
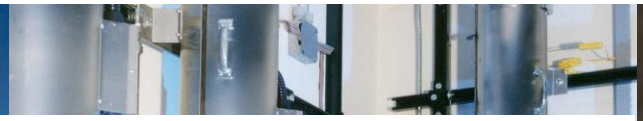


Safety Requirements

FOR FURNACE FUEL HANDLING SYSTEMS


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Safety requirements
Topics of the presentation

- “Valve proving” of fuel gas ESD valves
- Architecture of fuel gas ESD valves

Safety requirements
What can happen !!!

Here's What Happened:

This heater was severely damaged during start up as a result of a fire box explosion. The operator had some difficulty with the instrumentation and decided to complete the start up by bypassing the interlocks. This allowed the fuel line to be commissioned with the pilots out. The main gas valve was opened and gas filled the heater. Then… ***K A B O O M***, the heater exploded destroying the casing and damaging several tubes. Fortunately, no one was injured.

Why Did this Happen?

The operator thought that he could speed up the job by shortcutting some of the "unnecessary" things in the start up procedure. He misjudged the importance of the interlocks. He thought they could be by-passed…***just this one time***, but he was wrong. **They were important …… this time and every time!**

CCPS
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Process Safety Beacon

Sponsored by AIChE

Source: Process Safety Beacon June 2003

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Safety requirements
Application of this presentation

- Ethylene Cracking Furnace and Steam Methane Reformer
- Scheduled shutdowns every 1 to 4 years
- 50 to 150 burners each with 0.5 to 3 MWatt heat release

Safety requirements
International standards

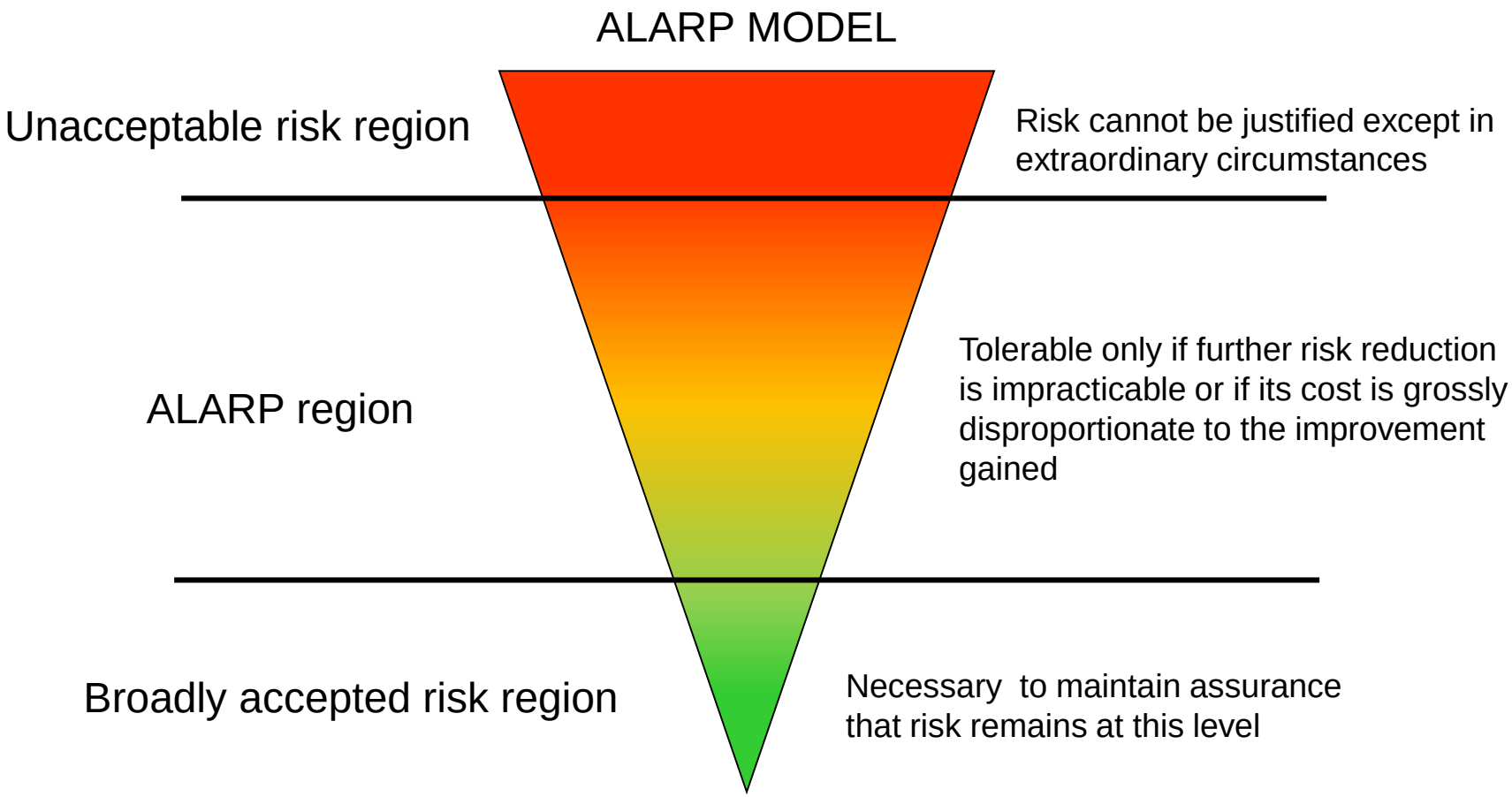
Standard	Description
EN 746-2	Safety requirements for combustion and fuel handling systems
ISO 13577	Industrial furnaces and associated processing equipment - Safety
NFPA 85	Boiler and combustion systems hazards code
NFPA 86	Standard for ovens and furnaces
NFPA 87	Recommended practice for fluid heaters
API 556	Instrumentation, control, and protective systems for gas fired heaters
API 560 / ISO 13705	Fired heaters for general refinery service
IEC 61511	Safety instrumented systems for the process industry sector

