



Understanding Reliability Analysis of Valves in Terms of Functional Safety

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Objective

- ▶ The objective of this presentation is to give the audience an overview of important reliability aspects in terms of functional safety concerning valves (and actuators)

Contents

- ▶ Some questions
- ▶ Failure modes
- ▶ The importance of the safety function
- ▶ Reliability analysis of valves
- ▶ Some final thoughts

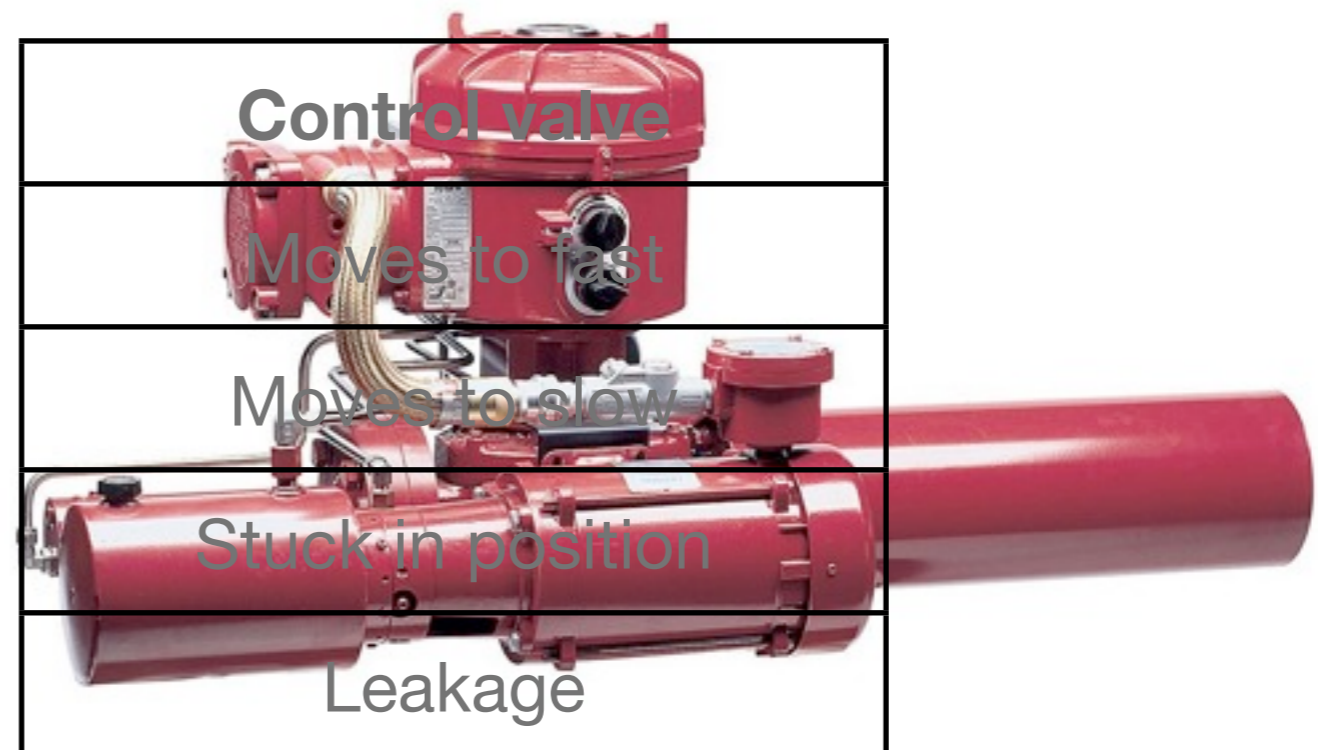
Some questions

- ▶ What are the most critical devices of a safety instrumented system?
- ▶ Why are they the most critical devices?
- ▶ Why do we apply proof (e.g. valve stroke) testing?
- ▶ What is better full stroke testing or partial stroke testing?
- ▶ Can proof testing reveal all failure modes of a valve?
- ▶ What should we do if a proof test reveals a valve failure?

Failure modes

- ▶ What are typical failure modes of a valve?

Safety valve
Stuck open
Stuck close
Stuck in position
Leakage



- ▶ Which of these failure modes are dangerous and which are safe?

