Instrumented Safety Systems

Associazione Italiana Strumentisti

ISA Italy Section

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Engineered Valve Systems for Control and Safety Applications

HIPPS Definition

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Agenda

- Foreword
- Definition
- Safety Requirement Specification
- Reliability Criteria
- Reliability Data

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Foreword

High integrity protection systems (HIPS) and especially high integrity pressure protection systems (HIPPS) are an increasingly common feature of oil and gas facilities worldwide.

They can provide an alternative to conventional mechanical protective devices (e.g. relief valves) or reduce the load upon them.

In some cases, they present the only practical option to facilitate field development and/or expansion.

Mokveld has started HIPPS B.U. in 1972

Definition- HIPS High Integrity Protection System

Within the oil and gas industry, there are various company-specific definitions as to what constitutes a HIPS.

According to the ISO/TR 12489 definition, a non-conventional, autonomous, safety instrumented system with sufficiently high safety integrity to protect equipment against exceeding the design parameters is considered a HIPS

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Definition- HIPS High Integrity Protection System

Examples:

- Deviations from industry standards describing mechanical protection systems (e.g. ISO 23251 = API Standard 521, ISO 10418, API RP 14C) are treated as HIPS
- An ultimate protection relying principally, but not necessary solely, on Safety Instrumented Systems (SIS) is qualified as HIPS, irrespective of its required Safety Integrity Level (SIL).

Definition- HIPS High Integrity Protection System

Examples:

- a final protection layer comprising a combination of partial mechanical and instrumented protective function

- an instrumented protection layer having an integrity requirement of SIL 3 or more

- an instrumented protection layer where the consequence of non-operation is major to catastrophic or disastrous

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Definition- HIPPS High Integrity Pressure Protection System

ISO/TR 12489 also defines HIPPS or OPPS as, “a HIPS exclusively devoted to protection against overpressure”.

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Definition- HIPPS - summary

Safety Instrumented System (SIS -IEC61508-61511)

Autonomous

Final, instrumented protection layer

Dedicated to protect equipment from overpressure by isolating the pressure source

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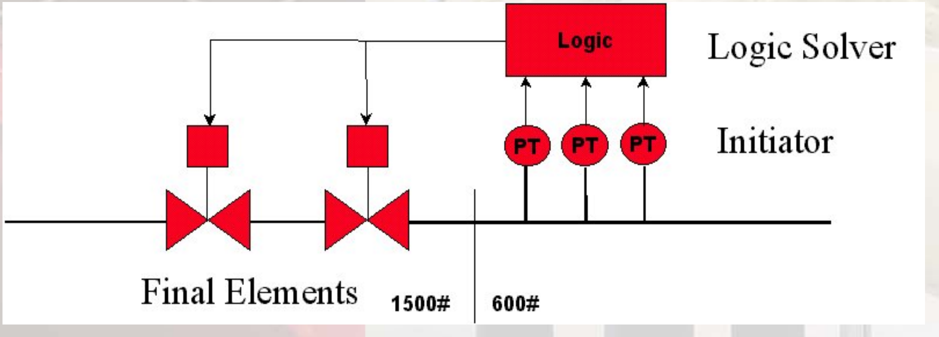
Definition- HIPPS – SYSTEM

Instrumented protection systems rely on instruments to provide a safety function for a given process. Such a function is performed by a Safety Loop consisting of one or more initiators (eg. Switches or transmitters), a logic solver (eg. a Safety Rated PLC) and final elements (eg. relays or valves).



Typical safety Loop

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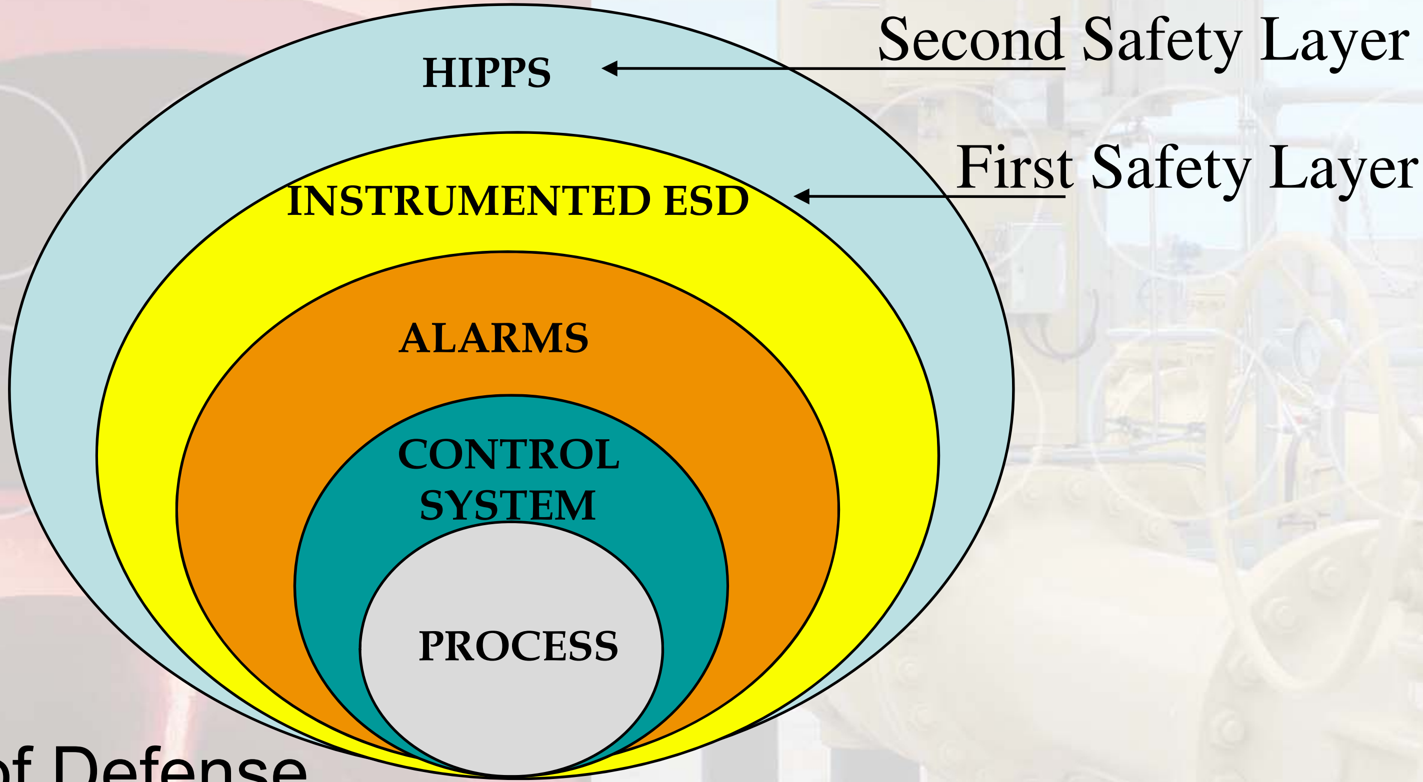
Definition- HIPPS – INDEPENDENT LAYER



