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# Introduction to Process Safety Engineering

## *Lessons learned from incidents*

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# 8 Safety Functions for a Chemical Plant

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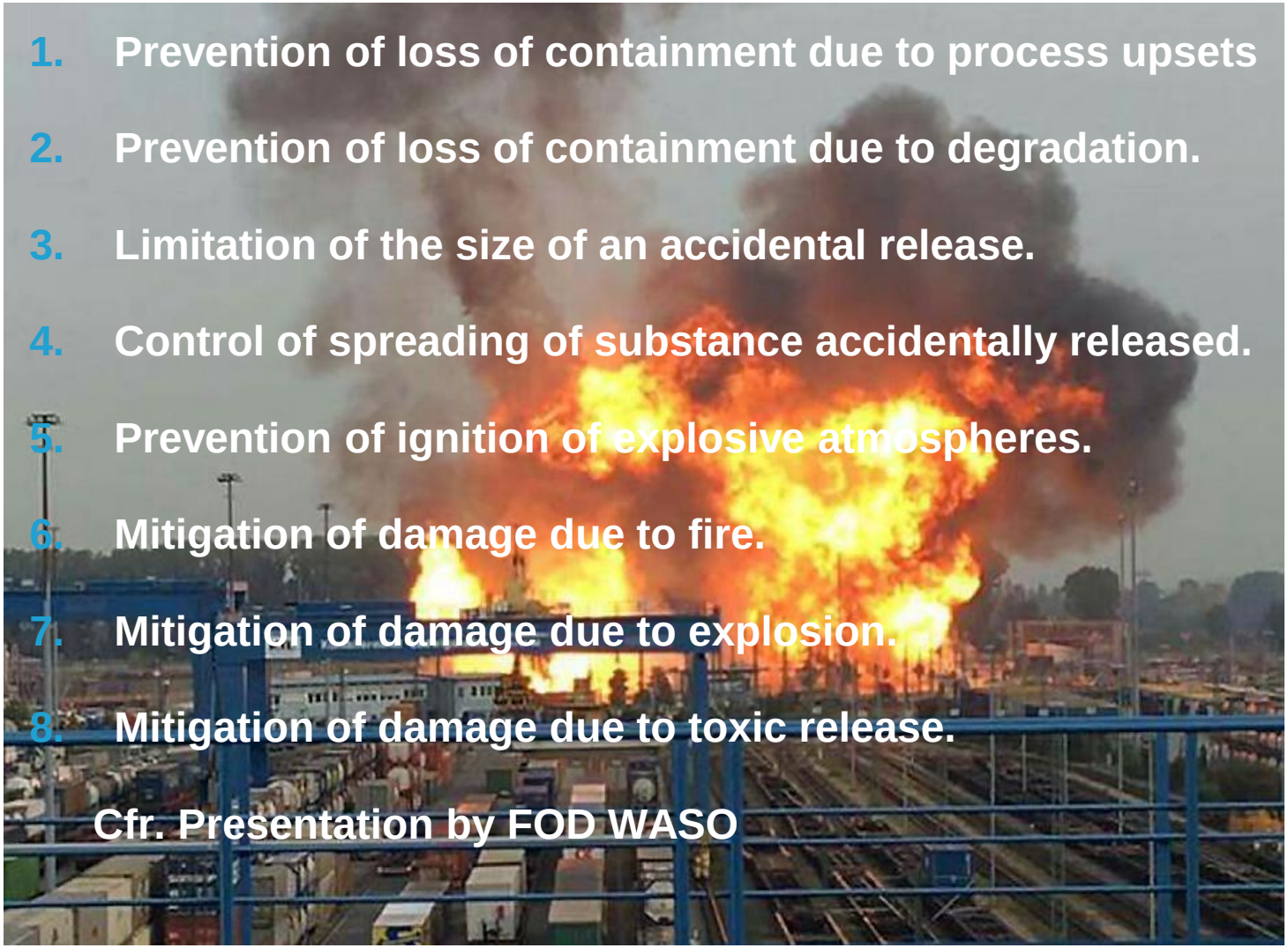
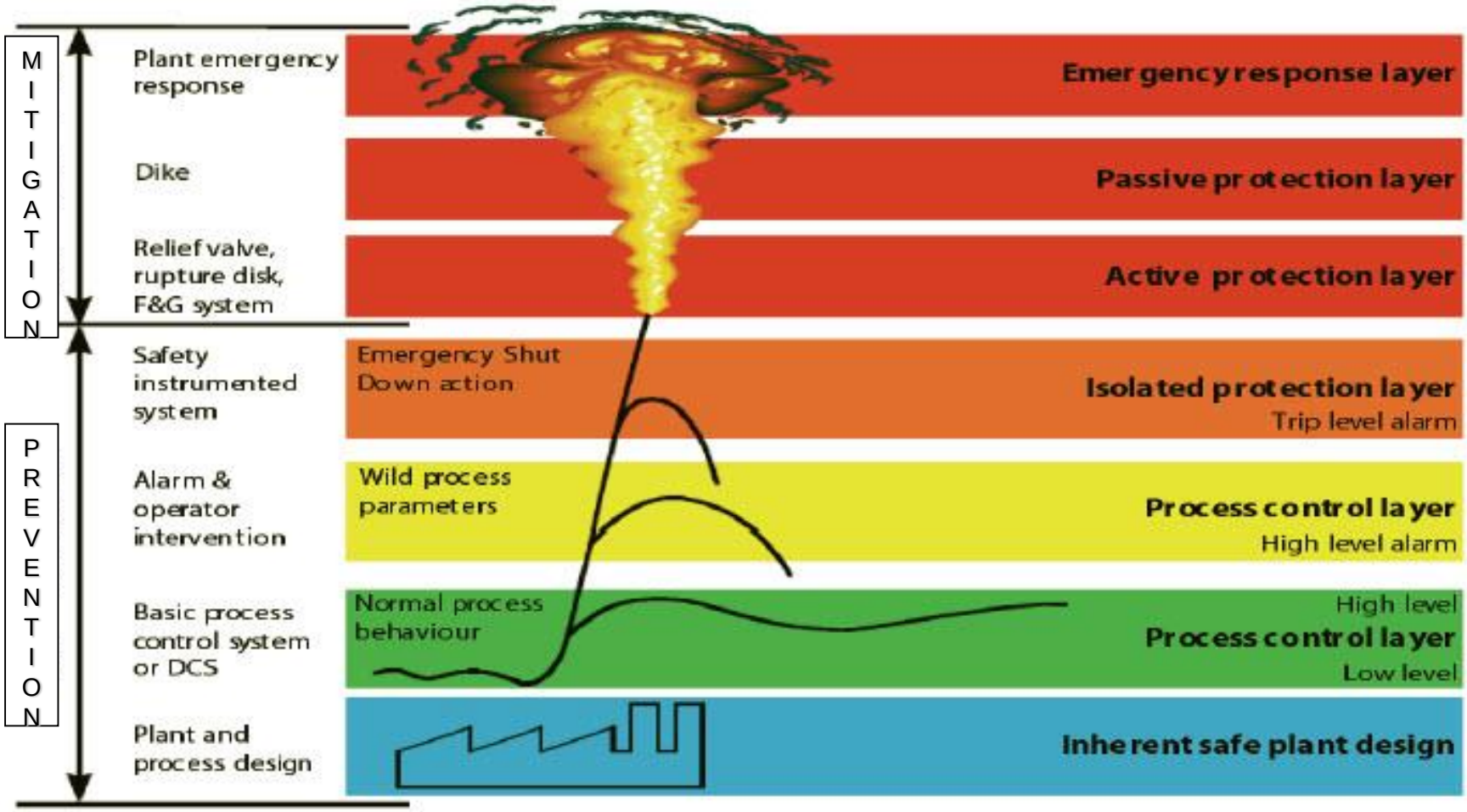


1. Prevention of loss of containment due to process upsets
2. Prevention of loss of containment due to degradation.
3. Limitation of the size of an accidental release.
4. Control of spreading of substance accidentally released.
5. Prevention of ignition of explosive atmospheres.
6. Mitigation of damage due to fire.
7. Mitigation of damage due to explosion.
8. Mitigation of damage due to toxic release.

