Prior Use assessment

pro6com

dé consultants voor de chemische industrie

Prior use assessment

By : Pro6com

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Vision

Creating a better world
by making processes
safer and more efficient

Mission

We create value for our customers by making their invisible process safety risks and energy or production losses visible.
This allows targeted actions to be taken to reduce these risks and optimize the plant performance

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Process Safety

Process Optimization

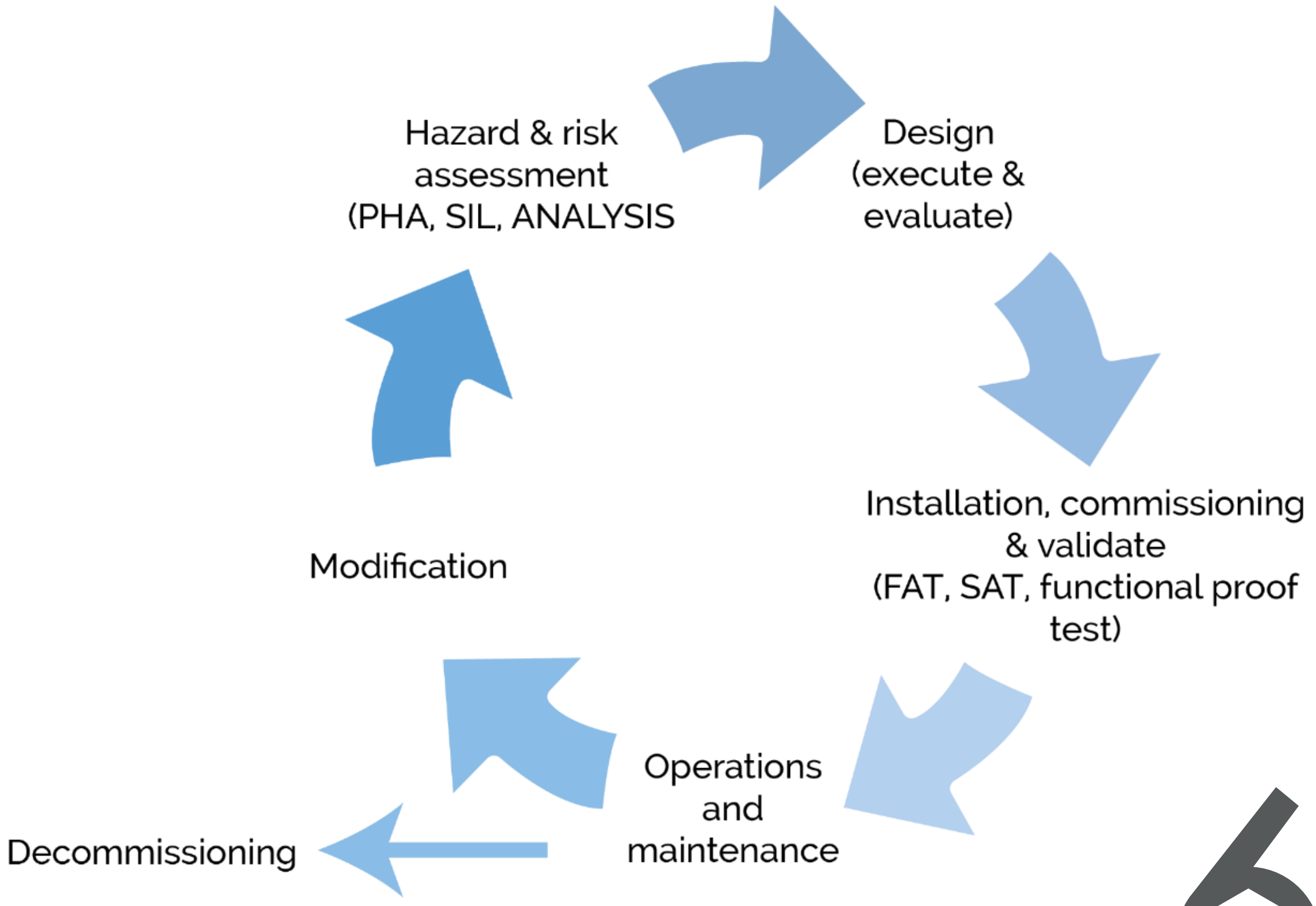
Technology Transfer

Prior in use assessment

- Safety Lifecycle
- Design
- Proven in use Assessment
- Examples
- Conclusion / discussion

