Instrumented Safety Systems

Associazione Italiana Strumentisti

ISA Italy Section

mokveld

ORI srl

Engineered Valve Systems for Control and Safety Applications

HIPPS – Final Elements

Associazione Italiana Strumentisti

ISA Italy Section

DINO OLIVIERI
Mokveld Agent

AIS – ISA Giornata di studio HIPPS

mokveld

Agenda

- The loop
- Final Elements
- Types
- Features
- Actuators
- CCF

mokveld

Final Elements

A HIPPS loop is composed of:

- initiators, that detect the high pressure
- logic solver, which processes the input from the sensors to an output to the final element
- final elements, that actually perform the corrective action in the field by bringing the process to a safe state. In case of a HIPPS this means shutting off the source of overpressure. The final element consists of a valve, actuator and solenoids.

mokveld

Final Elements

Final element selection should be done taking into account:

- The particular application
- The process and design conditions
- The suitability for use in safety applications
- The frequency of site testing
- The desired HIPPS lifetime before re-certification

mokveld

Final Elements

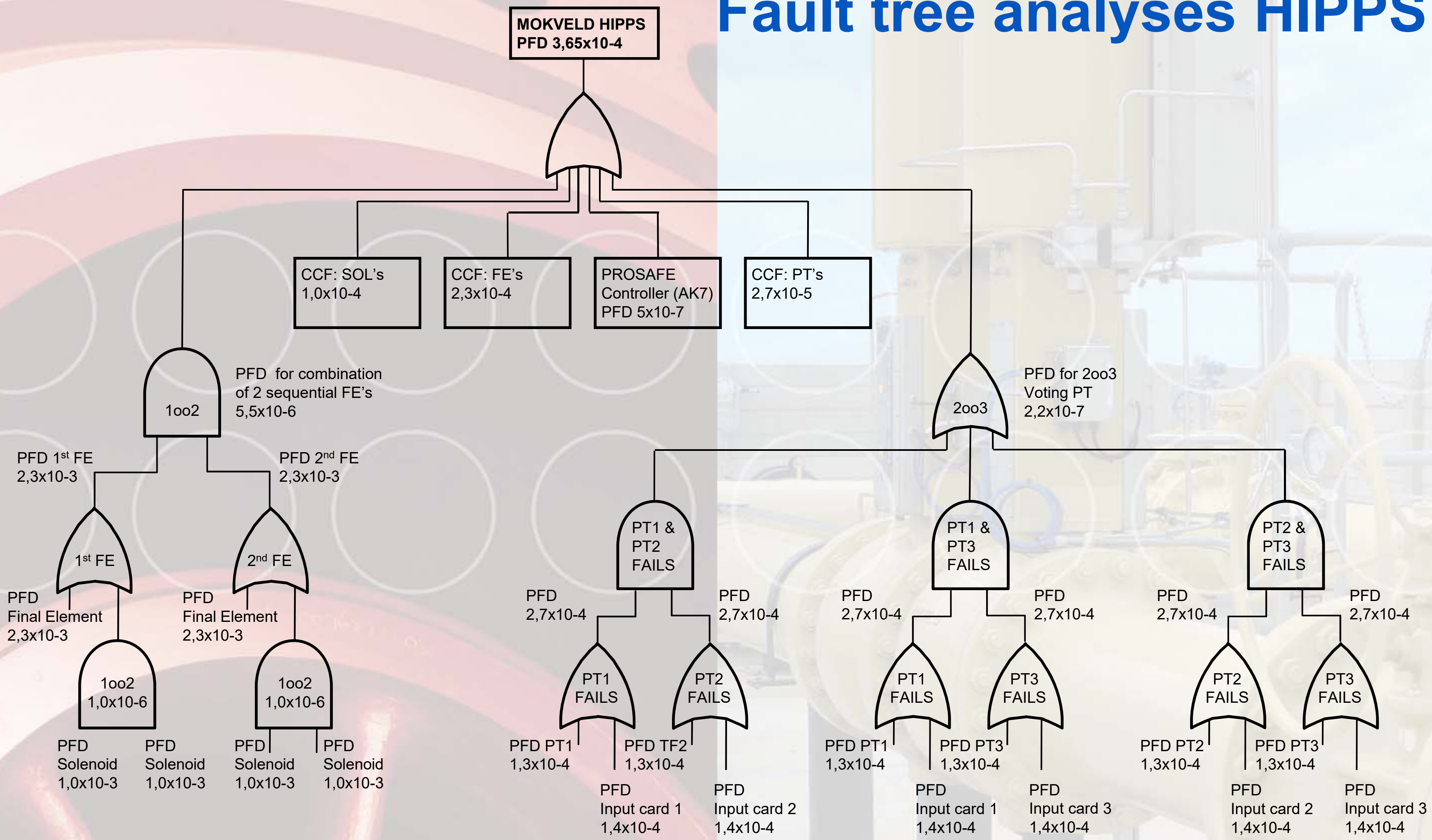
HIPPS final element assembly should be considered as a <u>whole sub-system</u>.

- valve
- actuator
- SOV's?...
- pedestal?...
- brackets?...

This should be taken into account in the design, the fabrication and the testing. Complete FAT required.