Cfr. Presentation by FOD WASO

# Layers of Protection



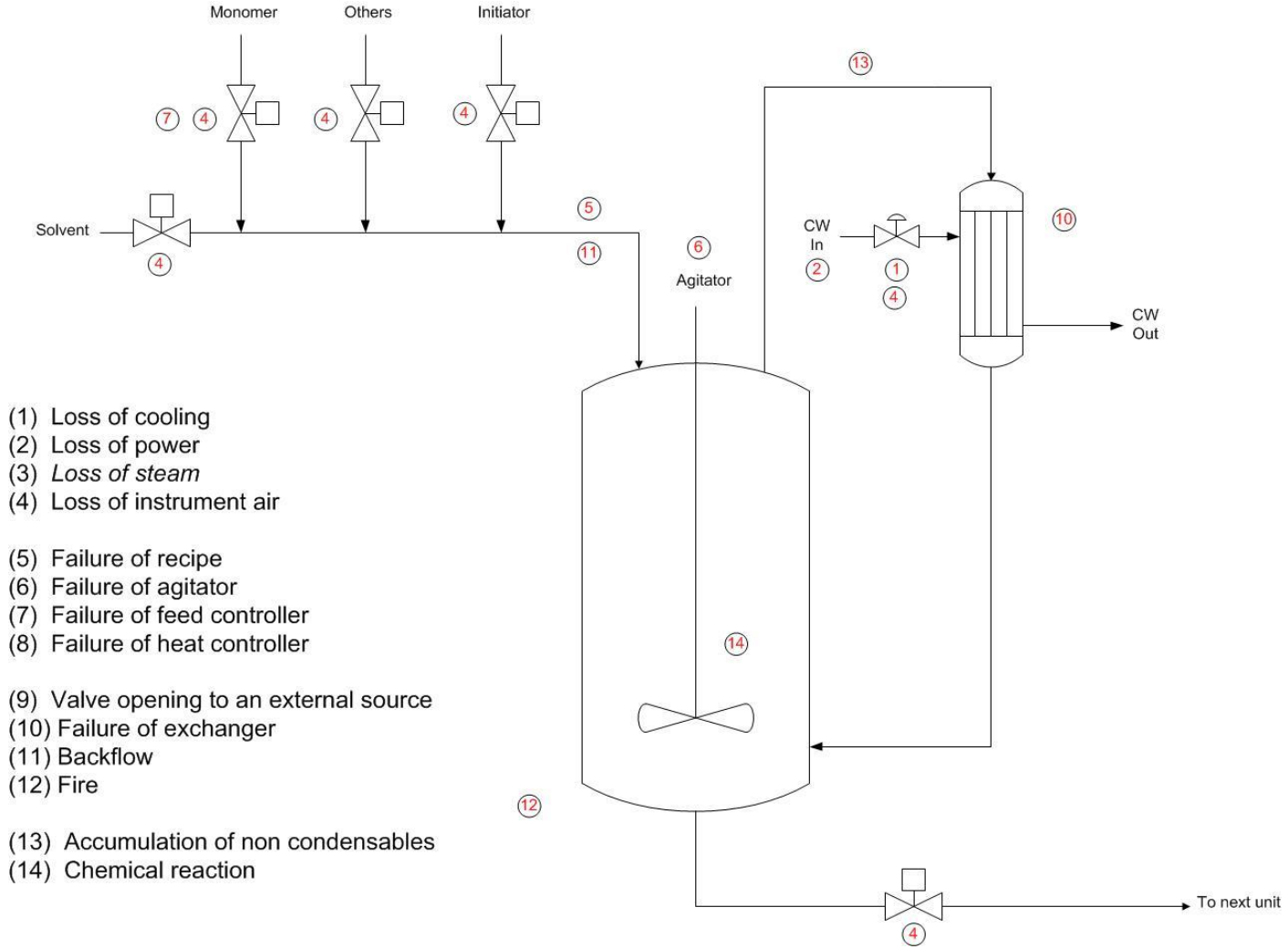
# Introduction

| Batch Reactor | Distillation Column |
| --- | --- |
| • Widely used<br>• Small volume applications<br>• General-purpose equipment can be shared between several products & processes<br>• By nature of batch operation no steady state operation<br>• Secure follow up of the sequence of the process steps – mimick “golden batch” typical | • Objective: separation of mixtures in pure components or different fractions.<br>• Technology is energy intensive as separation is based on gas / liquid interchange.<br>• “Internals” in a distillation column will not be further discussed. No fundamental difference in equipment design conditions nor process safety concept. |