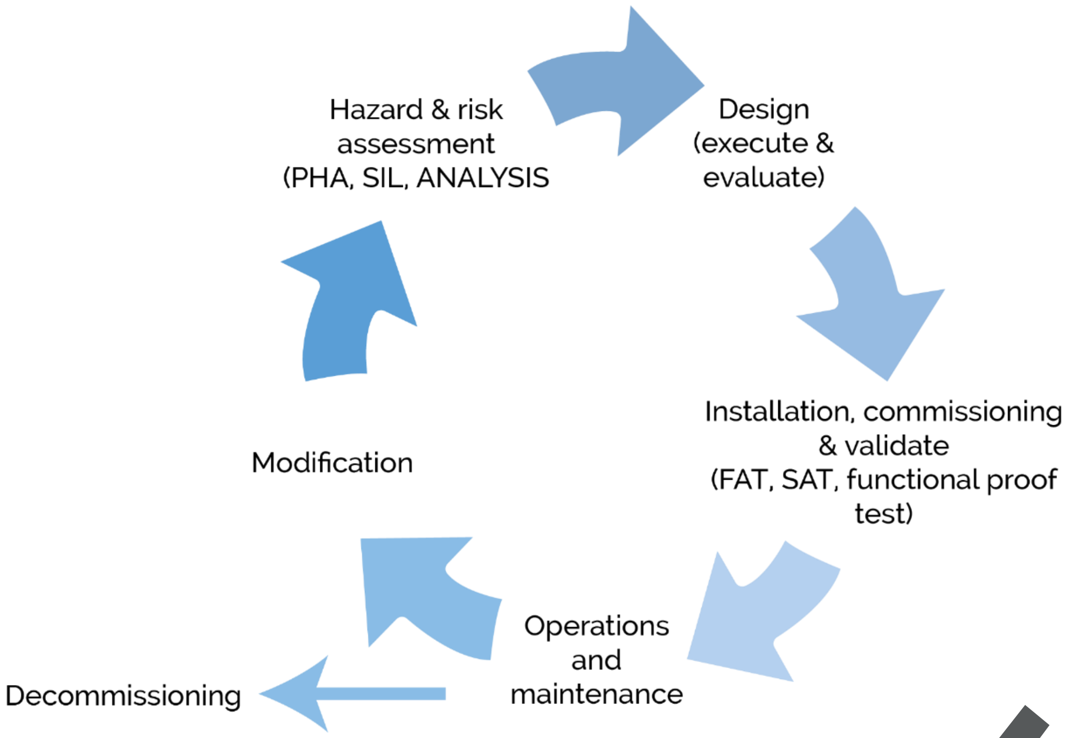
Safety Lifecycle

- PHA
- Design
- Installation
- Operation/maintenance
- MOC
- Decommissioning

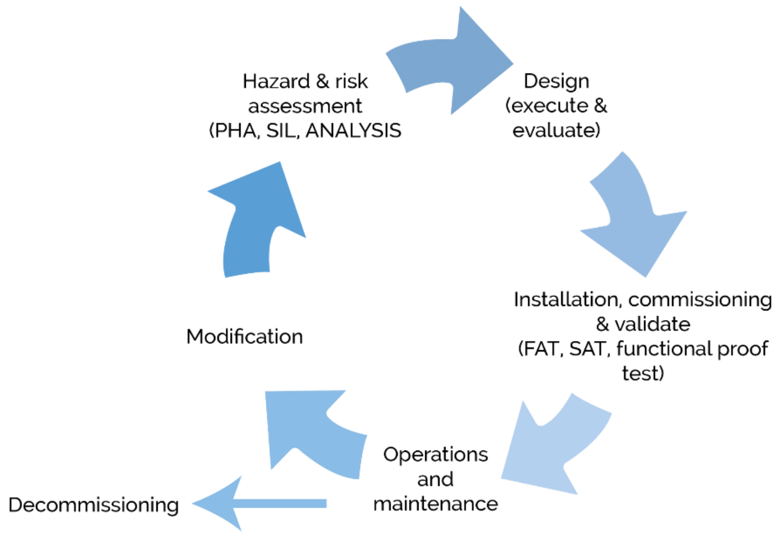


Safety Lifecycle - Design

- Selecting parts
  - Proven in use
  - Certified Data
  - Prior use

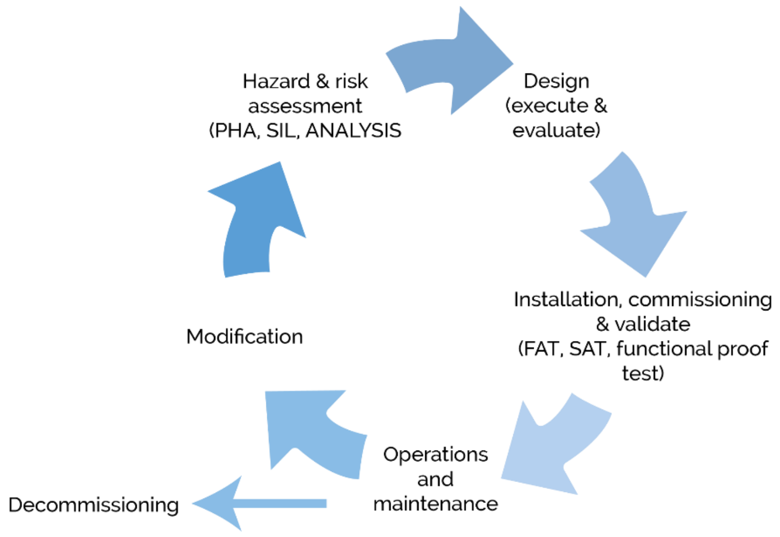


Safety Lifecycle - Design



- Proven in use
  - Data provided by manufacturer
  - Generic information
  - Not according plant situation (service, degradation mechanism, etc)
  - Not officially named in IEC 61511
  - Can be used together with plant information -> prior use

Safety Lifecycle - Design

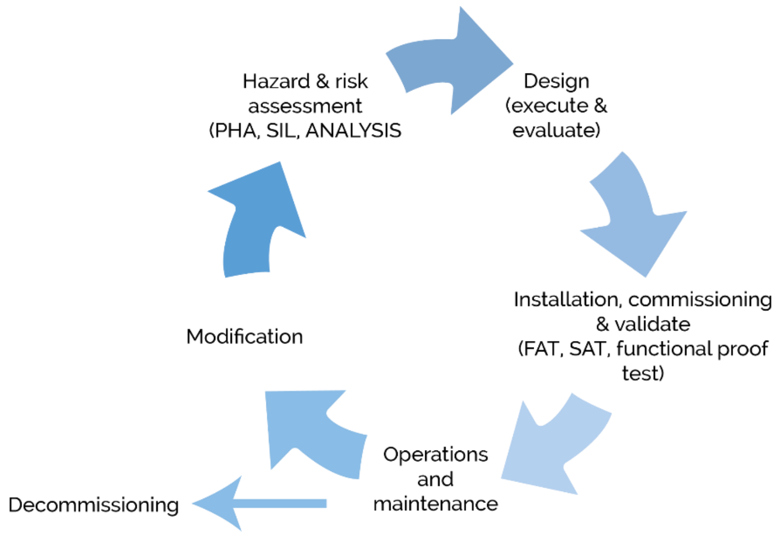


- Certified Data
  - Clear description of failure data
  - Provided installation and safety manual

  - Suitable for both type A and B components
  - Cover all SIL levels

  - No historical data needs to be used to verify component
  - Historical data can be used for validation the application

Safety Lifecycle - Design



- Prior use
  - Needs evidence according IEC 61511
  - Using historical data out of the field

  - Suitable for type A and some B components
  - Cover not all SIL levels

  - Used when no certified data is available

Prior Use Assessment

- Required evidence according IEC 61511
  - Consideration of the manufacturer's quality, management and configuration management systems
  - Adequate identification and specification of the devices
  - Demonstration of the performance of the devices in similar operating environments
  - The volume of the operating experience
  - Monitoring device performance

Prior Use Assessment

- Adequate identification and specification of the devices
  - Proof of manufacturer quality management
  - Availability of operational manual
  - Suitable for both type A and B components
  - For type B also a software assessment is required
  - For higher SIL levels, more evidence is required

Prior Use Assessment

- Volume of the operating experience
  - The reliability data uncertainties can be evaluated according to:
    - o Statistical approaches
    - o Engineering judgement techniques (generic data)
    - o Undertaking specific techniques (like FME(D)A)
  - The amount of field feedback
    - o Less data results in higher uncertainty
    - o Usage of statistical approach
    - o Observation time is only for similar components (size, service, model number

