 - Consistency of data collection and presentation,
 - Agreement with corporate performance objectives,
 - Agreement on data homogeneity,
 - Efficient calculation of relevant statistics.

DPD Examples

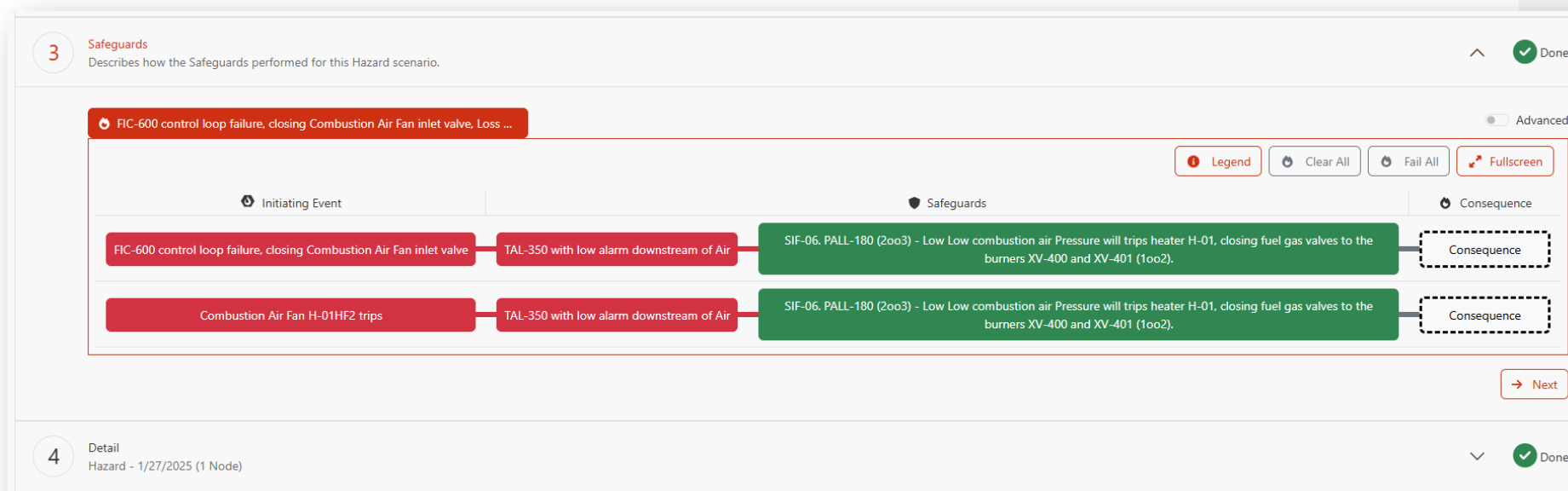
- Data collection starts on 01 Jan 2025
 - Operating Hours prior to 01 Jan 2025 are not considered as no failure recording was in place
 - Surveillance start date is 01 Jan 2025
 - Useful life will be considered from the install date of the device
 - Useful life replacement intervals are determined from install date
 - Mandatory maintenance intervals are determined from install date
- Bad Actors
 - Due to low (initial) number of operating hours, confidence intervals on calculated failure rates for device models will be large.
 - A single failure can throw off the field failure rate's calculated 70% upper confidence limit.
 - Provided the total number of operating hours is less than 100,000, no corrective action will be initiated for the specific device model if the calculated field failure rate is less than 5 times the assumed failure rate.
 - Monthly data reviews will focus on the specific device model

DPD Examples

- Combination of Data
 - Performance data (failures, operating hours, etc.) for pressure transmitters of type R in environment Z can be combined regardless if the transmitter is used for control or safety applications.
 - Performance data for ball valves in on/off applications (SIS) of type F in environment Z and application use X from site 1 can be combined with data from the same type ball valve in the same environment and application use from site 2.
 - *Performance data for valves in control applications shall never be combined with performance data for valves in safety applications (implied).*
- Data to be collected for devices includes
 - Installation date
 - Surveillance start date
 - Out of service data
 - Failures
 - Repair Actions
 - Replacements
 - Bypasses
 - Demands (request of action)

DPD Examples

Data Collection System	Sequence of Events	ERP System
EX-IE-SH-PT-101A-SENS	SIS-SHN-PT-101A	ERP-IRL-SHAN-PT-101A
EX-IE-SH-PT-101B-SENS	SIS-SHN-PT-101B	ERP-IRL-SHAN-PT-101B
EX-IE-SH-PT-101C-SENS	SIS-SHN-PT-101C	ERP-IRL-SHAN-PT-101C
...		
SIF-101-Demand	SIS-SHN-PT-101-TRIP	NA