# Introduction

- As technologies in the process industry are energy intensive there is a strong focus on the overpressure protection.
- This means that when a failure occurs the design conditions (pressure/temperature) should not be exceeded.
- Additionally it’s important to know and understand the background and dimensioning of the safety concept, especially for the evaluation of MOC’s (Management of Change – on all changes).
- In the next slide some generic failures are presented which should be included in the Process Hazard Analysis (PHA).

# Batch Polymerisation Reactor – Process Safety Scenarios



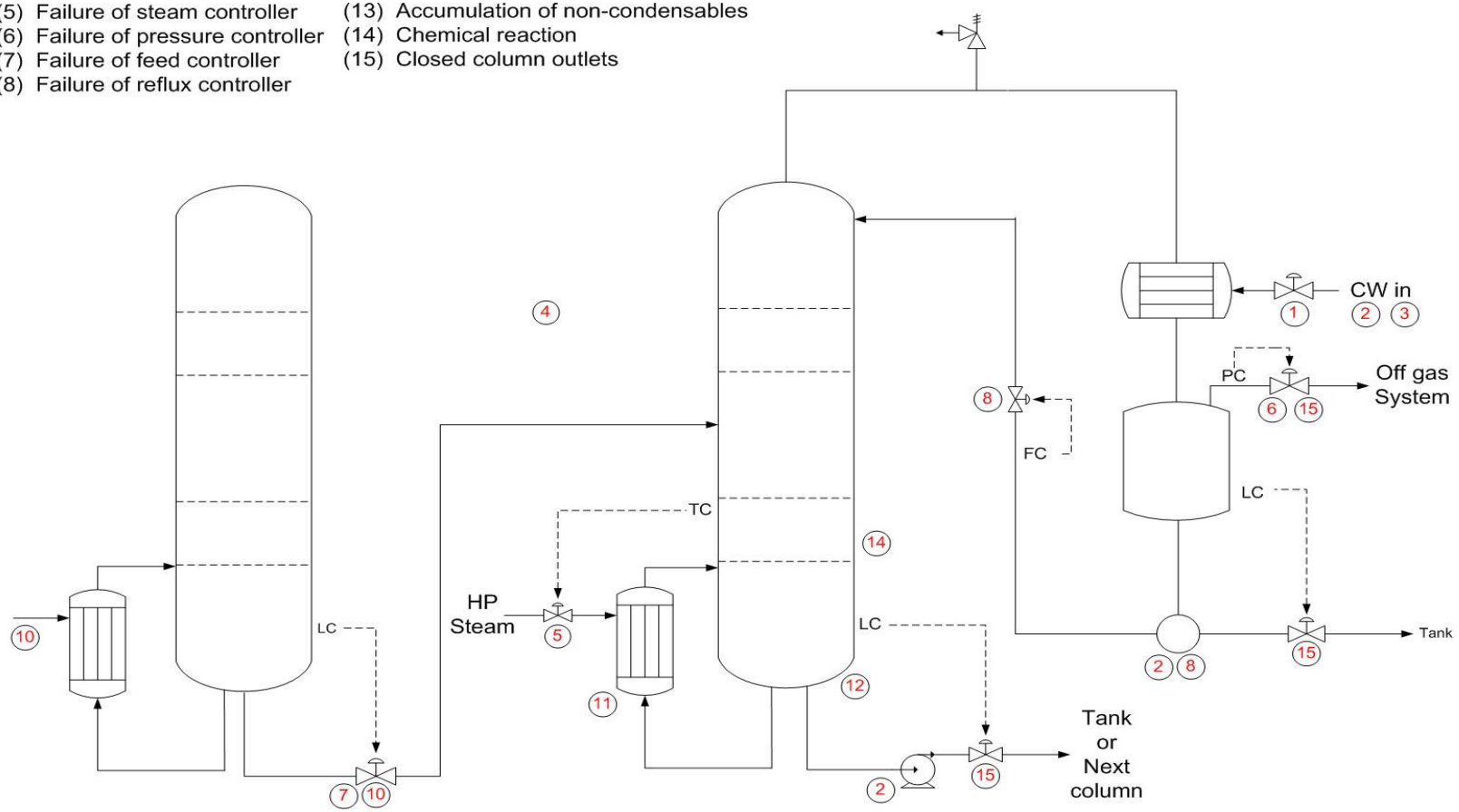
# Distillation – Process Safety Scenarios