Safety requirements
Scope of international standards

- Can be limited to steam boilers only
- Can exclude cracking furnaces and steam methane reformers
- Includes safety requirements for combustion process only

(does not include hazards resulting from fluid to be heated)

Safety requirements
Risk, As Low As Reasonably Practical (ALARP)



Source: IEC 61508-5

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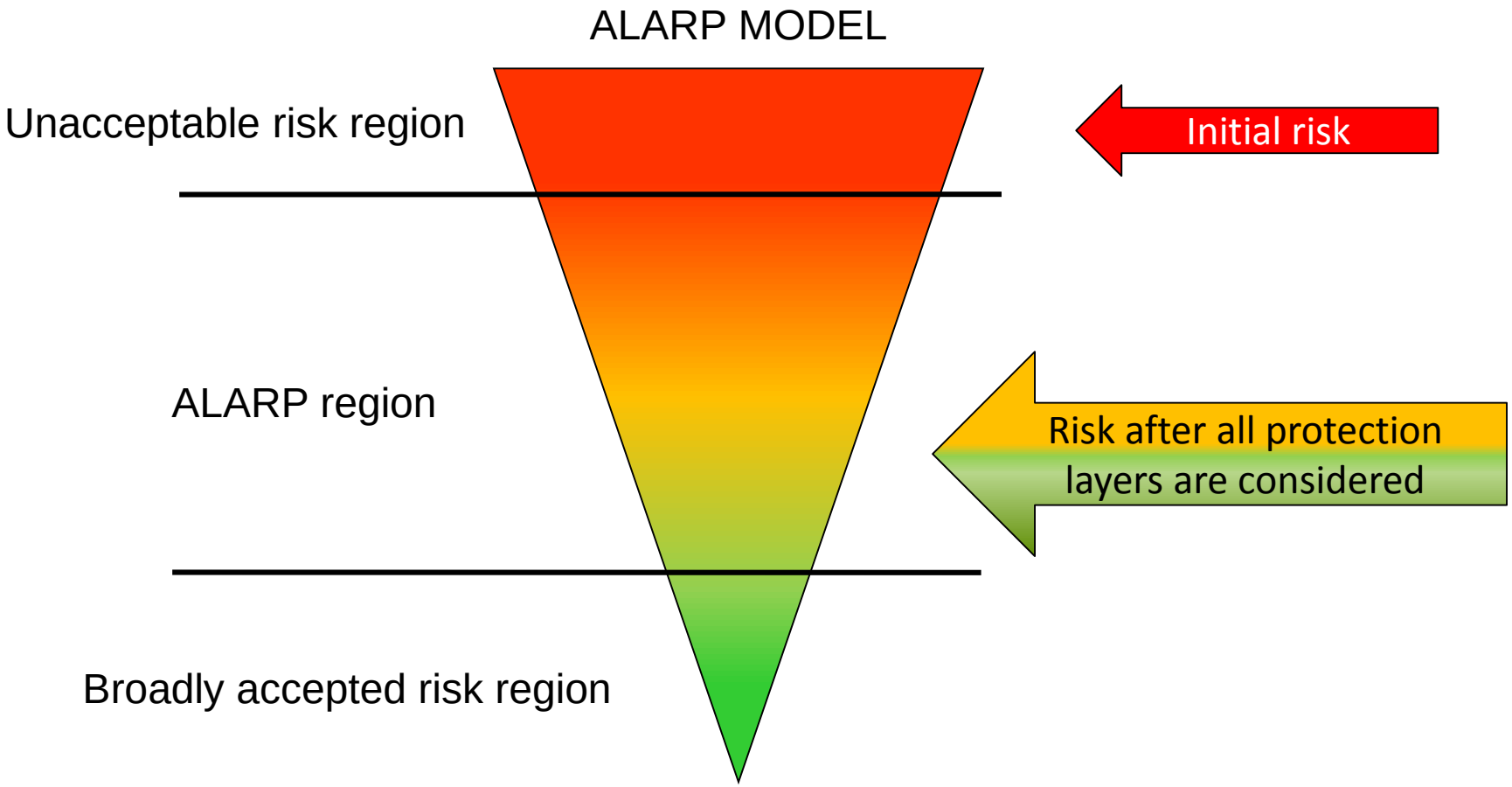
Safety requirements
Risk, As Low As Reasonably Practical (ALARP)