Prior Use Assessment

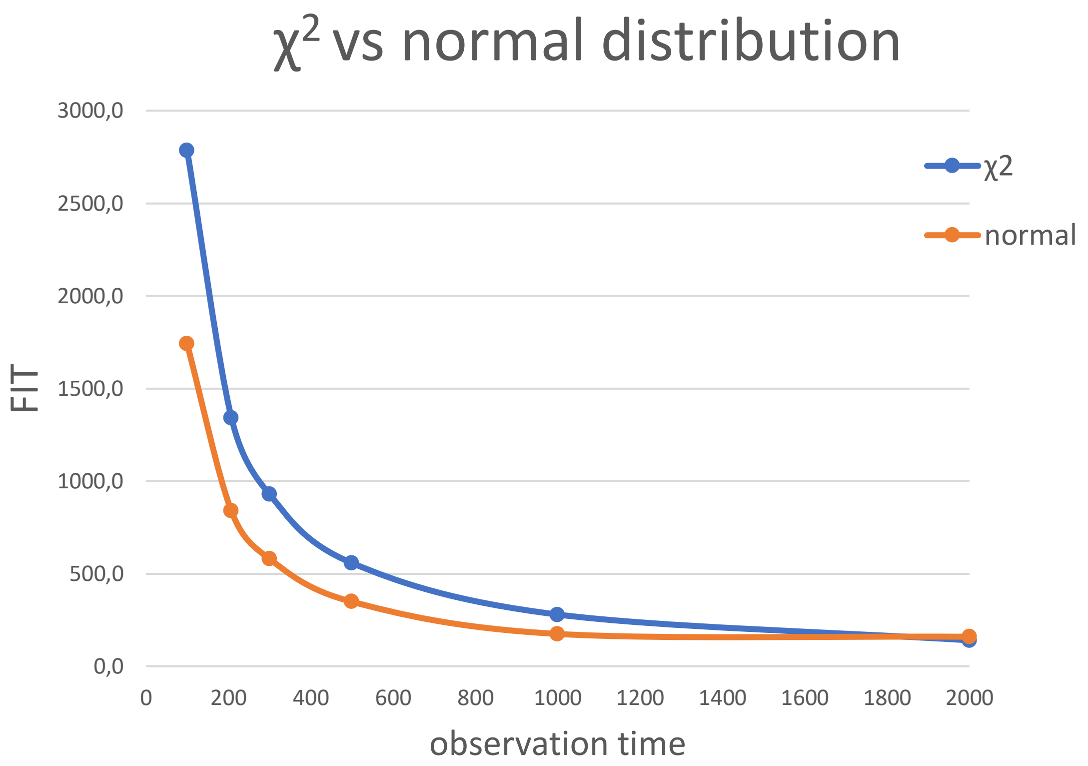
- Use of probabilistic distribution
  - χ^2 distribution: From a sample of n failures observed over a cumulated observation time T the confidence upper bound can be calculated by using the $\chi2$ function: $$\lambda_{0,7} = \frac{1}{2T}\chi^2_{0,3,\,2(n+1)}$$
  - Can be used with small size of data
  - Confidence level 70%
  - T = total observation time; n = observed failures

Prior Use Assessment

- Observation time (T)
  - Total time (in years) where a component is in service
    - Same model number
    - Same service
    - Same environmental impact
    - Same degradation
  - T ≠ number of component * service years
    - Replacement
    - Repair
    - MoC

Prior Use Assessment

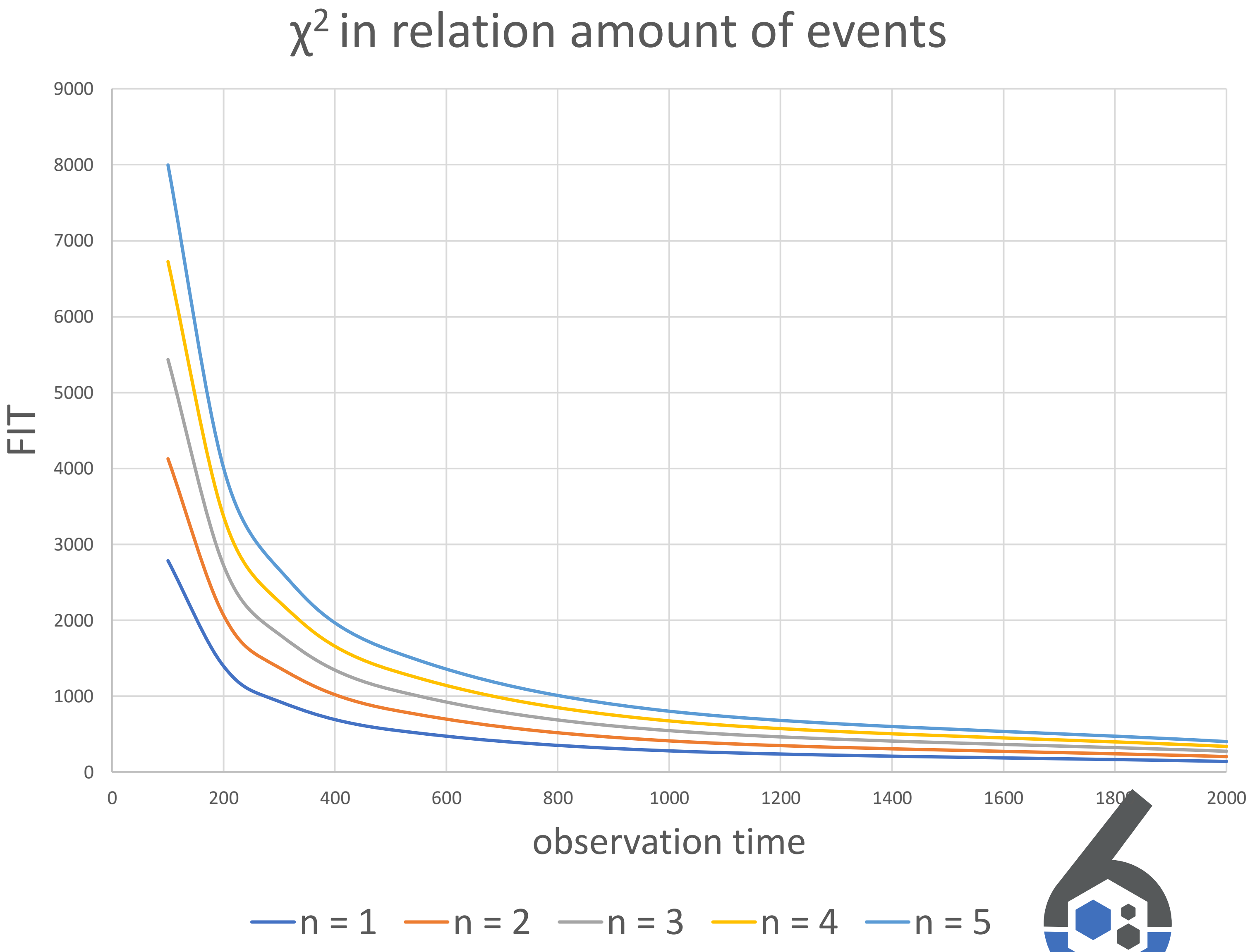
- Use of probabilistic distribution
  - χ^2 vs normal distribution
  - Confidence level 70%