(1) Loss of cooling
(2) Loss of power
(3) Loss of steam
(4) Loss of instrument air

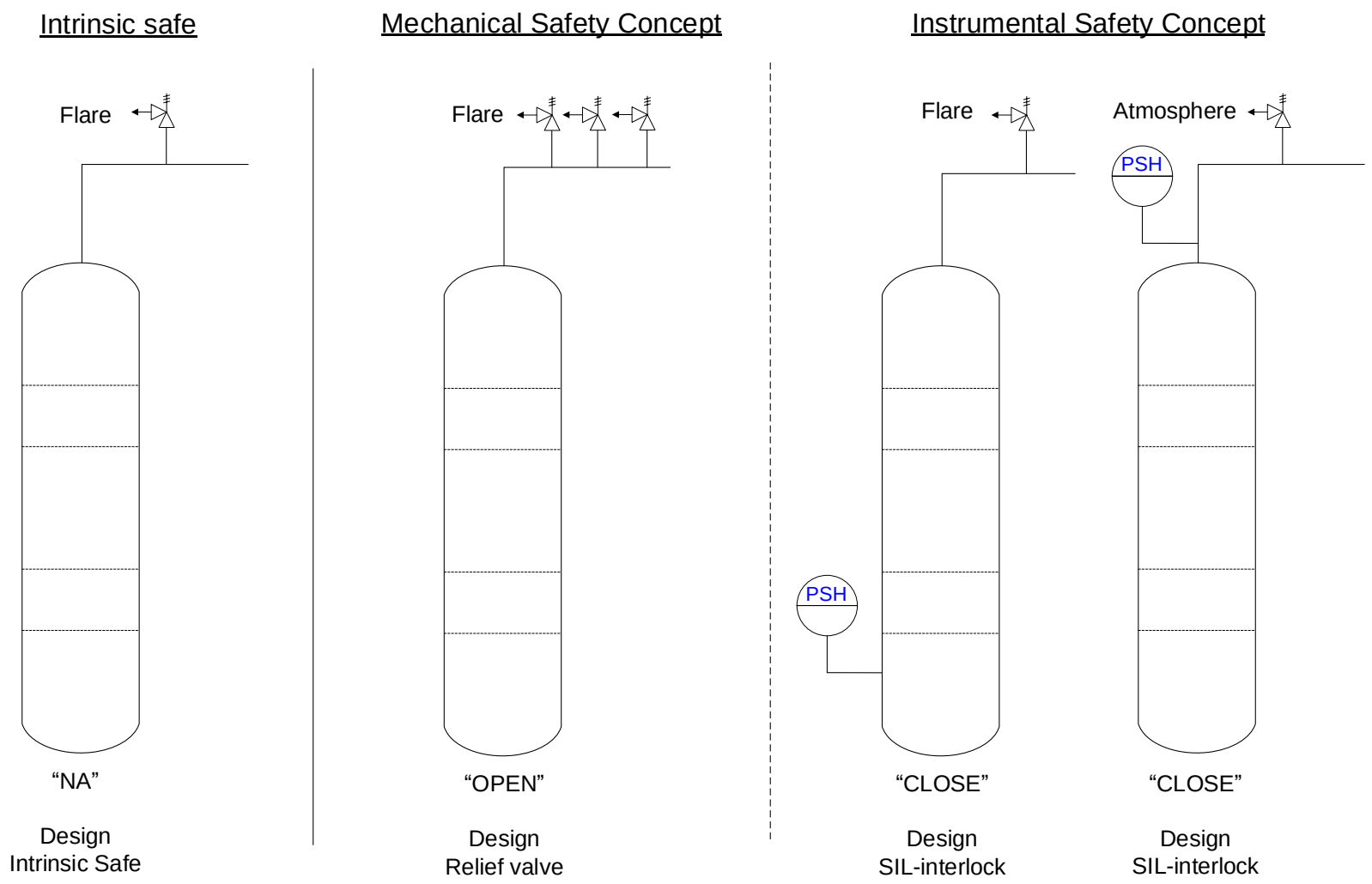
(5) Failure of steam controller
(6) Failure of pressure controller
(7) Failure of feed controller
(8) Failure of reflux controller