Levels of Defense

API RP requires 2 independent safety layers

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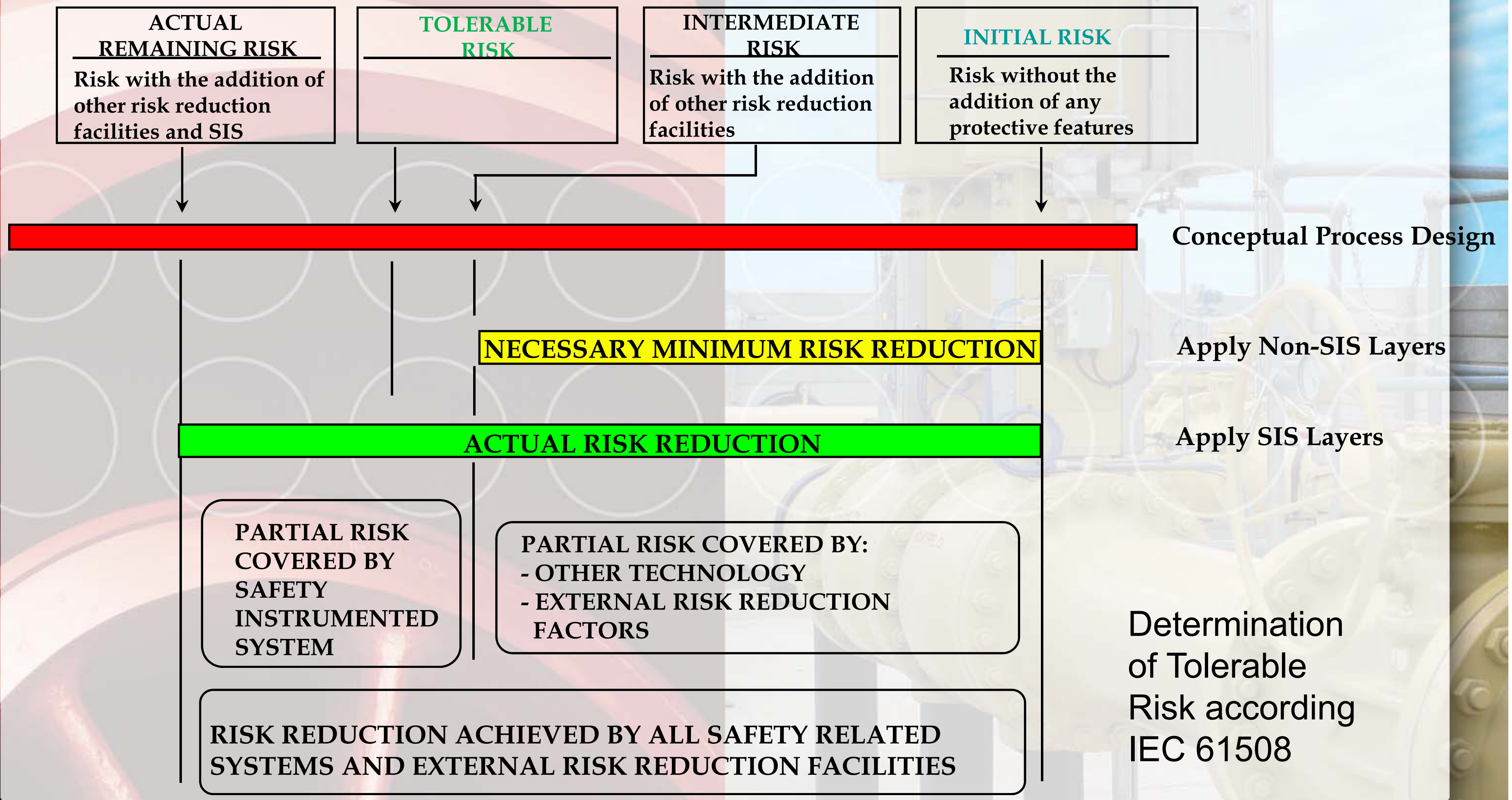
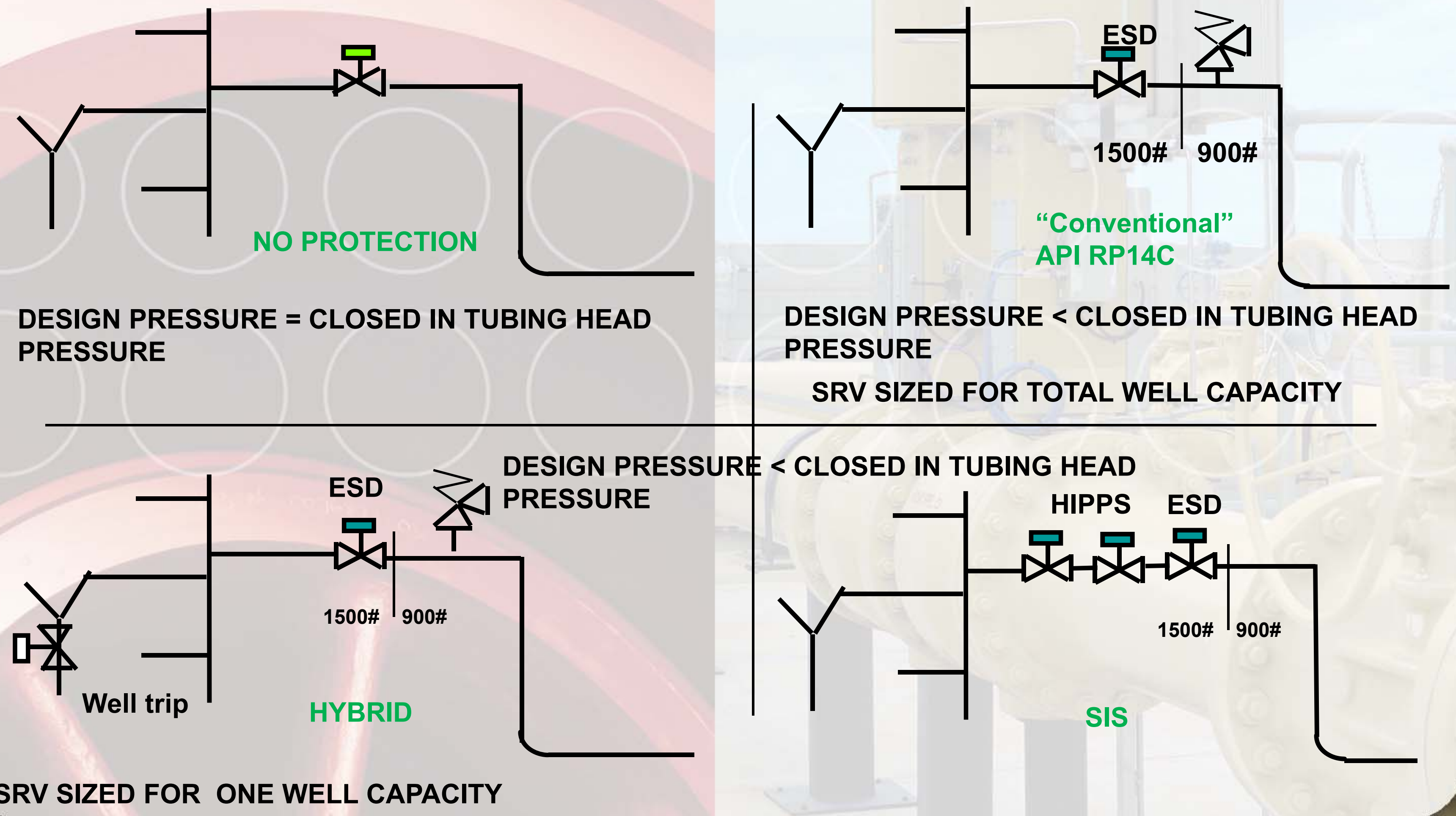
Definition- HIPPS – RISK PROTECTION



Determination of Tolerable Risk according IEC 61508

Definition- HIPPS – PROCESS DESIGN



Definition- HIPPS – WHY?

Reduction of the plant risk profile (insurance)

Reduction of Flare System and Piping Size

(or increase process system capacity without modifying flare system)