Source: IEC 61508-5

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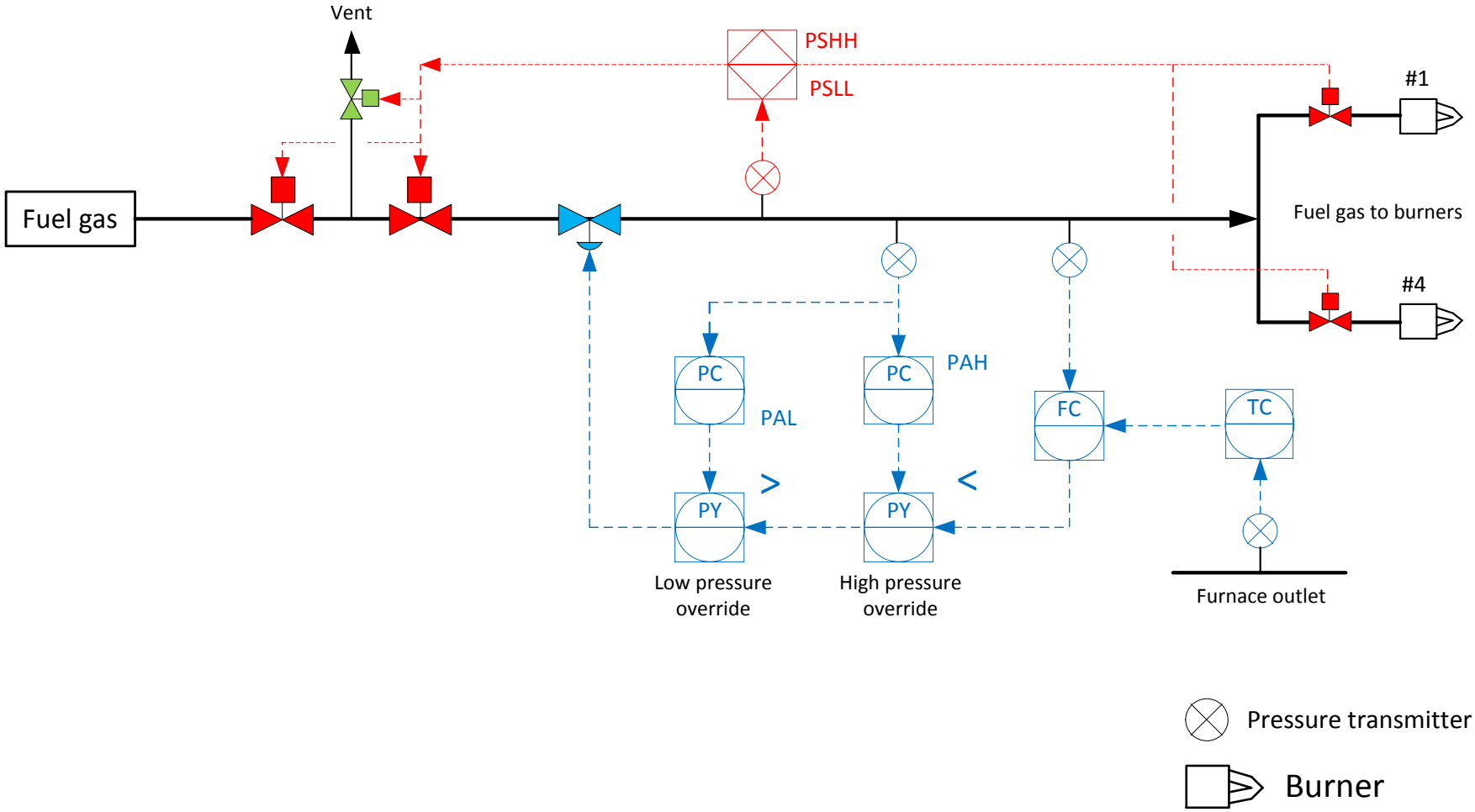
Safety requirements
Typical fuel supply system