The relevant documentation should be managed by the same principle.

Fault tree analyses HIPPS

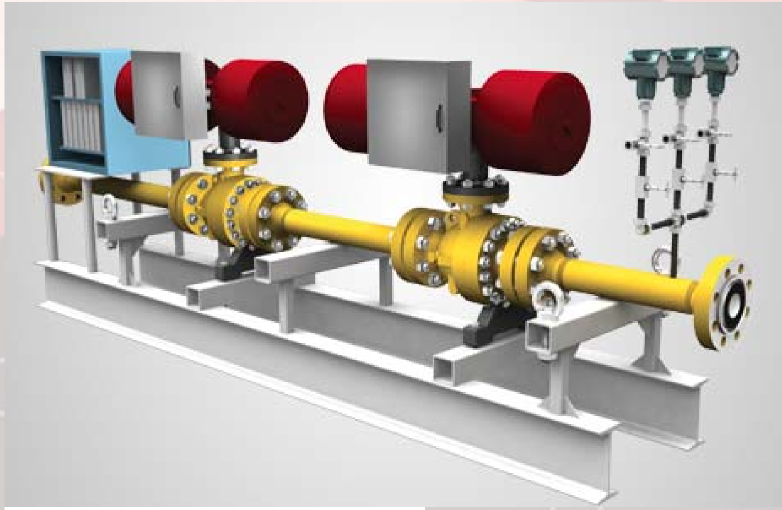


mokveld

Final Elements

- Final elements account for 50% of safety loop failures historically and their contribution to PFD(avg) is higher than that the one of sensors and logic solver.
- In short, performance of HIPPS is highly dependent on the “quality” of the FEs.

Final Elements



HIPPS Final element; Desired Features and Benefits

1. No equalising by-pass required
2. Low pressure drop
3. Fast closure
4. Excellent sealing
5. Compact and low weight
6. Fire safe
7. Infrequent use w/o partial stroking
8. Failure data from field experience

Bypass Lines

- Where a HIPPS bypass is required (e.g. for pressure equalization post HIPPS activation), this should not compromise the HIPPS integrity.
- The bypass should be locked closed or similar (e.g. interlocked) to prevent being left in the open position. Leak tightness and SIL specification for the bypass should be equivalent to that of the main HIPPS valves.

“Fast” Closing

The process safety time, HIPPS reaction time and HIPPS response time should be defined in the HIPPS SRS

HIPPS reaction time

The maximum allowable time in which the HIPPS should prevent a hazardous operational condition. It is thus the time between the process threshold value occurring and the occurrence of the hazardous event.

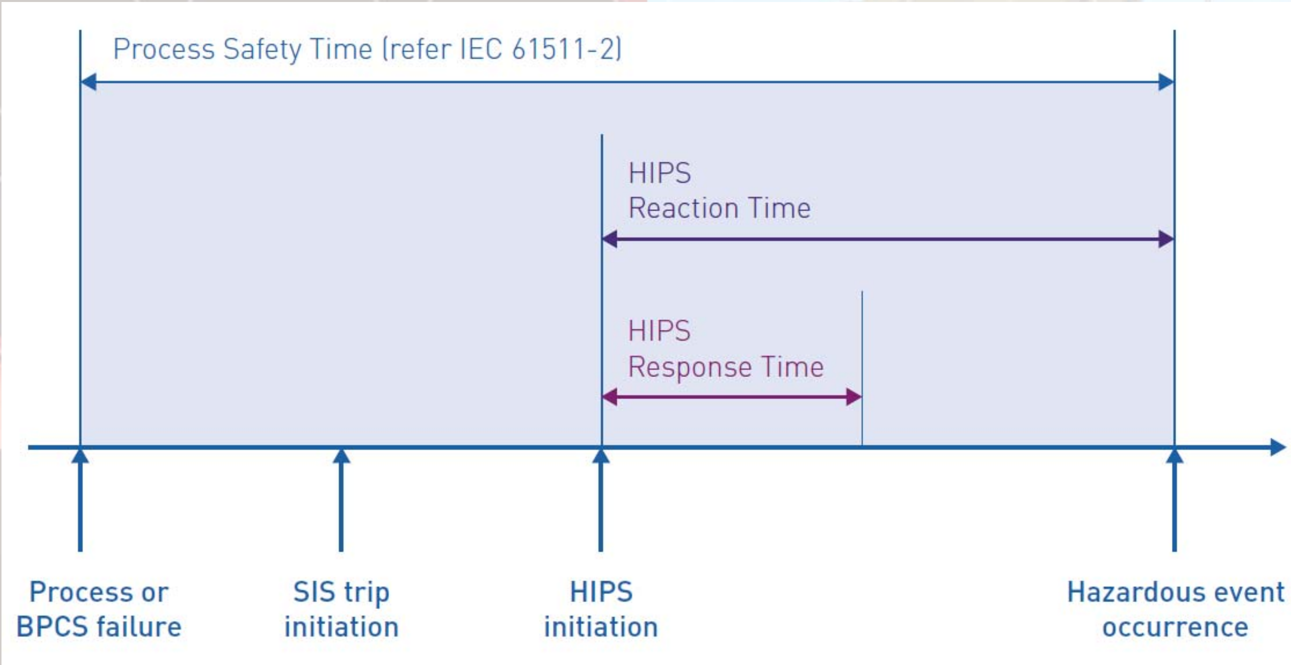
HIPPS response time

The time between the process threshold value occurring until the final element has reached its safe state.