Regulations issues

Elimination of Separate Platform

Reduction in Weight

Environmental factors for IOCS

- no flaring
- reduced emissions
- perception of public

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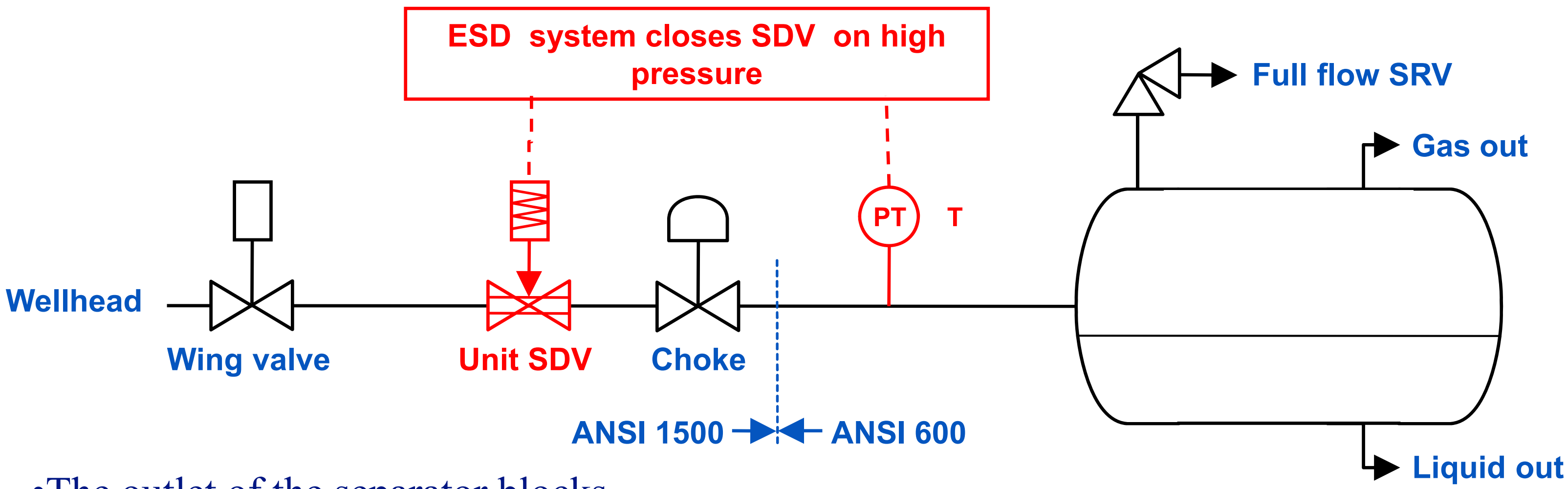
Production Separator with PSV

API Recommended Practice 14C



- The outlet of the separator blocks,
- The choke does not close,
- The Unit SDV does not close,
- The SRV is sized for full flow of the well

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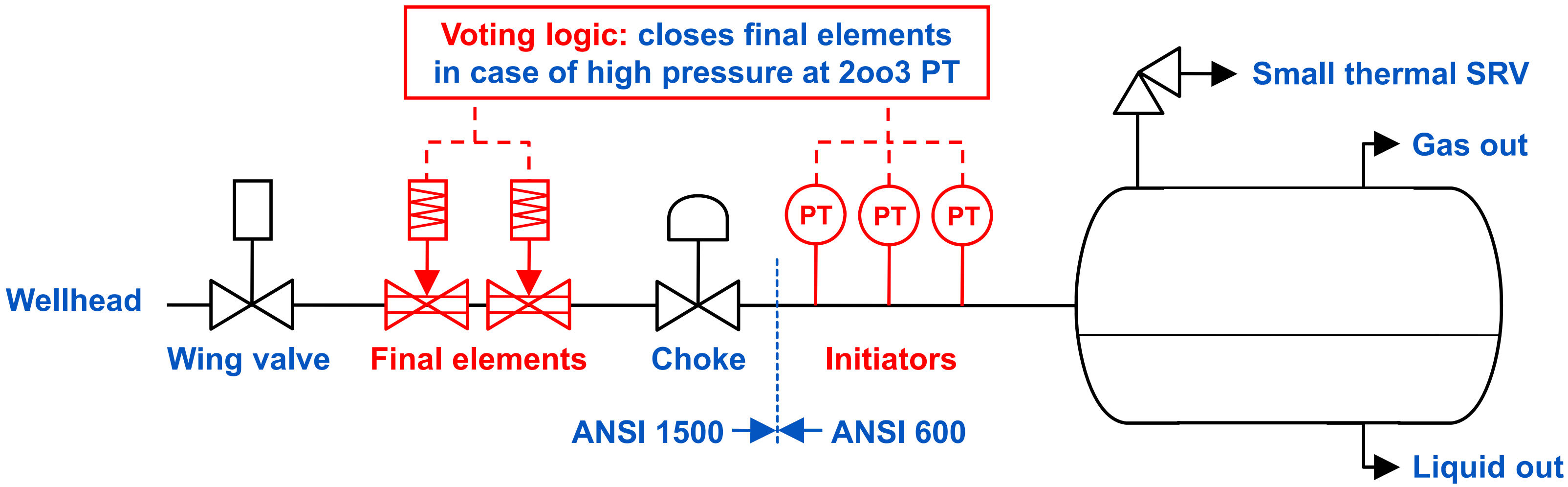
Production Separator with HIPPS