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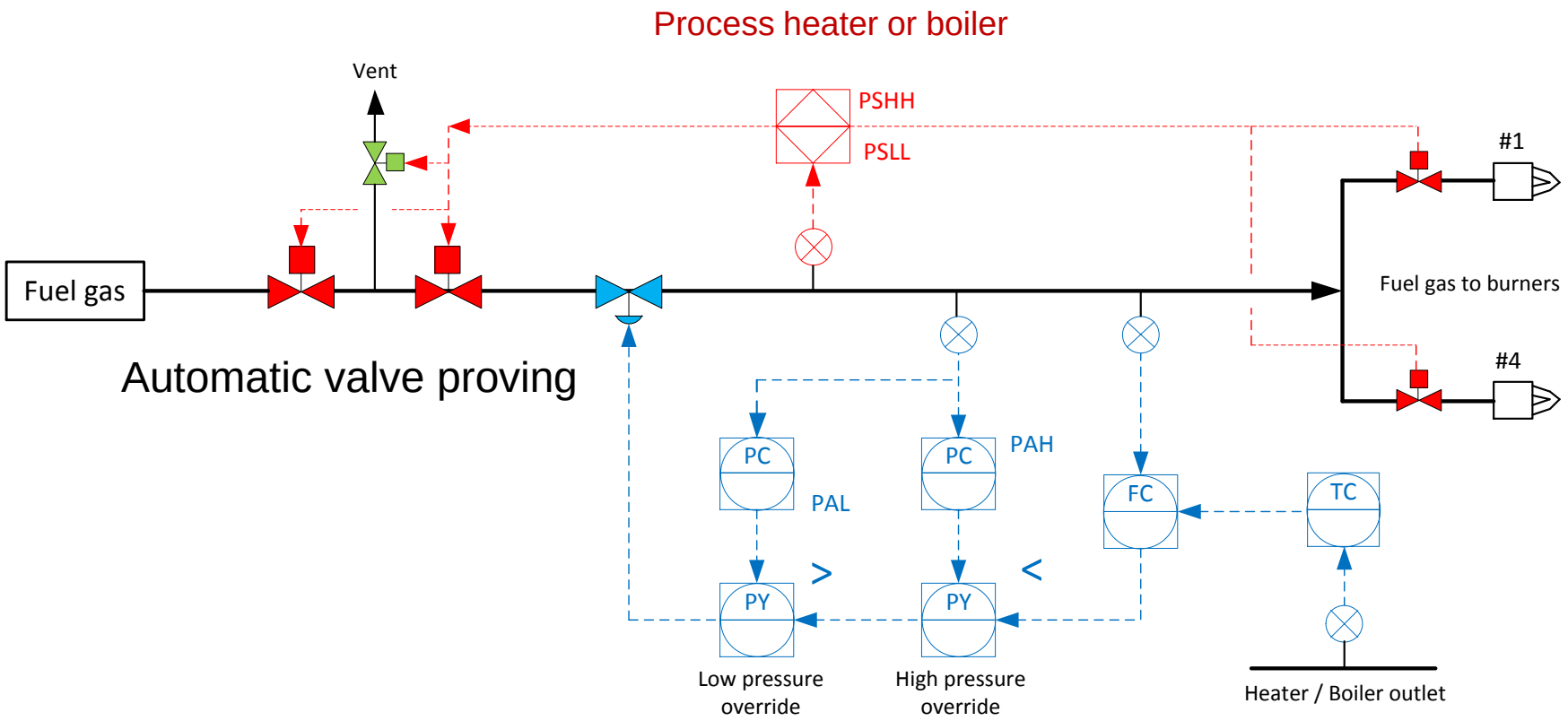
Safety requirement
Requirements for valve proving

EN 746-2 Automatic shut-off valves controlling capacities greater than 1,200 kW shall be equipped with a valve proving system in compliance with EN 1643 or give an equivalent level of safety.

ISO 13577-2 Automatic shut-off valves controlling capacities higher than 1,200 kW shall be proved closed at each start-up of the TPE.