Safe or Dangerous? That is the question...

- ▶ From a functional safety point of view valves can typically have 3 kinds of failures
 - ▶ Dangerous failures
 - ▶ Safe failures
 - ▶ Don't care or no effect failures



Dangerous failures

- ▶ When is a valve failure a dangerous failure?
 - ▶ When the safety function of the valve cannot be carried out upon on demand from the process
 - ▶ For example: A shutdown valve which cannot close up on demand

Safe failures

- ▶ When is a valve failure a safe failure?
 - ▶ When the safety function of a valve is carried out without a demand from the process
 - ▶ For example: A blowdown valve which opens without a demand

Don't care failures

- ▶ When is a valve failure a don't care failure?
 - ▶ When a failure occurs that does not effect the safety function of the valve
 - ▶ For example: A shutdown valve that can only open 99% instead of 100% but can still close up on demand
 - ▶ Or, the name plate that falls of the valve

Safety Function

- ▶ Thus, whether a failure mode is safe or dangerous depends on the safety function that is actually carried out with the valve
- ▶ One of the most underestimated but most important aspects in the functional safety world is the definition of the safety function
 - ▶ Each safety loop has a safety function
 - ▶ Each device used in the safety loop has its own safety function

Safety function on loop and device level

- ▶ Example on loop level
 - ▶ Measure the pressure in the vessel and when the pressure exceeds 3 bar stop the supply flow and drain the material in the tank. Perform this function within 5 seconds and on SIL 3 level
- ▶ Example on device level
 - ▶ Measure the temperature with an accuracy of $\pm 2\%$ and provide the correct output current within 100ms. If an internal failure is detected drive the output current out of range according to user settings. Perform this function on SIL 2 level
- ▶ Example on valve (and actuator) level
 - ▶ Upon demand close the valve 100% within 4 seconds, perform this function on SIL 2 level

Failure modes

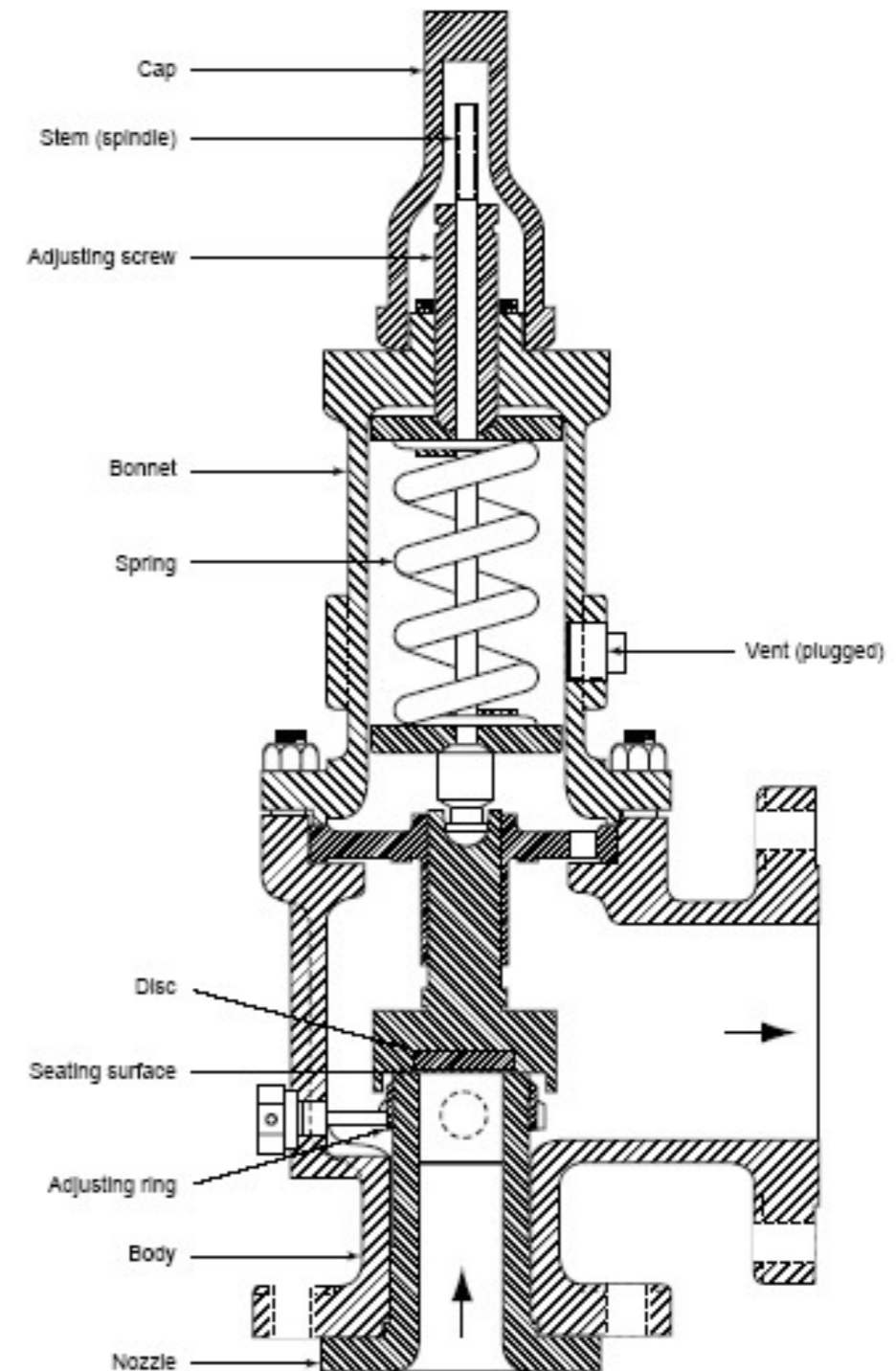
Failure mode	Close 100% upon demand	Open 100% upon demand
Stuck open	Dangerous	Safe
Stuck close	Safe	Dangerous
Stuck in position	Dangerous	Dangerous
Leakage	Dangerous	Don't care