mokveld

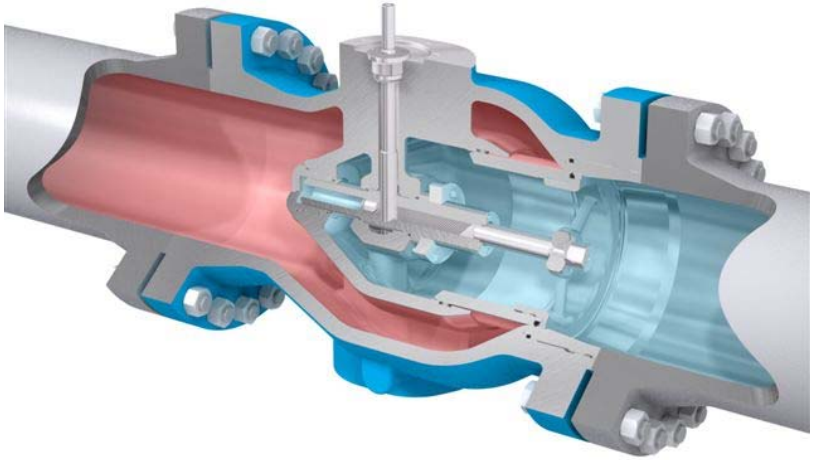
“Fast” Closing

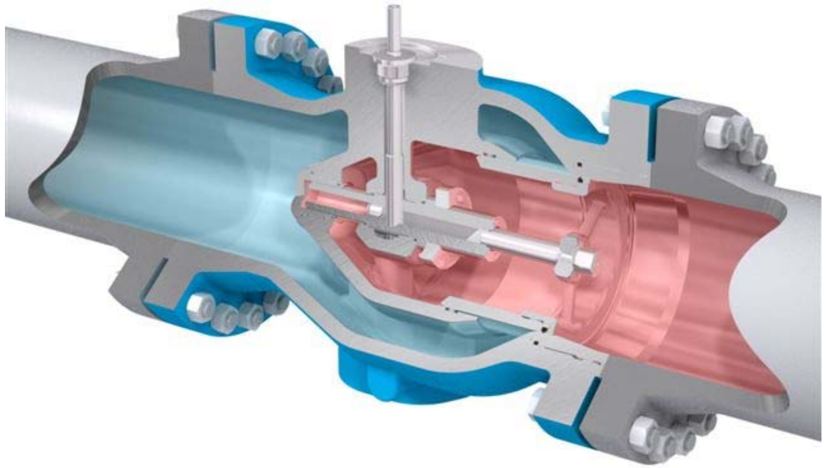
A «fast» closing valve may still not meet the process safety time! All elements have to be considered.



mokveld

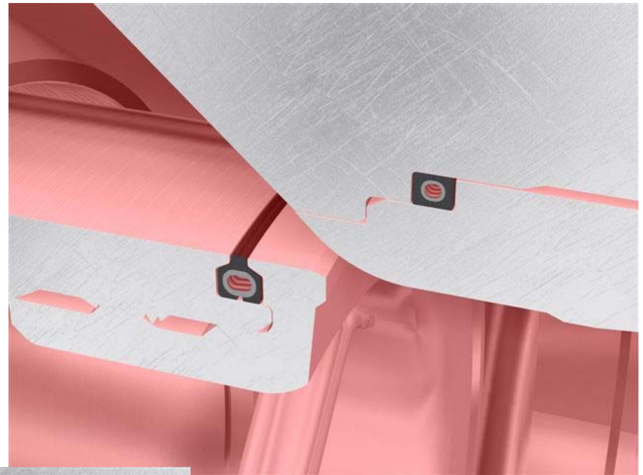
Fast Closing with Full Pressure Balancing

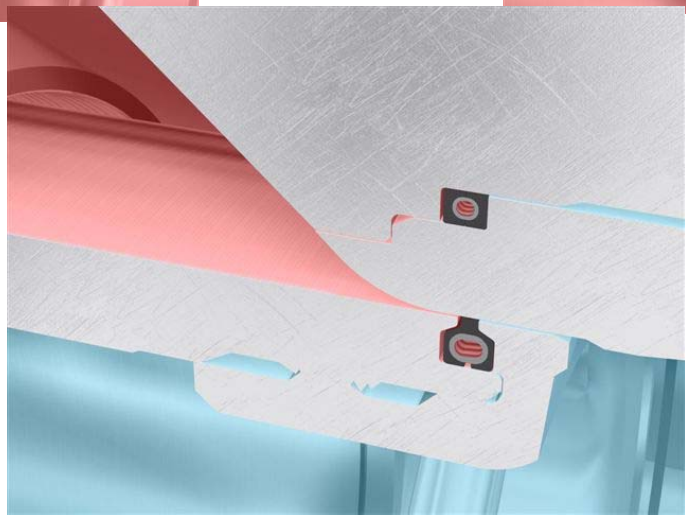




mokveld

Sealing: Bi-directional Tight Shut-Off, even on unclean duty





mokveld

Leakage rates

Although valves may be specified as zeroleakage (e.g. ISO 5208 or API Standard 598), in reality it should be assumed that some leakage in service will always occur. As such, the downstream process system should be able to handle a degree of leakage.