For a TPE intended to be started up more than two times a year, the automatic shut-off valve(s) shall be proved closed by an automatic system.

Safety requirements
Typical fuel supply system

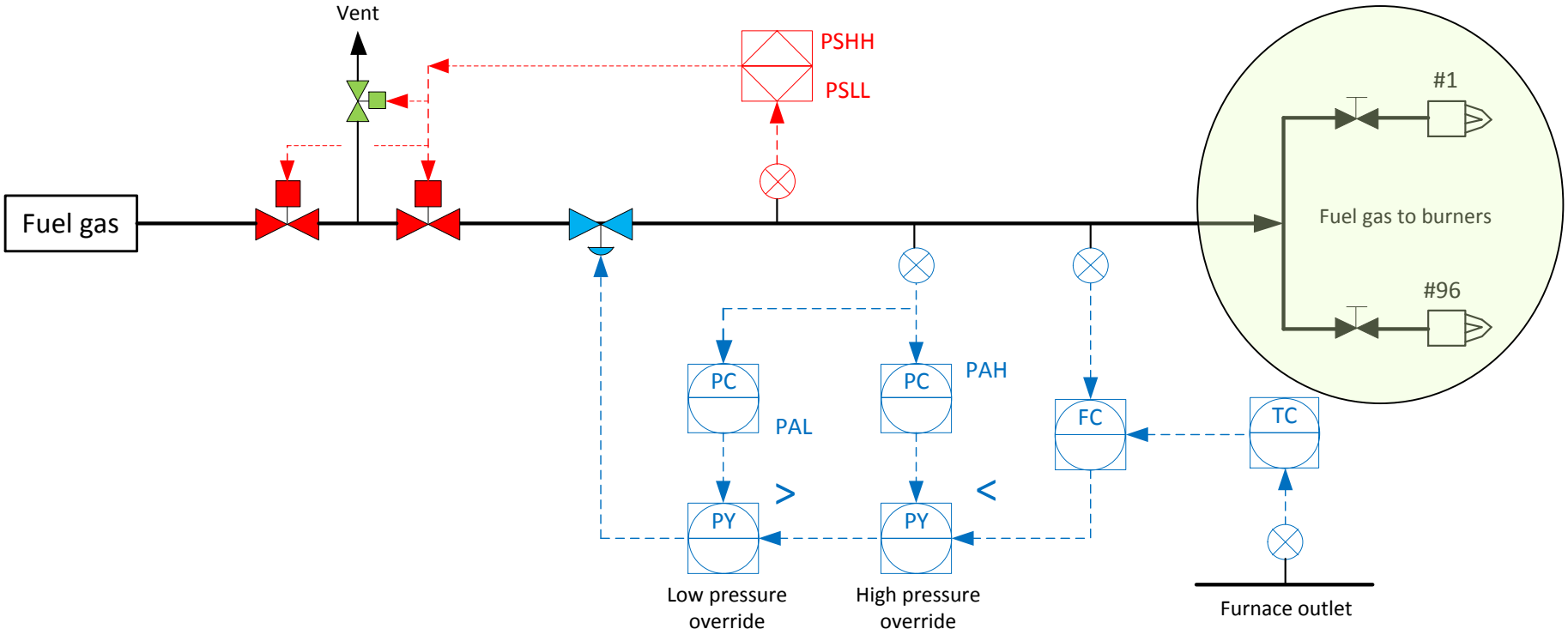


Burners with automatic ignition (e.g. pilot burners) and flame detectors.

Before ignition is permitted, the combustion chamber has to be purged with fresh air !!

Safety requirements
Typical fuel supply system

REFORMER & CRACKING FURNACE



Burners with manual ignition – NO flame detectors.