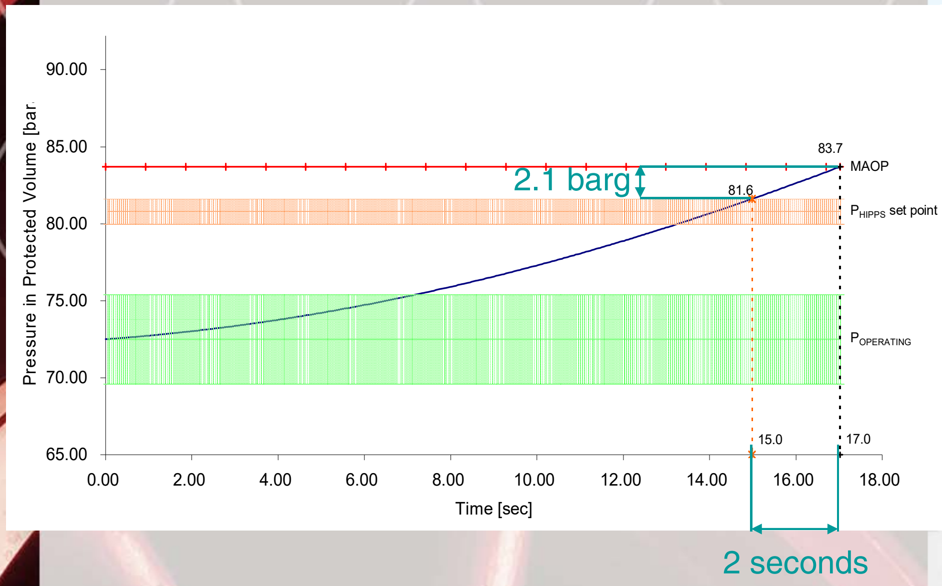


•The outlet of the separator blocks,
•The choke does not close,
•The SRV is sized for thermal relief / leakage only,
•The HIPPS SHALL close is 2 seconds to avoid overpressure in the separator.

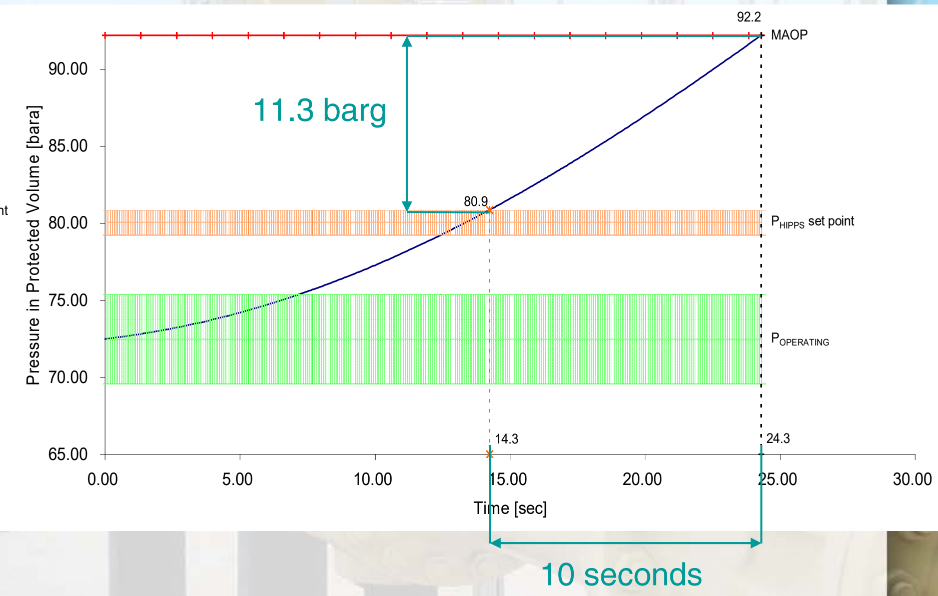
Design and Hardware considerations

Shorter stroking times allow tighter design pressures

- Dynamic simulation is strongly recommended
  - System operation (valve closing) may not be fast enough so the solution may be inadequate (check SRS!)



2 seconds



10 seconds

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HIPPS - General recommendations

Safety Requirements Specification

HIPPS functions should be defined independently of other safety systems in a specific HIPPS Safety Requirements Specification (SRS), normally produced by the end user.

This should consider the complete system comprising sensing element(s), logic solver and final element(s). The HIPPS should be developed and implemented in a similarly complete system manner.

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HIPPS - General recommendations

IEC 61511 part 1: performance requirements relating to:

- Functionality
- Availability
- Survivability
- Interdependencies

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HIPPS - General recommendations

Additional common requirements:

- HIPPS should execute all safety functions in automatic mode.
- HIPPS should be autonomous, with dedicated sensors, logic and final elements.
- HIPPS should be a physically segregated system, interfaced with the facility automation system for monitoring only. Any communications with HIPPS should not be able to impede or override the safety function(s).

HIPPS - General recommendations

Additional common requirements:

- HIPPS should be designed according to fail-to-safe principles.
- Resetting should not be possible without a clear understanding of the initiating cause and/or fault (eg. Manual reset on SOVs)
- Signals between sensors, logic solver and final elements should be hardwired.

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HIPPS - General recommendations

Additional common requirements:

- HIPPS design should define and include allowance for test and maintenance activities. Bypass functions should be avoided. When required, bypass functions should be subject to a thorough assessment of the risk and consequences for system integrity.
- HIPPS packages should be designated as ‘high’ focus with respect to quality management

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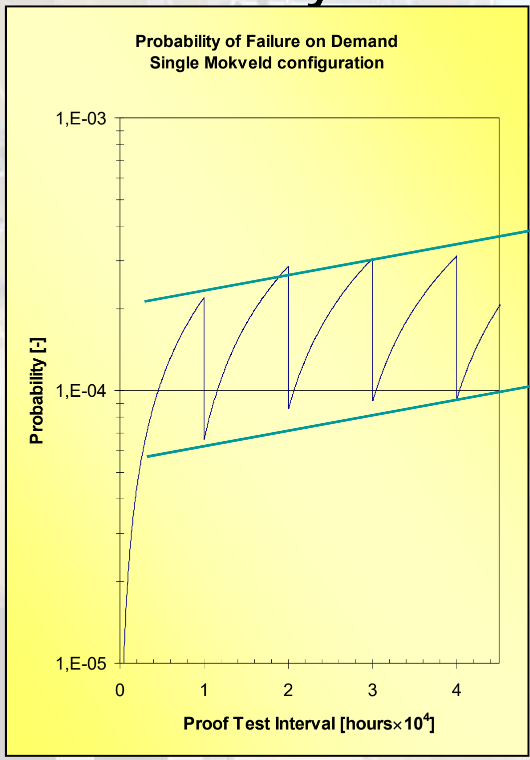
HIPPS - General recommendations

Additional common requirements:

- HIPPS design should consider the full safety life cycle.
  - As component age the probability of failure increases.
  - The component(s) lifetime depends on the test frequency and ability to detect dangerous failure
  - Less reliable systems will therefore require higher test frequencies to suit same SIL requirement!