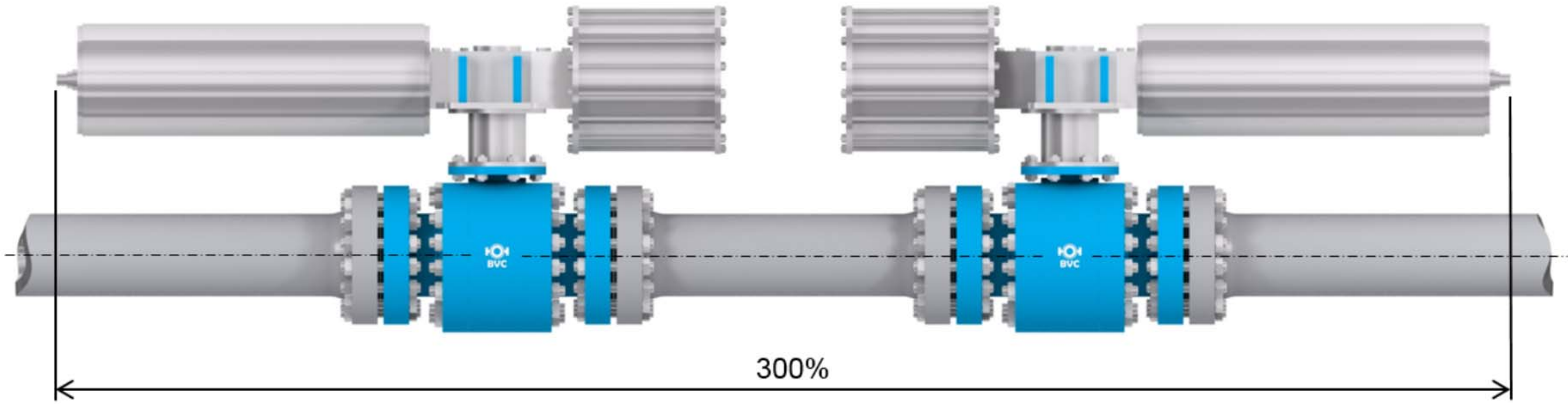
The leakage rate should be determined in conjunction with Process design Engineers and will typically be based upon the greatest of:

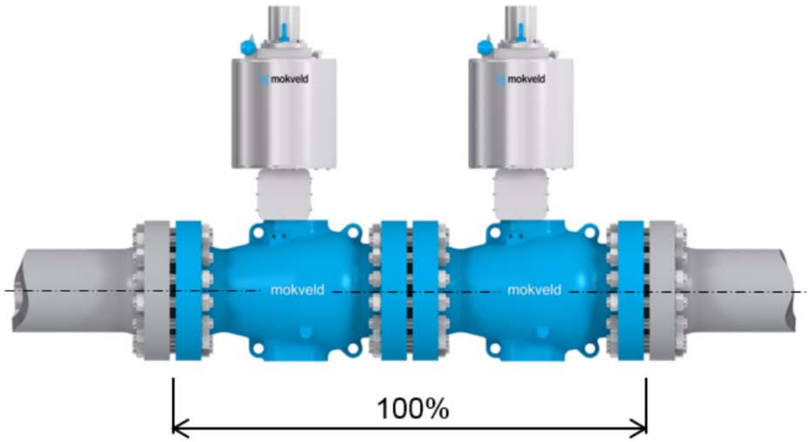
- 100% Flow through a valve bypass (if installed) when open
- that experienced following total collapse of soft seats (where fitted)
- a percentage of design flow (assessed in discussion with valve manufacturer) for metal seated valves.