Safety Availability versus Plant Availability

Failure mode valve	Safety system	Plant
Dangerous	Unavailable	Available but not protected
Safe	Causes a trip	Unavailable
Don't care	No effect	Most of the time no effect

Reliability analysis

- ▶ Reliability analysis from a functional safety point of view includes:
 - ▶ Failure mode and effect analysis FMEA or FMDEA
 - ▶ Reliability model
 - ▶ Data



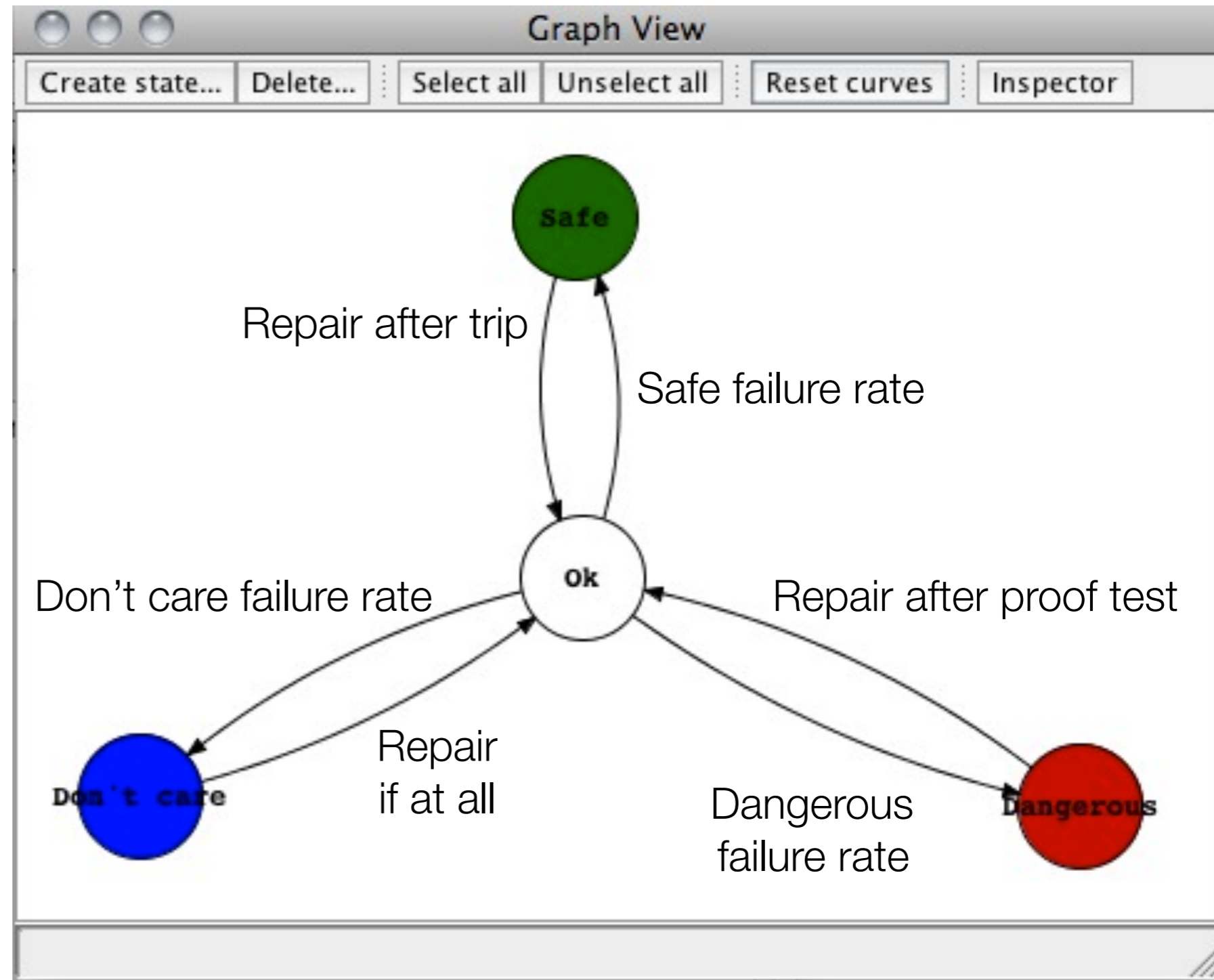
Failure mode and effect analysis

- ▶ Single failure mode analysis technique
- ▶ Helps record failure rates
- ▶ Important technique to understand the coverage of proof testing