(9) Valve opening to an external source
(10) Loss of heating upstream column
(11) Failure of exchanger
(12) Exterior fire

(13) Accumulation of non-condensables
(14) Chemical reaction
(15) Closed column outlets



# Overpressure Protection Distillation Columns



# Mechanical Safety Concept

- Relief devices are ususally designed to protect the equipment and auxillaries from overpressure due to any single cause.

- The probability of two unrelated failures occurring simultaneously is considered remote and is not normally designed for.

- API RP 521 defines causes to be unrelated if no process, mechanical or electrical linkages exist among them.

# Instrumentational Safety Concept

- Safety instrumented functions are ususally designed to protect the equipment and auxillaries from overpressure due to different type of causes.

- IEC 61511 is the guideline used in EMEA.

- Specific engineering concepts:
  - Functional safety – the complete set up from sensor till actor is described.
  - “Voting systems” 1oo1, 1oo2, 2oo3, …
  - Complexity requires on line testing – calibration.

# Process Safety … still more to be done

Process Safety … still more to be done :

| Time | Incident |
|---|---|
| Nov 2013 | Steam clamp explosion at Total Antwerp |
| Jun 2014 | Explosion at Shell Moerdijk |
| Jan 2015 | Pipe rupture and Explosion at BASF Antwerp |
| Feb 2016 | Runaway and explosion at Indaver Antwerp |
| Oct 2016 | HP Ethylene pipe explosion at BASF Lu |
| Aug 2017 | Furnace Fire at Exxon Refinery |