mokveld

Compact and low weight design

mokveld



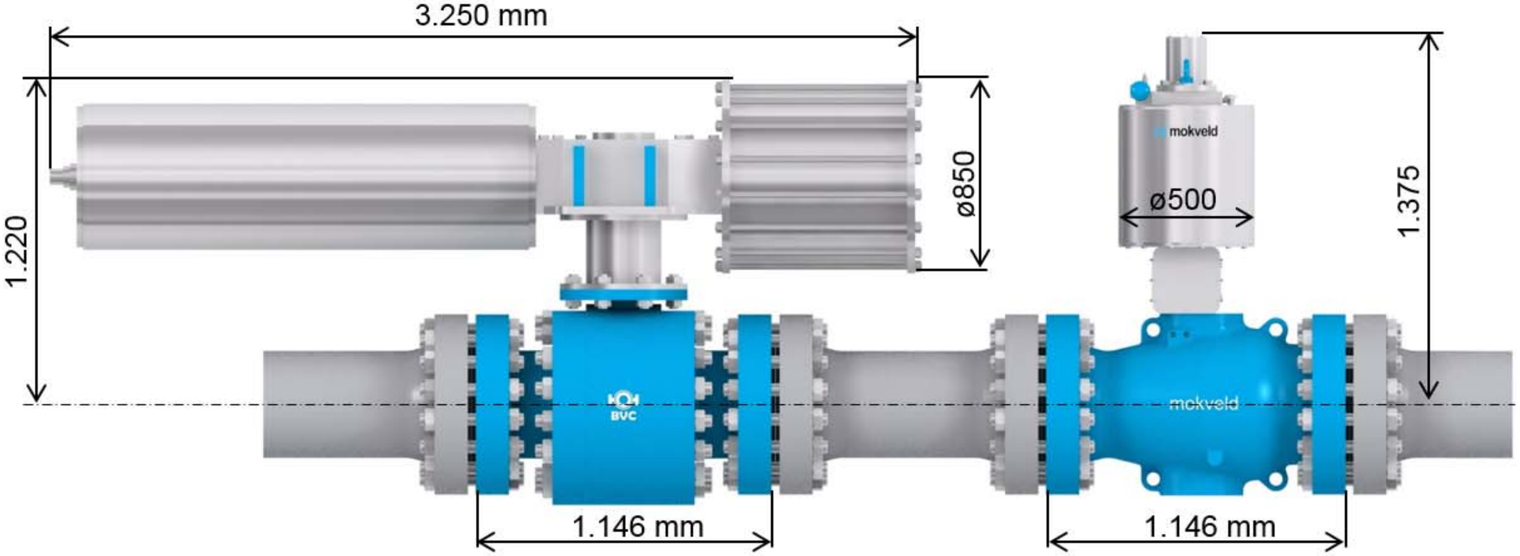


Ball valves: dependent on actuator orientation spool pieces, lengthy piping or skid mounting will be required.

Axial on-off valves can be bolted together and do not require any additional spool pieces, piping or skid mounting.

mokveld

Compact and low weight design



12" / ASME 1500 ball valve (3 pcs)
Pneum. scotch yoke act. (fail close)

Weight valve	= 1.800 kg
Weight actuator	= 2.000 kg +
Total	= 3.800 kg

12" / ASME 1500 axial on-off valve
Linear pneum. piston act. (fail close)

Weight valve	= 1.450 kg
Weight actuator	= 500 kg +
Total	= 1.950 kg

Factor 2 weight benefit and factor 2 improvement on Safety Factors (average)!

mokveld

HIPPS actuators

- Linear piston or quarter turn actuator
- integrated dampening
- pneumatic or hydraulic
- multiple parallel springs
- closed pedestal
- rugged design

mokveld

Final Elements/ actuators

- The IEC 61508 does not give the final elements the attention they deserve, the IEC 61511 already has more focus on this part of the loop.
- This is specifically required for fast acting safety loops (requiring shut-off within 2 seconds) in a low demand mode.
- The EN 12186 recognizes this and refers to the EN 14382 for the design of the final element

Final Elements/ actuators

The European standard EN 12186 (DIN G491) and more specific the EN 14382 (DIN 3381) has been used for many years in (mechanically) instrumented overpressure protection systems.

These standards prescribe the requirements for the over-pressure protection systems, and their components, in gas plants. Not only the response time and accuracy of the loop but also safety factors for over-sizing of the actuator of the final element are dictated by these standards. Independent design verification and testing to prove compliance to the EN 14382 standard is suggested..

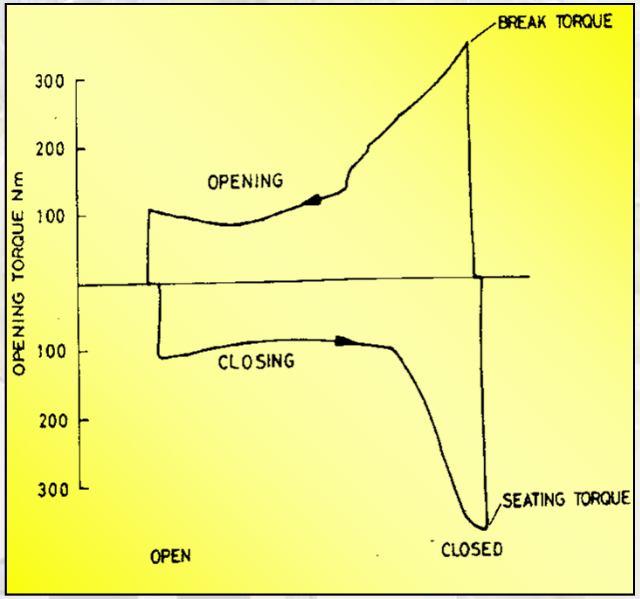
mokveld

Torque considerations

Torque on a trunnion ball valve is a function of:

(1) stem packing adjustment;
(2) spring tension on the seats;
(3) coefficient of sliding friction between the ball and the seating material;
(4) trunnion bearing friction;
(5) dP across the valve.