- χ^2 is more conservative and required by IEC 61511
- χ^2 could be 'less required' at large observation time

Prior Use Assessment

- χ^2 distribution
  - Reliability (FIT) against observation time
  - Different observed events
  - Shows importance of available data



Prior Use Assessment - examples

- Simple SIF configuration

$$\boxed{\text{Sensor}} \longrightarrow \boxed{\text{LS}} \longrightarrow \boxed{\text{Actuator}}\boxed{\text{Valve}}$$

- Sensor, Logic Solver and Actuator does have valid SIL certificates
  - Sensor: $PFD_{avg} = 2.85 \times 10^{-4}$
  - Logic Solver: $PFD_{avg} = 4.82 \times 10^{-4}$
  - Actuator: $PFD_{avg} = 5.30 \times 10^{-3}$
- Valve doesn't have a valid SIL certificate

Prior in Use Assessment

- Simple Safety loop
  - High level in tank closes tank-valve
  - All components, except valve, contain necessary certification documents
- Service time plant 18 years
- Total # of valves in service: 90
  - In critical application: 30
  - In process application: 60
- Combines operational service: 500 year
  - Valves in similar service – clean
  - Valves within same model number

Prior in Use Assessment - examples

- Example 1
  - Fictitious vs probabilistic (χ^2) approach
  - Fixed set of results
- Example 2
  - χ^2 - approach
  - Lack of maintenance data
- Example 3
  - χ^2 - approach
  - Relation between reliability and # events

Example 1 - results valve

- Out of maintenance report, the following data is acquired

Tag #	date	service	failure	Event [1)]	SD	SU	DD	DU	Maintenance	MTTR
XV-003	25-01-99	Clean	Packing leak	Fail safe	1				Packing replacement	45 min
XV-034	04-10-02	Clean	Build up material	Poss. danger			1		Cleaning	1 hour
XV-010	18-08-02	Clean	Shaft damage	Fail to danger				1	Valve replacement	12 hours
XV-150	06-02-09	Clean	Packing leak	Fail safe	1				Packing replacement	1,5 uur
XV-068	19-04-15	Clean	Valve not closed 100%	Poss. Danger			1		Valve replacement	16 hours
XV-099	31-10-19	Clean	Build up material	Poss. Danger			1		Cleaning	30 min

- Proof-test interval (T1) = 8760 hours (1 year)
- MTTR = 5.3 hours (average)

[1)] In relation to functional safety, not process safety

Example 1 – Fictitious example

- Failure rate [in FIT(Failure in Time)]:
  - $\lambda = n / T$
  - λ_{DU} = 228 FIT; λ_{DD} = 685 FIT; λ_{SD} = 457 FIT; λ_{D} = 913 FIT
- Calculate PFD_{avg}
  - PFDavg = 5.36×10^{-4}

Example 1 – probabilistic example

- $\chi^2[\alpha/2, 2n+2]$; $\alpha/2 = 0.3$ (70% confidense, n = amount of events)
- $\lambda = \chi^2/(2 \times T)$
- Failure rate:
  - $\lambda_{DU} = 556$ FIT; $\lambda_{DD} = 1090$ FIT; $\lambda_{SD} = 825$ FIT $\lambda_D = 856$ FIT
- Calculate PFD_{avg}
  - $PFD_{avg} = 2.46 \times 10^{-3}$

Example 1

- Results prior use calculation:
  - Fictitious approach (prior use): $PFD_{avg} = 5.36 \times 10^{-4}$
  - Probabilistic approach (prior use): $PFD_{avg} = 2.46 \times 10^{-3}$