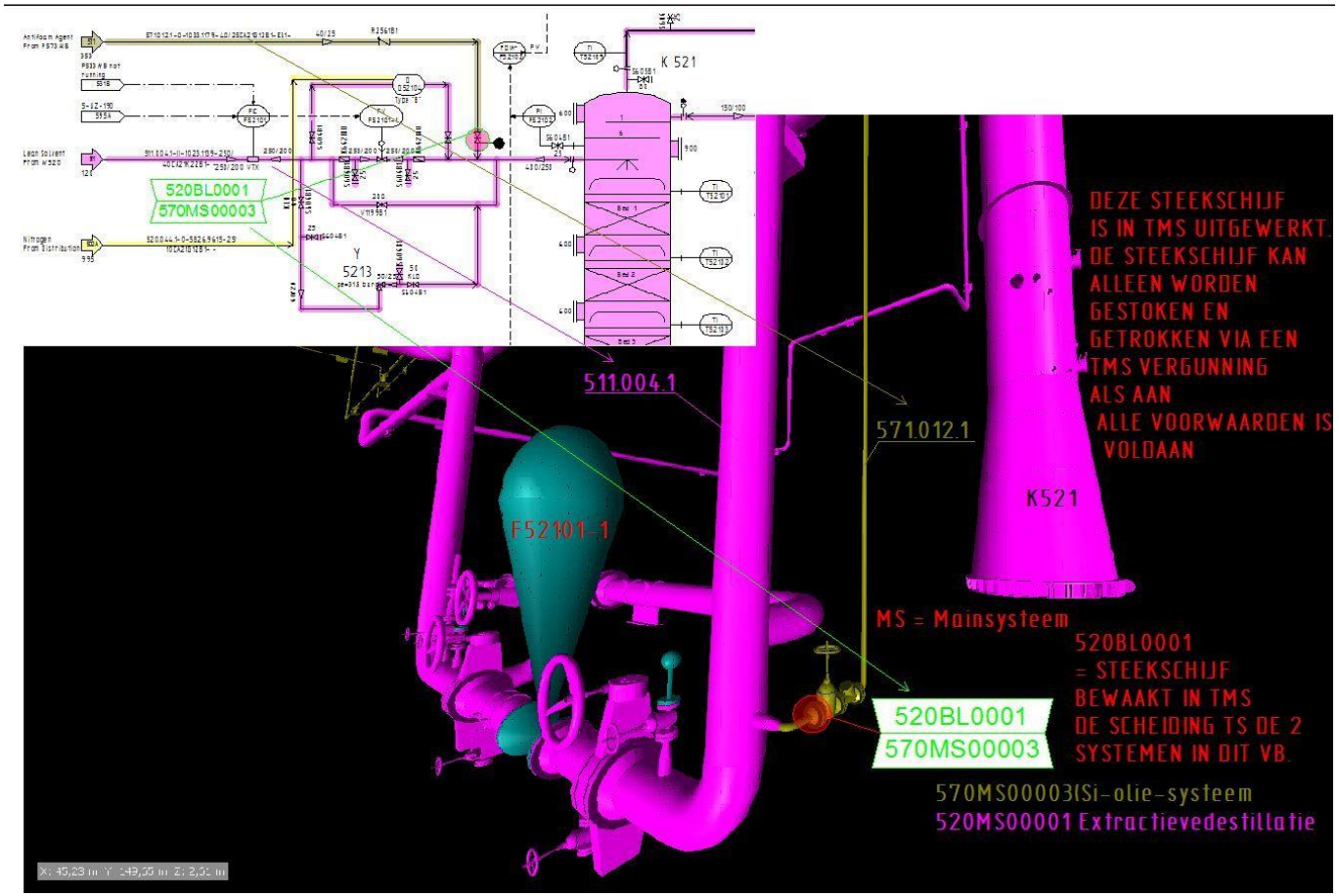
Process Safety Incidents (LOPC) are investigated and root causes are addressed.

# Process Safety … still more to be done Industry 4.0

- Further focus on :
  - Prevention of loss of containment due to process upsets.
  - Prevention of loss of containment due to degradation.
  - Prevention of human and organizational errors.

- Industry 4.0 will lead to better tools to tackle main root causes leading to Process Safety Incidents :
  - Specific tool for isolation management.
  - Improved communication tools between operating teams and maintenance.
  - Visualization tool for permits and process systems – improve decision making for emergency management.