Benefits of Studying Operational Data

Identify Bad Actors

- Bad Actors can refer to
 - Devices that prevent the safety action
 - Devices that cause (excessive) spurious trips
 - Physical locations that are prone to failure
- A repaired device may be put back in service at a different location, tracking the unique serial number will help identify if it is a bad actor
- Malfunctioning heat tracing may cause multiple transmitters to fail at the same location, tracking the performance of a physical location in a plant will identify if there is a location specific issue

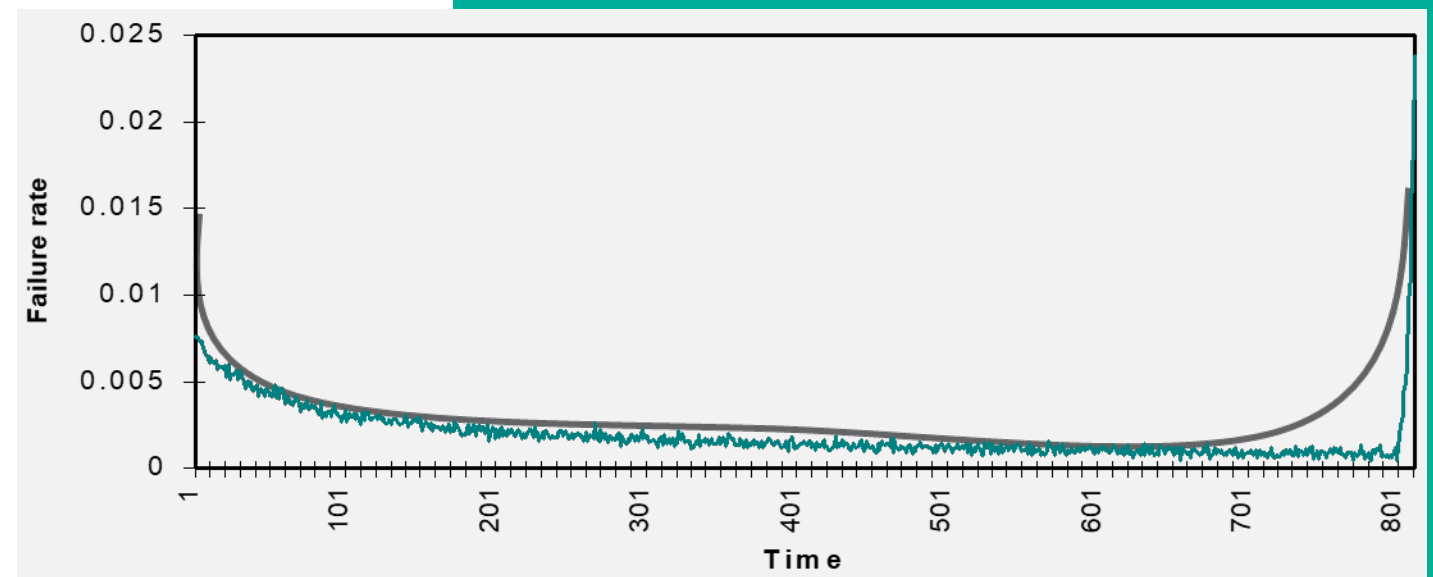
Ensure Designed Safety Integrity is Maintained

- Verify that failure rates are as assumed
- Verify that proof test intervals are as assumed
- Verify that demand frequencies are as assumed

- How often is a SIF bypassed?
 - Bypassing negates the risk reduction
 - Reliability issues could trigger operations to bypass a SIF

Optimize Maintenance Strategy

- Useful life is a device specific property
- At the end of useful life, the device is to be replaced or completely refurbished
 - Timely replacement avoids wear out failures in Safety Instrumented Functions with potential increase of nuisance trips.
 - Tracking useful life per device avoids early replacement of devices with longer useful life, e.g., transmitter 50 years, solenoid 10 years.
 - Scheduling useful life replacements can help anticipate product lead time/availability



Conclusion

Conclusion

- There are clear benefits to studying operational data (even beyond the IEC 61511 scope)
 - Identify Bad Actors
 - Ensure Designed Safety Integrity is Maintained
 - Optimize Maintenance Strategy
- Establishing basic definitions, principles, and processes for the design, implementation, and management of a data collection system is essential
- A Data Philosophy Document (DPD) provides guidance for a consistent approach to data collection

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