- Total loop results:
  - Fictitious approach: $PFD_{avg} = 6.60 \times 10^{-3}$ -> RRF 151
  - Probabilistic approach: $PFD_{avg} = 8.53 \times 10^{-3}$ -> RRF 117

Example 2 - results valve

- Out of maintenance report the following data is acquired

Tag #	date	service	failure	Event	SD	SU	DD	DU	Maintenance	MTTR
XV-003	25-01-99	Clean	Packing leak	Fail safe	1				Packing replacement	45 min
XV-034	04-10-02	Clean	Build up material	Poss. danger			1		Cleaning	1 hour
XV-010	18-08-02	Clean	Shaft damage	Fail to danger				1	Valve replacement	12 hours
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- Proof-test interval (T_1) = 8760 hours (1 year)
- MTTR = 5.3 hours

Example 2 - results valve

- Out of maintenance report the following data is acquired

Tag #	date	service	failure	Event	SD	SU	DD	DU	Maintenance	MTTR
XV-003	25-01-99	Clean	Packing leak	Fail safe				1	Packing replacement	45 min
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XV-150	06-02-09	Clean	Packing leak	Fail safe				1	Packing replacement	1,5 uur
XV-068	19-04-15	Clean	Valve not closed 100%	Poss. Danger				1	Valve replacement	16 hours
XV-099	31-10-19	Clean	Build up material	Poss. Danger				1	Cleaning	30 min

- Prooftest interval (T1) = 8760 hours (1 year)
- MTTR = 5.3 hours
- Lack of maintenance data – all events considered as dangerous failure