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HIPPS - Reliability Criteria

HIPPS components, including sensors, logic solver and final elements should each be designed as <u>fail-safe</u> (i.e. failure of any component/ sensor/logic solver/power supply/motive fluids moves final elements to the safe state).

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HIPPS - Reliability Criteria

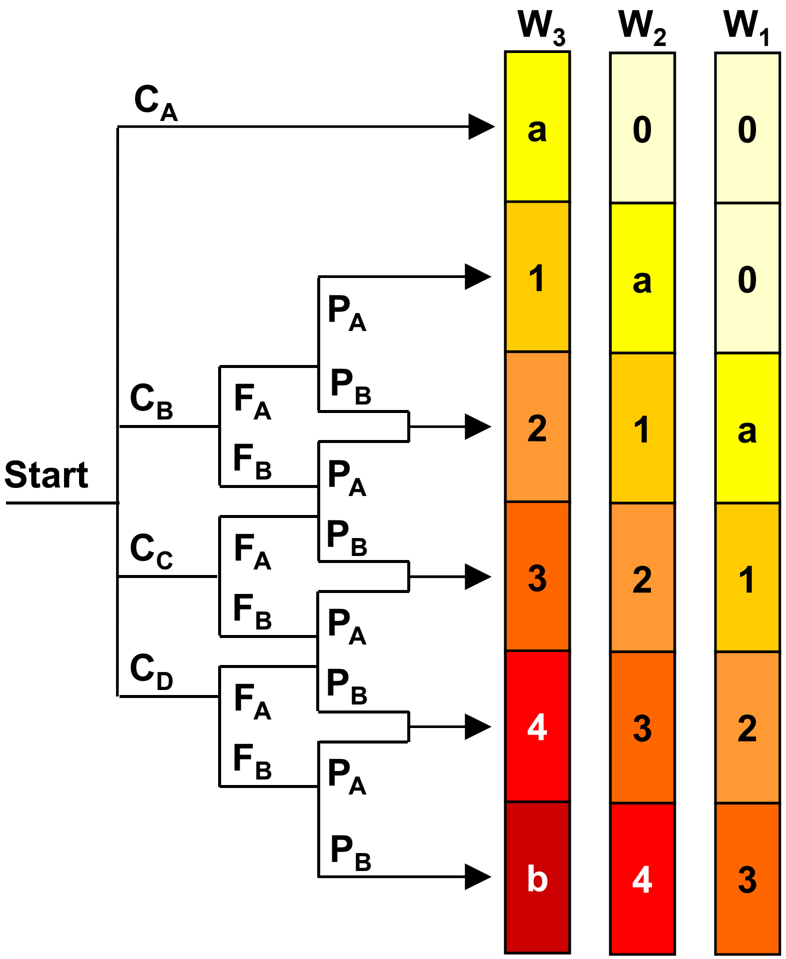
IEC 61511

SIL assessment → PDFavg or failure rate → HIPPS SRS

HIPPS components or sub-systems are then selected such that the overall integrity (SIL) target of the HIPPS Safety Instrumented Function (SIF) is achieved.

$$PFD_{sis} = PFD_{I} + PFD_{LS} + PFD_{SOV} + PFD_{SDV}$$

Risk graph based on HAZOP defines SIL



C = Consequence parameter

- C_A = Minor injury
- C_B = Serious injury to one or more, death to one
- C_C = Death to several people
- C_D = Very many people killed