2,0x safety factor suggested.



mokveld

Torque considerations

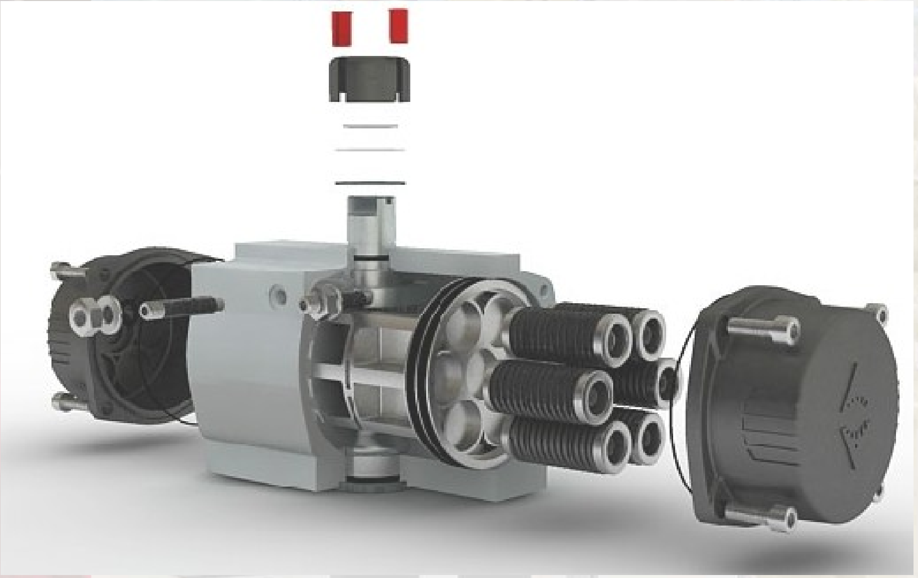
Workshop tests should simulate or otherwise be representative of:

- actual service in which the valve will be employed, i.e. gas service or liquid service
- maximum design differential pressures across the valve
- actual valve configurations i.e. seat type, stem extensions, etc.
- closure within specified time (speed of closure affects torque required).

Fail Safe function

The valve fail-safe function should be achieved by spring return actuators.

Other solutions such as operating pressure inside the valve or double acting piston actuators should only be considered if there are justifiable reasons not to use the spring return option.



mokveld

Required redundancy acc. IEC 61508 route 2_s

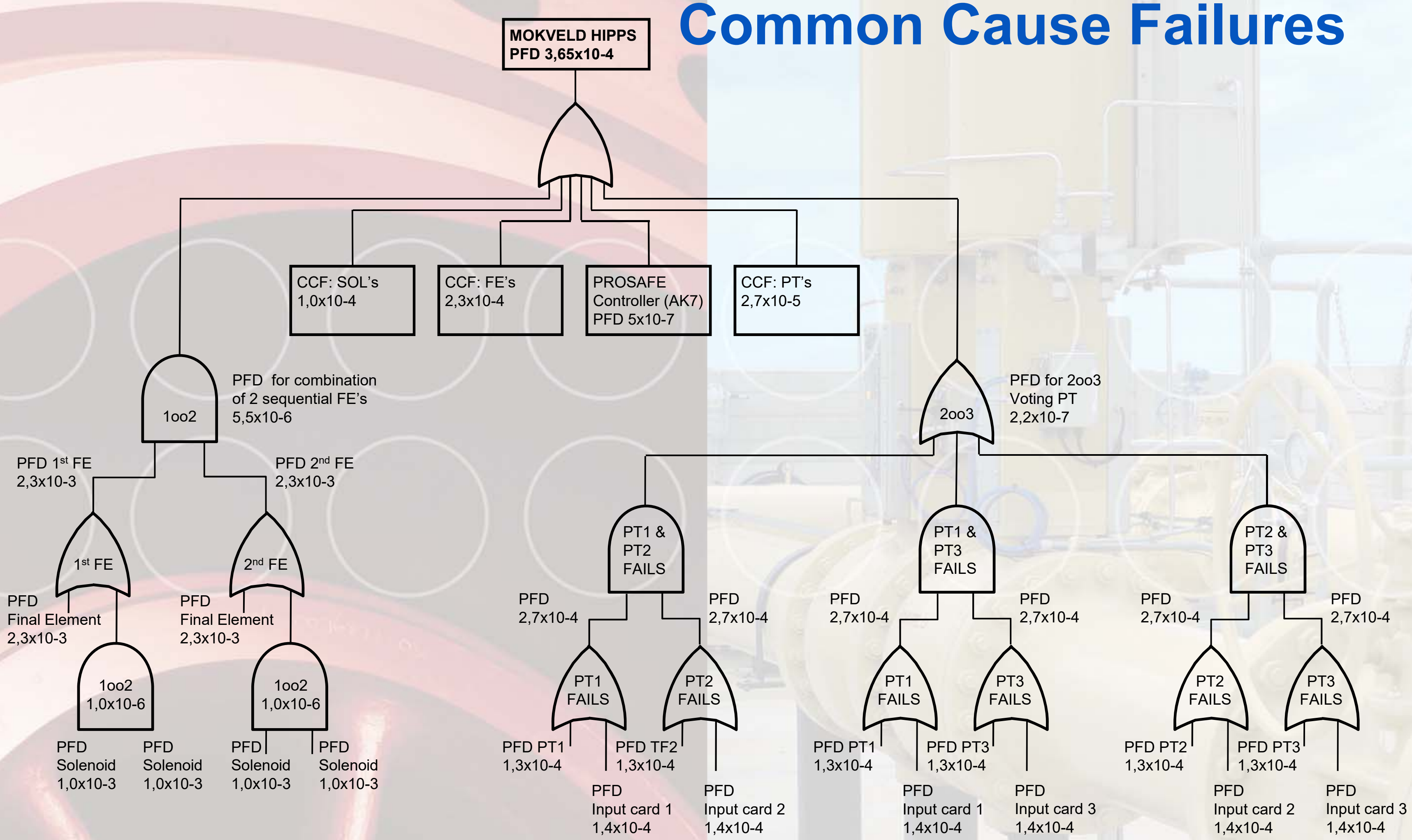
Safety Integrity Level	Architecture for final elements and sensors “proven in use”		Comments
SIL	**HWFT**	**Redundancy**	**For type A and B where for type B DC shall be > 60%**
1	0	1oo1	All cases
2	1	1oo2	High or Continuous mode
2	0	1oo1	Low demand mode <1 per year
3	1	1oo2	All cases
4	2 but should be avoided		