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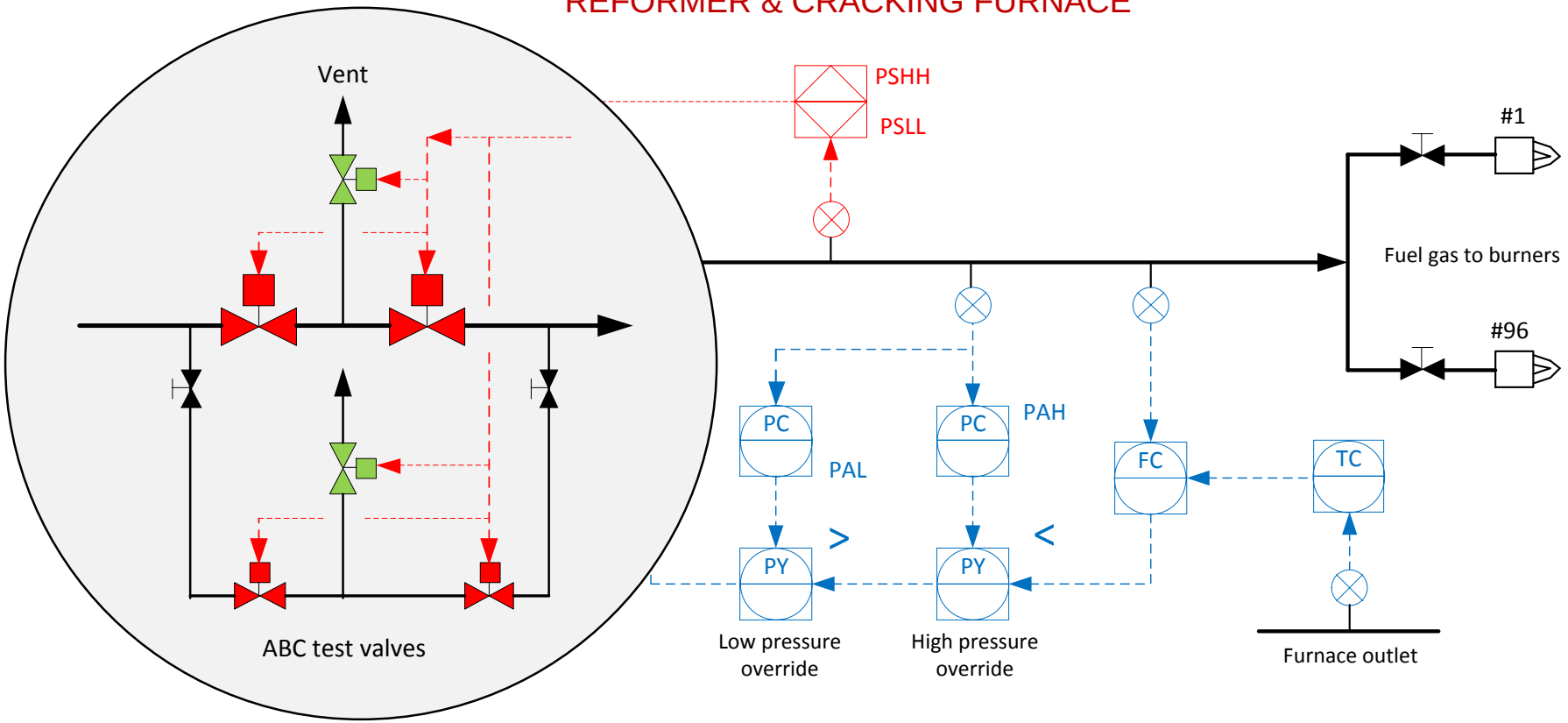
Safety requirements
All Burner Closed (ABC) test

REFORMER & CRACKING FURNACE



Burners with manual ignition – NO flame detectors.

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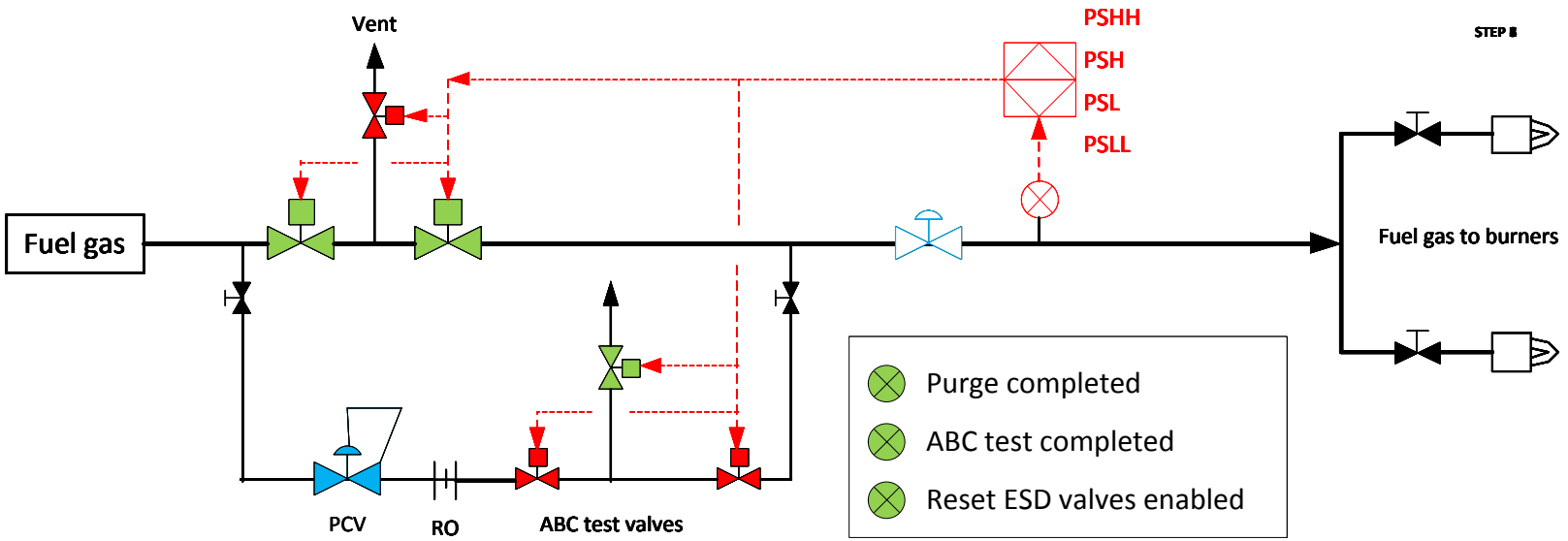
Safety requirements
All Burner Closed (ABC) test