F = Frequency of exposure parameter

- F_A = Rare to more often exposure
- F_B = Frequently to continuously

P = Possibility of escape

- P_A = Possible under certain conditions
- P_B = Almost impossible

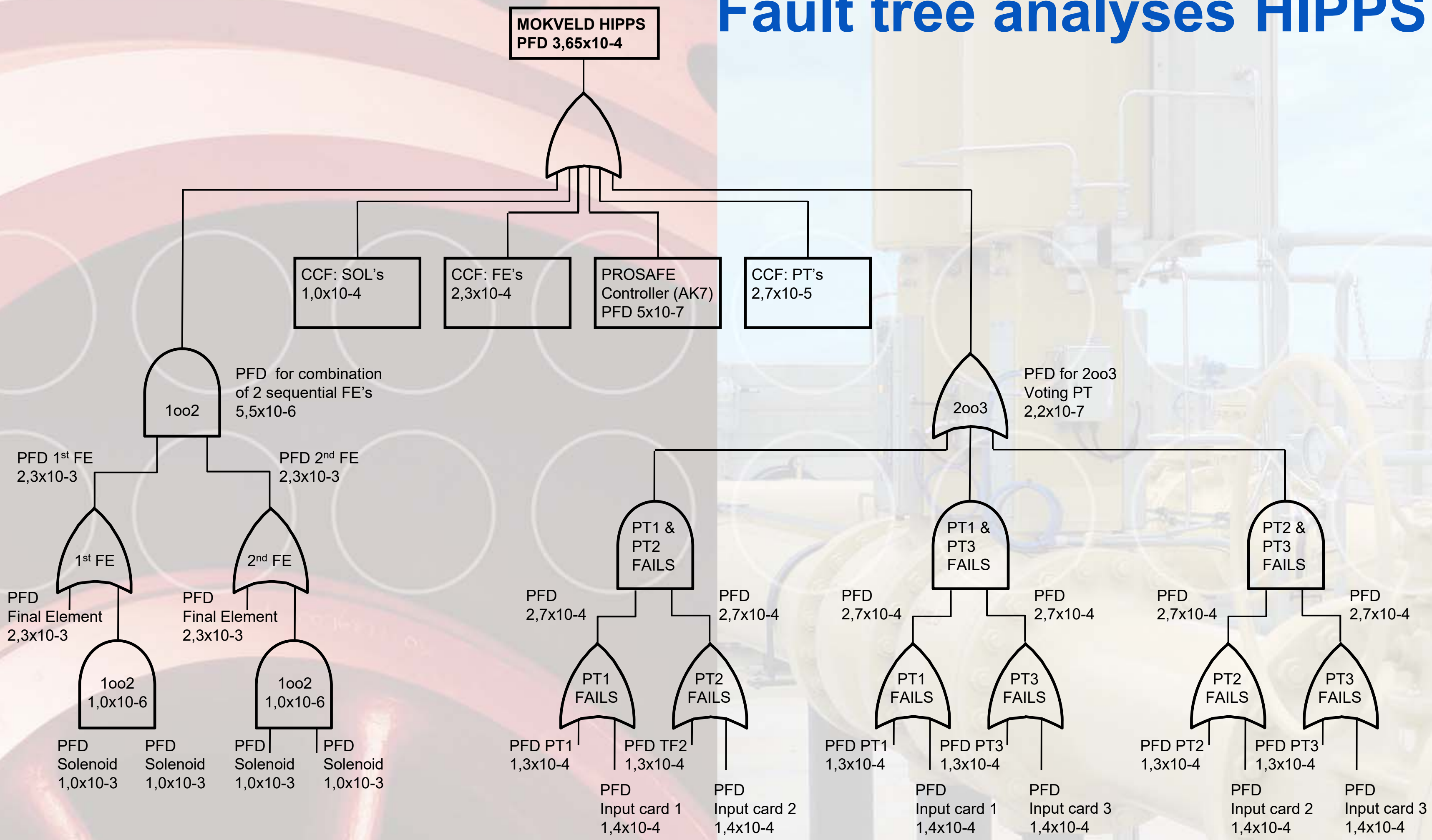
W= Likelihood of event

- W_1 = a relatively slight probability
- W_2 = a relatively medium probability
- W_3 = a relatively high probability

SIL required defines the design of safety loop

Safety Integrity Level	Probability of Failure on Demand	Risk Reduction Factor
SIL	**PFD**	**RRF**
0	No safety requirements (at all)	
a	No special safety requirements (e.g. only a procedure)	
1	$\geq 10^{-2}$ to $<10^{-1}$	> 10 to ≤ 100
2	$\geq 10^{-3}$ to $<10^{-2}$	> 100 to ≤ 1.000
3	$\geq 10^{-4}$ to $<10^{-3}$	> 1.000 to ≤ 10.000
4	$\geq 10^{-5}$ to $<10^{-4}$	> 10.000 or better
b	A single safety system is not sufficient (even with redundant components)	

Fault tree analyses HIPPS



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HIPPS - Reliability Data

The HIPPS operator should approve the reliability data utilized to demonstrate the integrity achieved by the HIPPS. Reliability data sources include, in order of preference:

1. Field data – but only where the quantity collected is sufficient to be considered statistically significant

See 7.4.10.4 : A proven in use safety justification shall be documented that the element supports the required safety function with the required systematic safety integrity. This shall include: the suitability analysis and testing of the element for the intended application and the demonstration of equivalence between the intended operation and the previous operation experience, including the impact analysis on the differences

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Database filled since 70's

Each after-sales related action entered in database

Prod.Year	Valve-SN	Location	Country	Product Grp	Description	Qty	Buyer
2007	43011	Bab Field	United Ar	12 Hipps valves	RZD-X-SAV 6"/2500 RTJ+M475-1VS	48	Descon Engineering
2007	43012	Bab Field	United Ar	12 Hipps valves	RZD-X-SAV 8"/2500 RTJ+M475-1VS	12	Descon Engineering

MP

Proj.lijst (NB) incl. evt. verwijzingen

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11-FEB-11

Projekt | Herk | Aan | Typ | Uitvoer | Afmeting | Drukkl | Aandrijving | Klant | Eindgebruiker | Bestelnummerklant | Lev.wk | Service | Pb nr | Invoerdat