mokveld

Required redundancy according IEC 61511

Safety Integrity Level	Architecture for final elements and sensors		Architecture when “proven in use”	
SIL	**HWFT**	**Redundancy**	**HWFT**	**Redundancy**
1	0	1oo1	0	1oo1
2	1	1oo2	0	1oo1
3	2	1oo3	1	1oo2
4	Special requirements to IEC 61508			

Common Cause Failures



mokveld

Common Cause Failures

- modeled with β - factor
- CCF influenced by:
  - equipment selection
  - maintenance / commissioning
  - environment (external, internal / corrosion)
  - Physical separation
- IEC 61508: lower than 1% difficult to obtain
  IEC 61511: examples / typical 10%
- Identical equipment, same personnel min. 5%

Common Cause Failures

1) Within HIPPS: the use of identical sensors/final elements in a voting (e.g. 1oo2/2oo3) configuration has the advantage of simplifying procurement and maintenance activities, but will increase the potential for CMF

Common Cause Failures

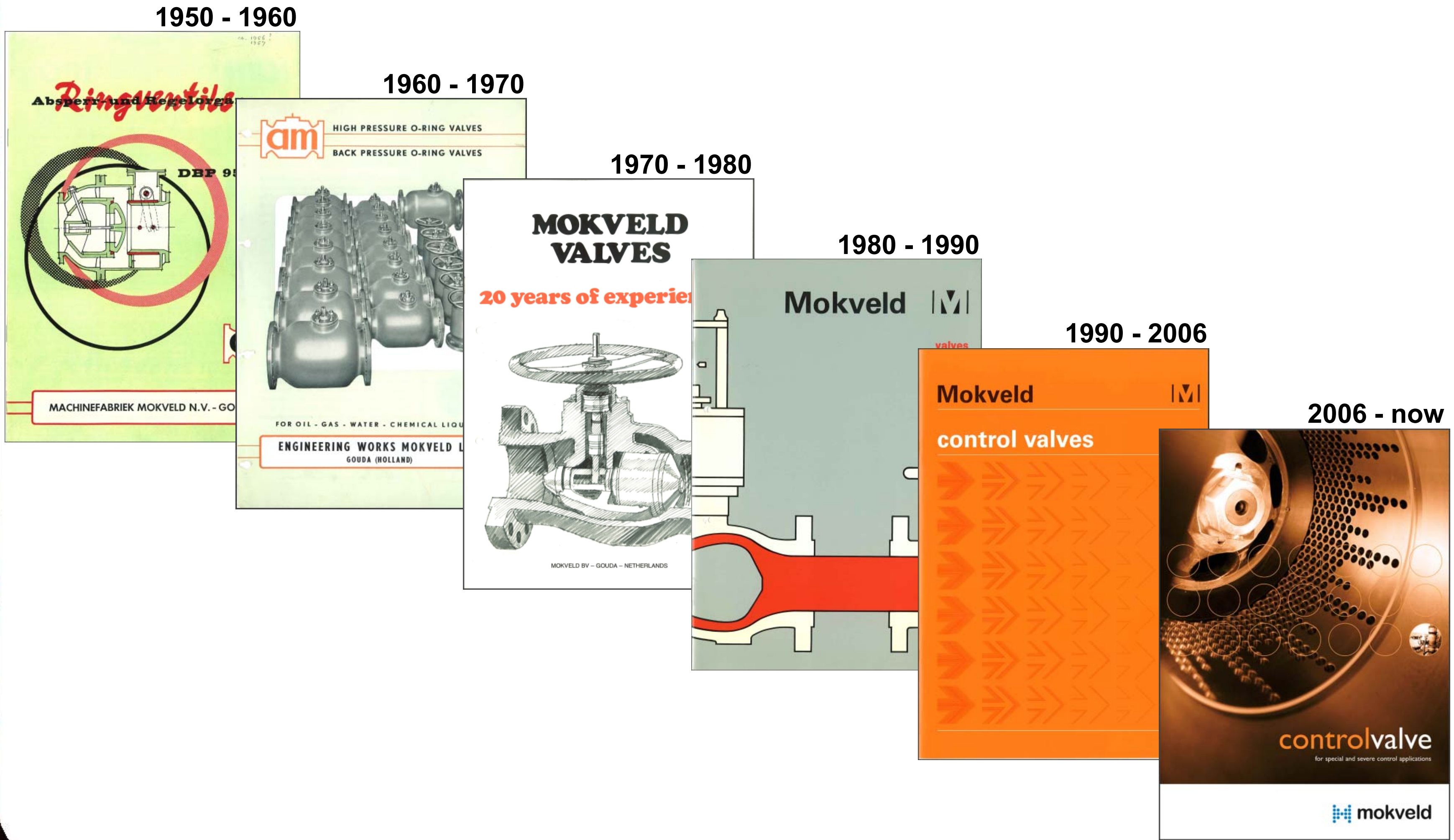
For SIL 3 (and below) HIPPS, it is usually acceptable to utilize identical sensing/final element devices, but for higher integrity service diverse (i.e. make/model) sensing and final element devices should be deployed.