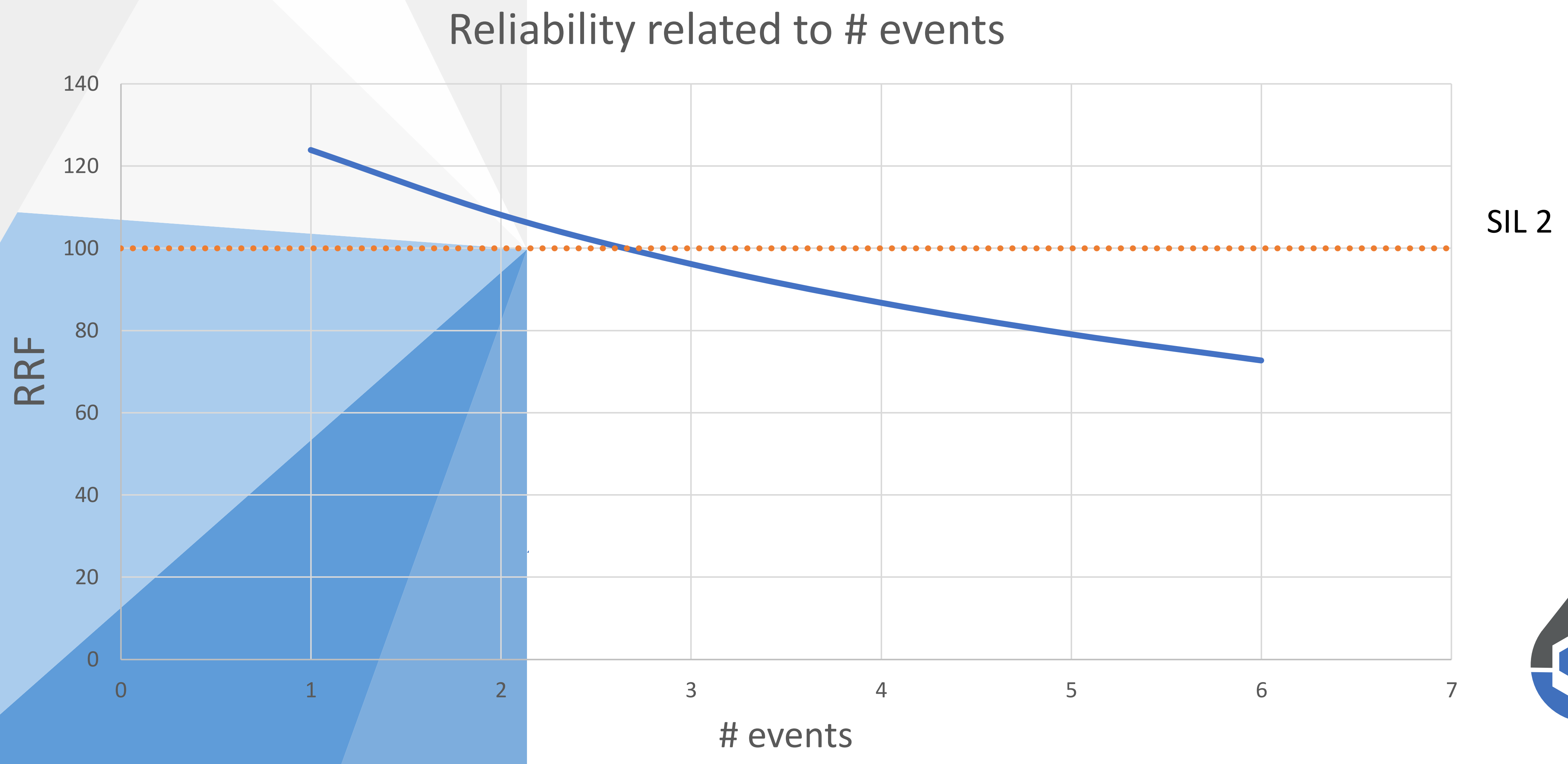
Example 2

- $\chi^2[\alpha/2, 2n+2]$; (70% confidence, n = number of events = 6)
- $\lambda = \chi^2/(2 \times T)$
- Failure rate:
  - λ_{DU} = 185 FIT
- Calculate PFD_{avg} for SIF
  - $PFD_{avg} = 1.42 \times 10^{-2}$
  - RRF = 71

Example 3

- Same data as previous examples
- Considered only λ_{DU} values
- Increased number of found DU events
- Data based on χ^2 distribution

Example 3


Reliability related to # events
RRF
140
120
100
80
60
40
20
0
0
1
2
3
4
5
6
7
events
SIL 2

Prior in Use Assessment – summary

- Volume of the operating experience:
  - High observation time -> decrease of FIT
  - Observed events will then contribute less
- Monitoring device performance
  - Better monitoring and documentation -> RRF increases
  - Example 71 -> 117
- Gives a good overview regarding reliability related to observed events

Prior Use Assessment – Discussion

Can ‘certified data’ being replaced by ‘prior use’ data ?

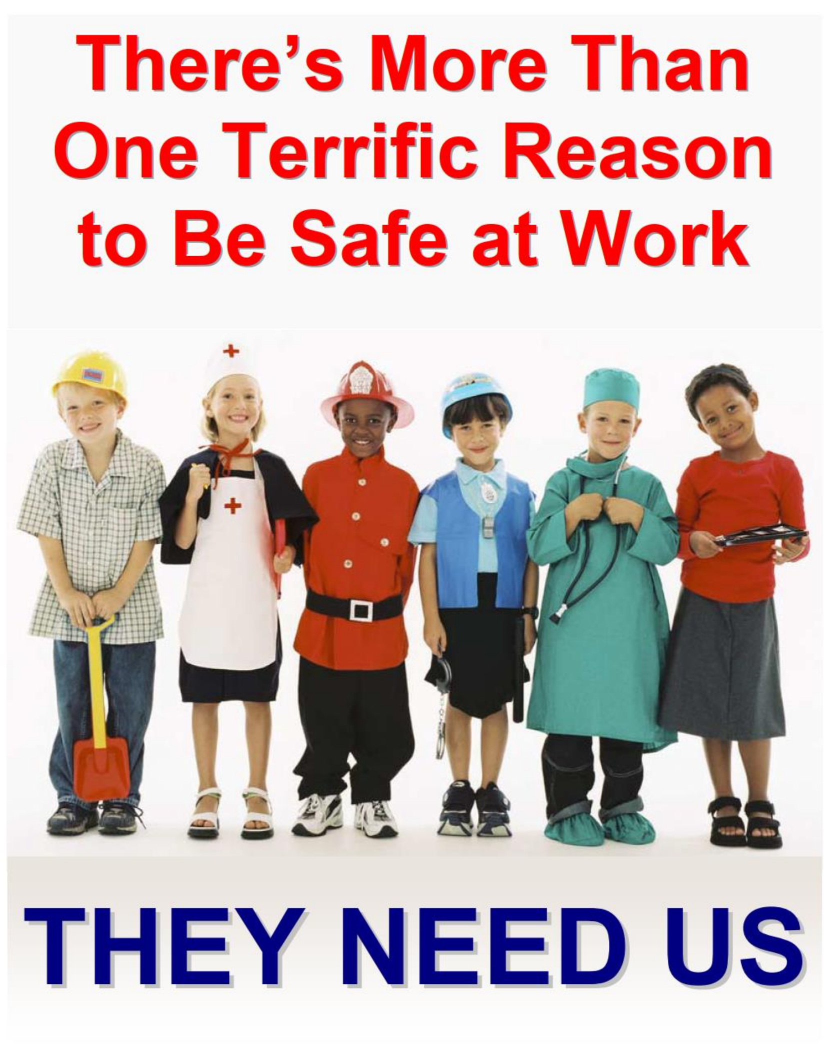
	Certified data	Prior use
Used within green field	👍	👎
Used within brown field	👍	👍
Predictive	👎	👍
Realistic	👍	👎
Cover all SIFs	👍	👎
Clear failure data	👍	👎
Clear operational data	👎	👍 👎
Use of historical data	👎	👍