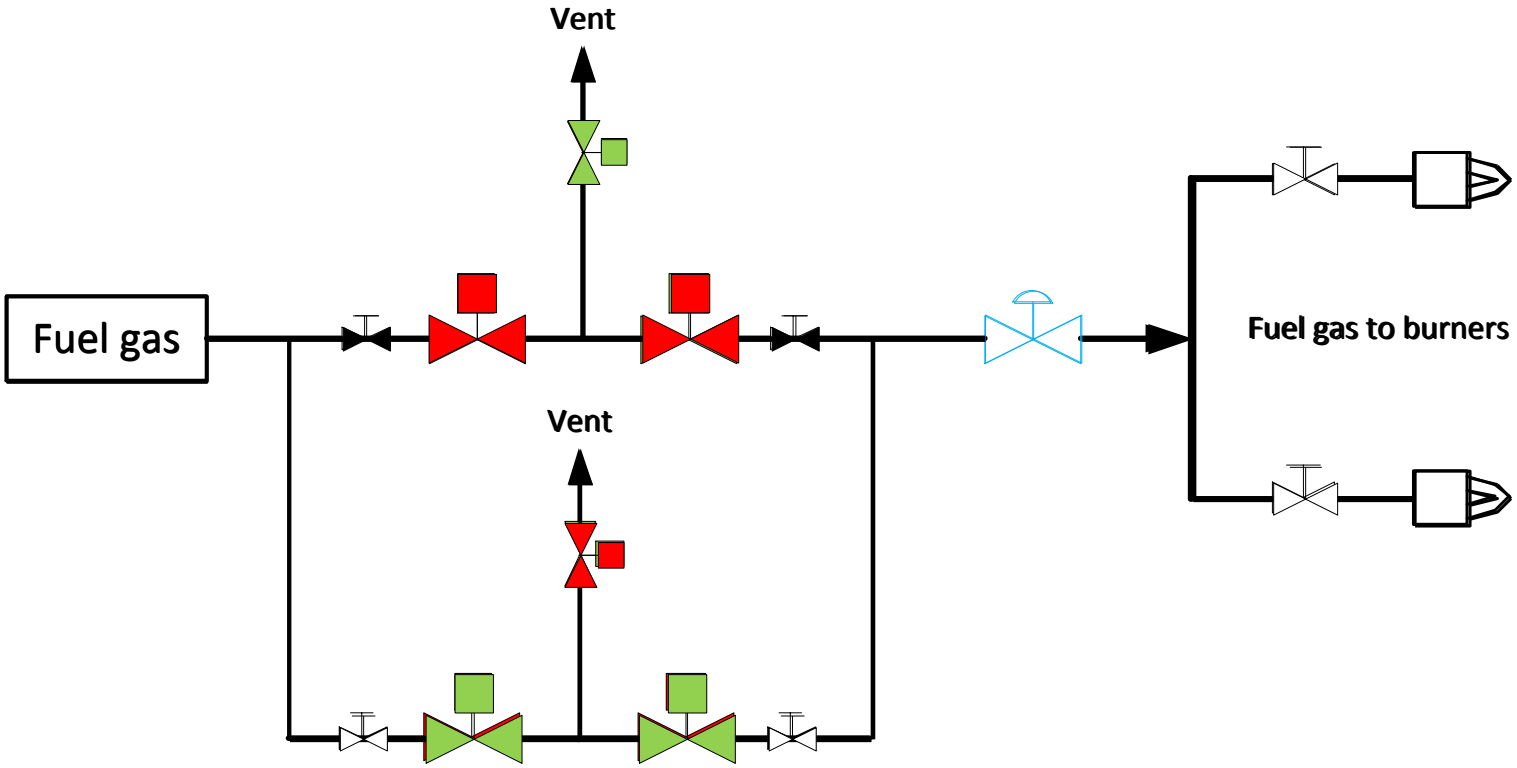


Safety requirements
Fuel gas ESD valve architecture requirements

EN 746-2 Low cycling applications intended to operate continuously for periods longer than 1 year shall have a redundant safety shut-off that allows testing the effective closure of the valves at least once a year.

ISO 13577-4 Except as permitted by method D, the testing of all safety functions shall be performed at least annually. Method D shall be used if the testing of all safety functions is performed beyond 1 year.

Safety requirements
Redundant fuel gas ESD valves EN 746-2



Note: Valves for ABC test are not shown

Safety requirements
ISO 13577-4, method D

[…]

Each functional safety requirement, as identified in ISO 13577, shall be evaluated for its need in accordance with the standards, such as IEC 61511, ISO 13849-1:2006, and IEC 62061, and implemented with the required SIL for each function.

[…]

NOTE An extended risk assessment in Method D can take precedence over the safety requirements in ISO 13577. By nature of the extended risk assessment under Method D, the overall safety is not reduced and meets or exceeds the intended requirements of ISO 13577.

HAZOP STUDY

LAYER OF PROTECTION ANALYSIS

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Safety requirements
Safety assessment Hazop study and LOPA

A Hazop study will list all hazardous scenario's

Safeguards, e.g Safety Instrumented Functions will be identified

A LOPA will determine the required strength of a SIF

This strength is expressed as a Safety Integrity Level

SIL	PFDavg	Risk Reduction
4	≥ 10^{-5} to < 10^{-4}	> 1,0000 – ≤ 100,000
3	≥ 10-4 to < 10-3	> 1,000 – ≤ 10,000
2	≥ 10^{-3} to < 10^{-2}	> 100 – ≤ 1,000
1	≥ 10^{-2} to < 10^{-1}	> 10 - ≤ 100

Hazop = Hazard and Operability LOPA = Layer Of Protection Analysis

Safety requirements