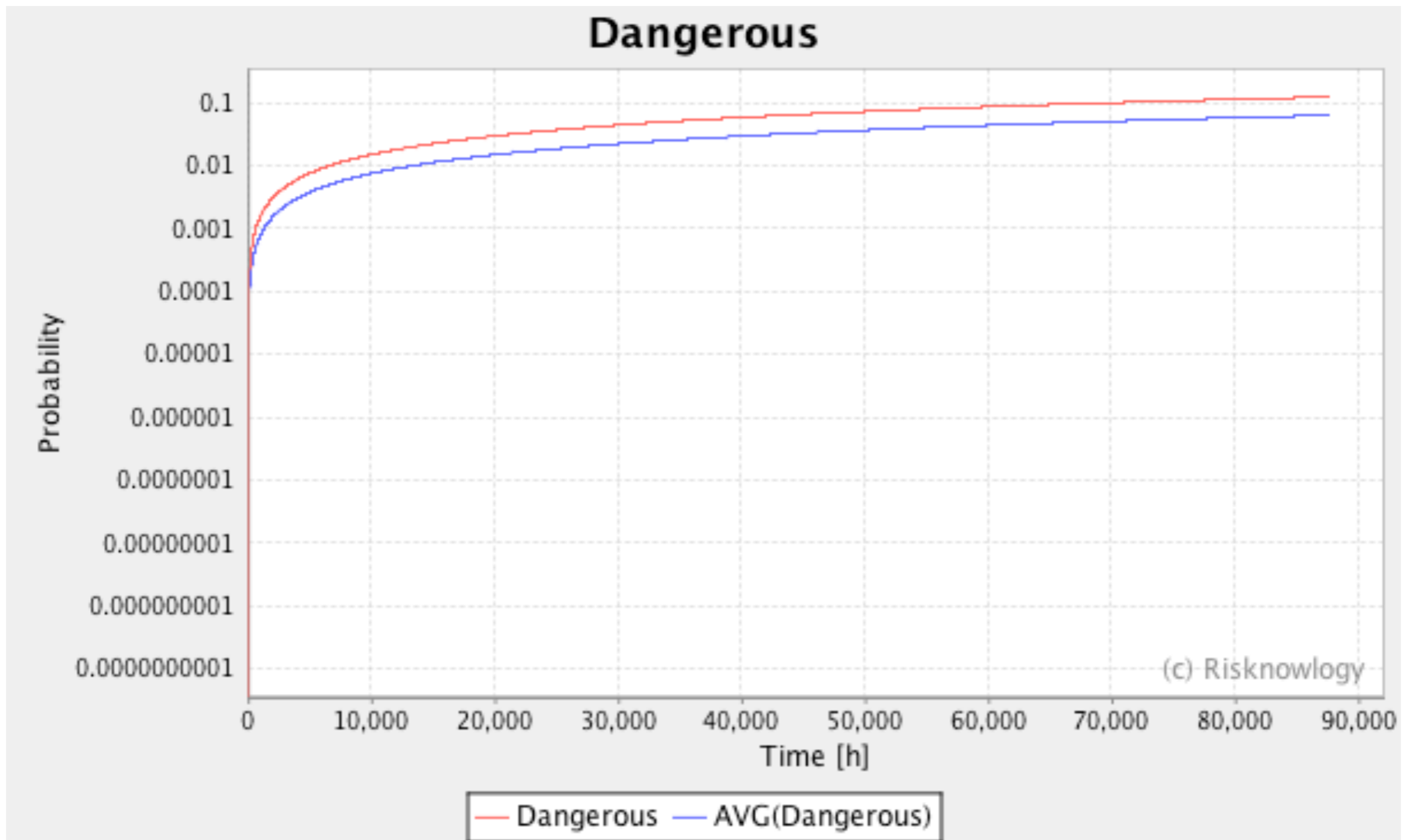
Pos	P/N	Name	Qty	Failure Mode	Effect safety function
1	T61-2224	ADAPTOR	1	Failure to replace with goose neck	None
2	T44-3692	AQ PISTON SEAL 225.0MM OD	1	Leakage	Allow hydraulic pressure leakage into compensator system causing ST (Spurious Trip)
3	T44-3693	AQ ROD SEAL 50.0MM ID	2	Leakage	Allow hydraulic pressure leakage into compensator system causing ST
4	T33219-56	BEARING HOUSING	1	Structural failure	None
			1	Structural failure due to over torque	Valve locked in open position, cant move to safe state
5	T33219-61	BLANK PLUG	2	Leakage due to use	Allow hydraulic pressure leakage into Environment causing ST
			2	Leakage due to incorrect assembly	Allow hydraulic pressure leakage into Environment
6	T33219-47	BLANK PLUG	3	Leakage due to use	Seawater ingress into spring chamber leading to corrosion and jamming of valve. Valve cant move to safe state
			3	Leakage due to incorrect assembly	Seawater ingress into spring chamber leading to corrosion and jamming of valve. Valve cant move to safe state
7	T34107-01-1	BODY	1	Leakage Past Seat Ring	Pressure build up downstream over time causing failure of equipment >2mmscf

Reliability Model - 1oo1 Valve

- ▶ Reliability models are required to make calculations
 - ▶ PFD
 - ▶ PFS
 - ▶ Availability



Calculations



Some Final Thoughts

- ▶ Valves used for safety have basically 3 different failures
 - ▶ Dangerous
 - ▶ Safe
 - ▶ Don't care
- ▶ Whether a valves fails dangerous or safe depends on the safety function that is actually carried out with the valve
- ▶ In order to make reliability calculations we need
 - ▶ An FMEDA
 - ▶ A Reliability model, and
 - ▶ Data

Some final thoughts

- ▶ Numbers are nice... but in the end the valve just needs to work, no number can guarantee you that, but what is helpful is
 - ▶ Good maintenance
 - ▶ Proper repair
 - ▶ Periodic testing
 - ▶ Common sense
 - ▶ Valve diagnoses

Thank you for your attention



Further information

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