Off/Proj | Volgnr | Txtnr | Omschrijving1 | Lev.wk | Invoerdat

12/43011 TA 48 RZD X-SAV 6" 2500 RTJ - 09 MAR 2007

64/44100 1 Commissioning. - 13 SEP 2007

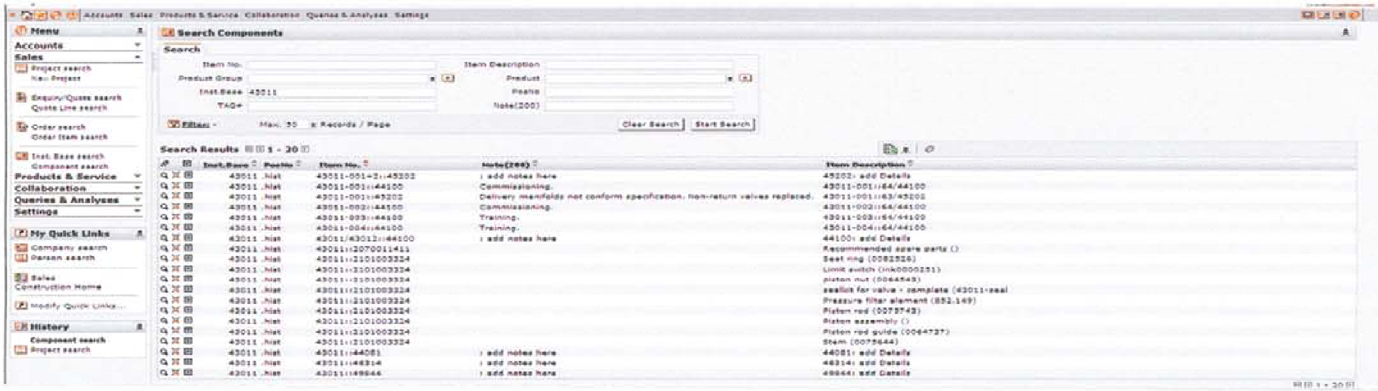
63/45202 1 Delivery manifolds not conform specification. - 03 MAR 2008

Non-return valves replaced.

64/44100 2 Commissioning. - 13 SEP 2007

64/44100 3 Training. - 13 SEP 2007

64/44100 4 Training. - 13 SEP 2007

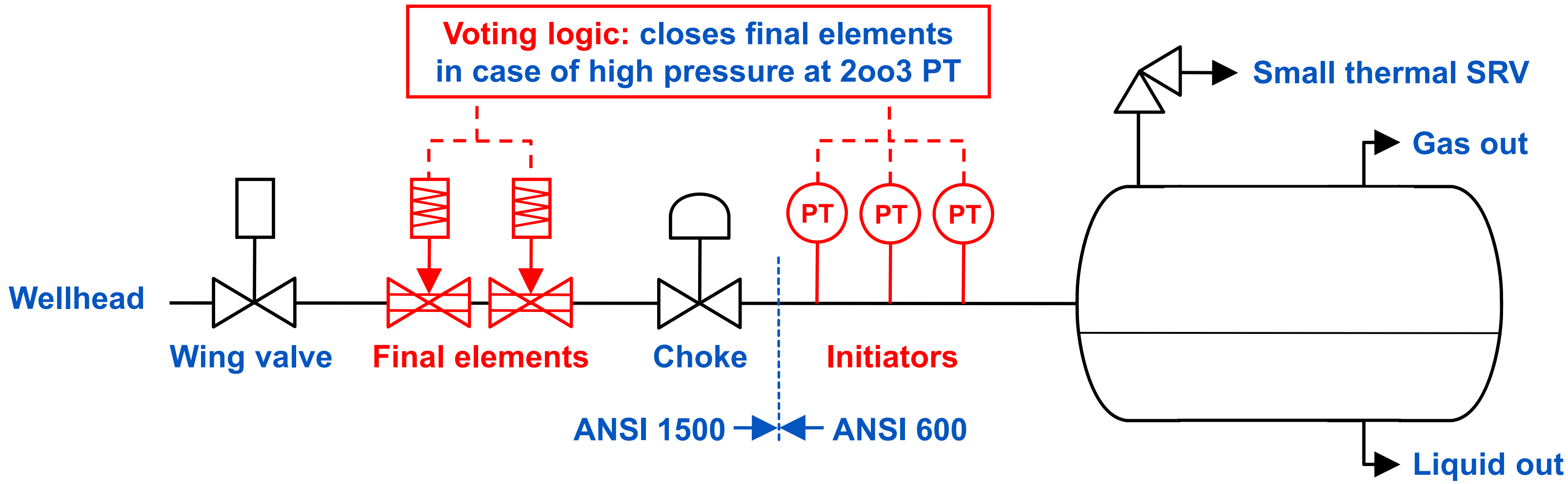


HIPPS - Reliability Data

2. Databases/reference handbooks– The data selection process should consider similar service and environmental conditions, and maintenance regimes (OREDA3, PDS Data Handbook4, SINTEF5)
3. Failure Mode and Effect Analysis (FMEA) reports
4. Vendor data

PFD / SIL of complete safety loop to be verified

- Architecture to be verified
- Failure rates shall be dependable or “proven in use”:
  - Based on field experience in same application
  - For same stroking time (< 2 sec.)
- Integrated FAT & SAT



Example in Europe

Location : Gasunie Netherlands BBL Balgzand pipeline
Specs : 2 x 1oo2 Electronic HIPPS protecting ANSI 600 control valves against pressure from ANSI 900 compressor

Example in Europe

Location : NAM Netherlands mobile production unit

Specs : 1oo2 Mechanical HIPPS protecting ANSI 900 pipeline against pressure from ANSI 2500 wellhead

Example in Europe

Location	:	Dong Denmark Nybro
Specs	:	1oo2 Electronic HIPPS protecting ANSI 600 onshore installation against pressure from ANSI 900 pipeline

Example in Europe

Location : Statoil Germany Zeepipe landfall

Specs : 1oo2 Mechanical HIPPS protecting ANSI 600 onshore installation against pressure from ANSI 900 pipeline

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