At SIL 3, the potential benefits of diverse sensing and final element devices versus the potential detriment to system maintenance should be considered.

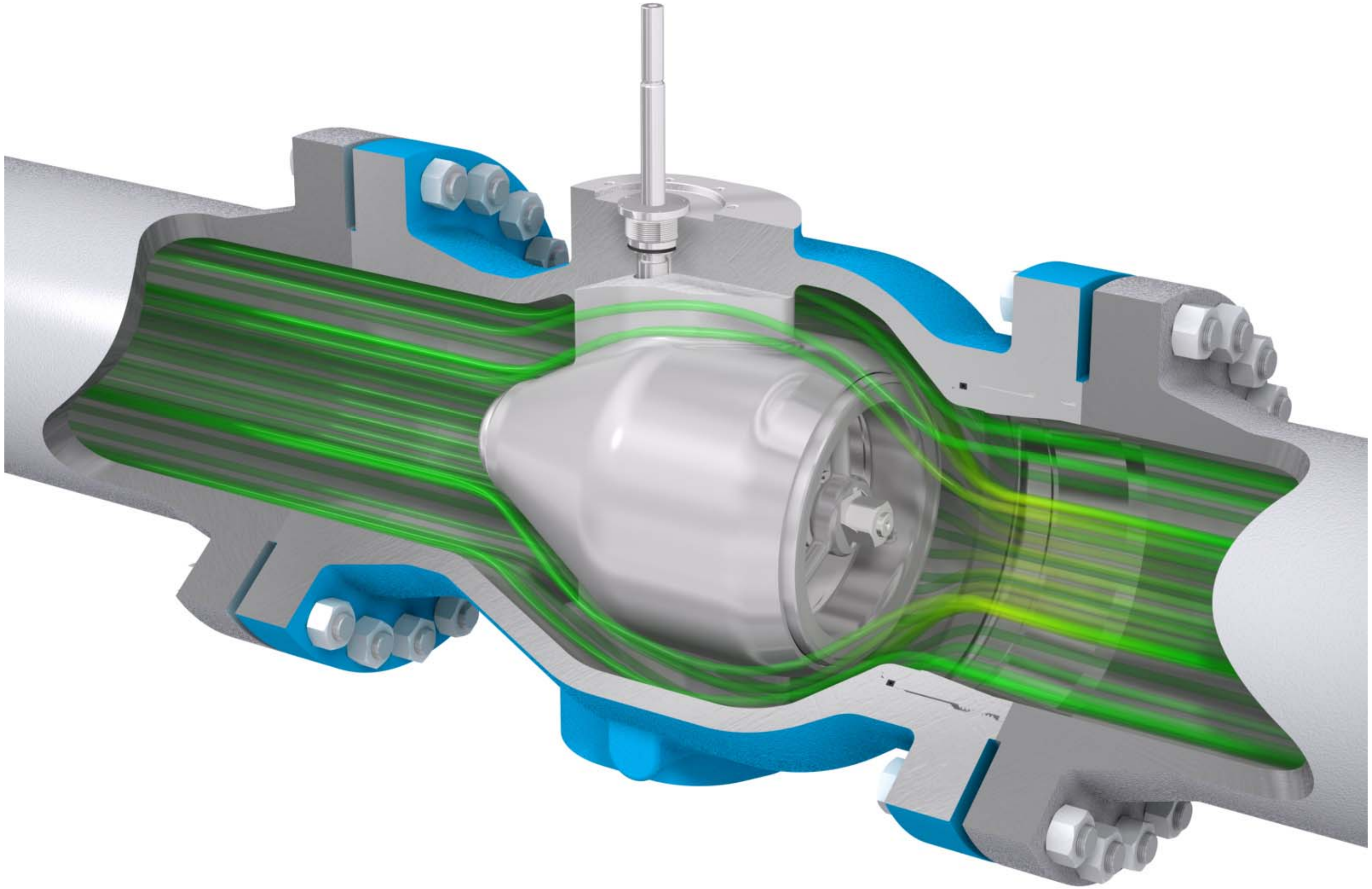
Common Cause Failures

2) Within other protection layers: if identical make and model of sensing and/ or final element is utilized for both the HIPPS and other protection layers, the potential for CMF between the HIPPS and other protection layers should be addressed.

Axial Flow – A Unique and Mature Design



Axial On-Off Valve



Axial Excellence

mokveld

Associazione Italiana Strumentisti

ISA Italy Section

mokveld

ORI srl