Prior Use Assessment – Discussion

- Can ‘**certified data**’ fully being replaced by ‘**prior in use**’ data:

- But.....
    - In some cases possible
    - Monitoring device performance during operational phase
    - Predictive to future reliability

Questions


There's More Than
One Terrific Reason
to Be Safe at Work
THEY NEED US

Back-up slides

Example 1 – fictitious example

- Failure rate:
  - λ_{DU} = 1 / 500 = 2.00 x 10^{-3} per year = 2.28 x 10^{-7} per hour = 228 FIT
  - λ_{DD} = 3/ 500 = 6.00 x 10^{-3} per year = 6.85 x 10^{-7} per hour = 685 FIT
  - λ_{SD} = 2 / 500 = 4.00 x 10^{-3} per year = 4.57 x 10^{-7} per hour = 457 FIT
  - $\lambda_D = \lambda_{DU} + \lambda_{DD}$ = 228 + 685= 913 FIT
- Calculate t_{CE}

$$t_{ce} = \frac{\lambda_{DU}}{\lambda_D} \text{ x } \left(\frac{T_1}{2} + \text{MTTR}\right) + \left(\frac{\lambda_{DD}}{\lambda_D} \text{ x MTTR}\right)$$

  - t_{CE} = (2.28 x 10^{-7} / 9.13 x 10^{-7}) * (8760/2 + 5.3) + (6.85 x 10^{-7} / 9.13 x 10^{-7} * 5.3)
    = 1.100 + 3.98 = 1104 hours
- Calculate PFD_{avg}

$$PFD_{avg} = [(\lambda_{DU}) + (\lambda_{DD})]\, t_{ce}$$

  - PFDavg = (2.28 x 10^{-7} + 6.85 x 10^{-7}) * 1104 = 5.36 x 10^{-4}

Example 1 – probabilistic example

- $\chi^2[\alpha/2, 2n+2]$; $\alpha/2 = 0.3$ (70% confidense, n = amount of events)
- Failure rate:
  - $\lambda_{DU} = \chi^2/(2 \times T) = 4.88 / (2 * 500) = 4.88 \times 10^{-3}$ per year $= 5.56 \times 10^{-7}$ per hour
  - $\lambda_{DD} = \chi^2/(2 \times T) = 9.52 / (2 * 500) = 9.52 \times 10^{-3}$ per year $= 1.09 \times 10^{-6}$ per hour
  - $\lambda_{SD} = \chi^2/(2 \times T) = 7.23 / (2 * 500) = 7.23 \times 10^{-3}$ per year $= 8.25 \times 10^{-7}$ per hour
  - $\lambda_D = \lambda_{DU} + \lambda_{DD} = 2.90 \times 10^{-7} + 5.66 \times 10^{-7} = 8.56 \times 10^{-7}$
- Calculate t_{CE}

$$\mathbf{t_{ce}} = \frac{\lambda_{DU}}{\lambda_D} \mathbf{x} \left(\frac{T_1}{2} + \mathbf{MTTR}\right) + \left(\frac{\lambda_{DD}}{\lambda_D} \mathbf{x}\ \mathbf{MTTR}\right)$$

  - $t_{CE} = (5.56 \times 10^{-7} / 1.09 \times 10^{-6}) * (8760/2 + 5.3) + (8.25 \times 10^{-7} / 1.09 \times 10^{-6} * 5.3)$
    $= 1490 + 3.50 = 1494$ hours
- Calculate PFD_{avg}

$$\mathbf{PFD_{avg}} = [(\lambda_{DU}) + (\lambda_{DD})]\ \mathbf{t_{ce}}$$

  - $PFD_{avg} = (5.56 \times 10^{-7} + 1.09 \times 10^{-6}) * 1494 = 2.46 \times 10^{-3}$

Example 2 – probabilistic example

- $\chi^2[\alpha/2, 2n+2]$; $\alpha/2 = 0.3$ (70% confidense, n = amount of events)
- Failure rate:
  - Amount of events (n) = 6
  - $\lambda_{DU} = \chi^2/(2 \times T) = 4.88 / (2 * 500) = 1.62 \times 10^{-2}$ per year = 1.85×10^{-6} per hour
- Calculate PFD_{avg} for valve
  - PFDavg = 8.11×10^{-3}
- Calculate PFD_{avg} for SIF
  - $PFD_{avg} = 2.85 \times 10^{-4} + 4.82 \times 10^{-4} + 5.30 \times 10^{-3} + 8.11 \times 10^{-3}$
    $= 1.42 \times 10^{-2}$
  - **RRF = 71**