Safety Instrumented Function (SIF)

INITIATORS

LOGIC SOLVER

FINAL ELEMENT

SAFETY INSTRUMENTED FUNCTION (SIF)

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Safety requirements
SIF requirements

- Systematic capability
- Hardware fault tolerance (voting architecture e.g. 1oo2)
- Probability of failure on demand (PFDavg)

FOR SIL 2

- SC = 2
- HFT = 0 (1oo1)
- PFDavg < 1/100

FOR SIL 3

- SC = 3
- HFT = 1 (1oo2)
- PFDavg < 1/1000

Note: Ti (test interval) is one of the variables that determines the PFDavg

Safety requirements
SIF comparison for variable test interval

γDU = 600 (valve) γDU = 40 (transmitter)

Device	Voting	ß	Ti	PFDavg	RR
Transmitter	2oo3	4 %	3 year	$4.32E^{-5}$	23,000
Valve	1oo2	3 %	2 years	$1.95E^{-4}$	5,000
Loop				$2.48E^{-4}$	4,000

Device	Voting	ß	Ti	PFDavg	RR
Transmitter	2oo3	4 %	3 year	$4.32E^{-5}$	23,000
Valve	1oo2	3 %	4 years	$4.6E^{-4}$	2,000
Loop				$5.03E^{-4}$	2,000

SIL	PFDavg	Risk Reduction
3	≥ 10-4 to < 10-3	> 1,000 – ≤ 10,000
2	≥ 10^{-3} to < 10^{-2}	> 100 – ≤ 1,000

In this example it is assumed that the PFD_{avg} of the logic solver is $1E^{-5}$

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Safety requirements
Fuel gas ESD valve architecture requirements

EN 746-2 Test interval full stroke test — Ti = 1 year

ISO 13577-4 Using method D, Hazop study followed by LOPA, test interval full stroke test — Ti = 3 to 4 years

Safety requirements
Summary and conclusions

- Compliance only with a standard may not be sufficient to ensure an acceptable safety level (ALARP)
- Standards may not cover / address all scenarios
- Additional safety assessments may require additional measures but can also justify less stringent implementation compared to the standard(s)

Switching between cracking and decoking

QUESTIONS ?

Thank you

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take it further®