# Industry 4.0
# Improve Standard Operating Procedures



# Process Safety … still more to be done
# Know How & Competence

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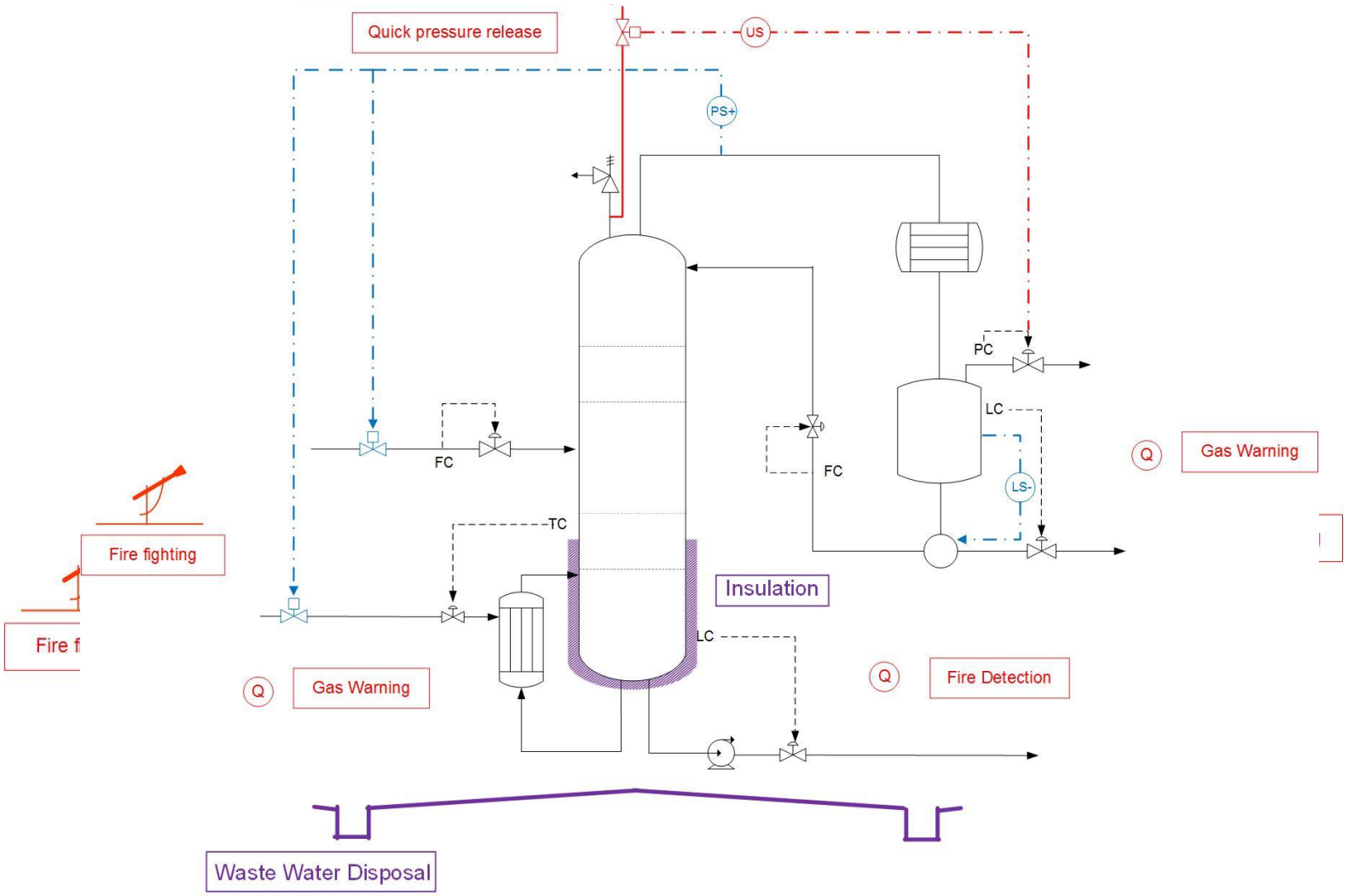
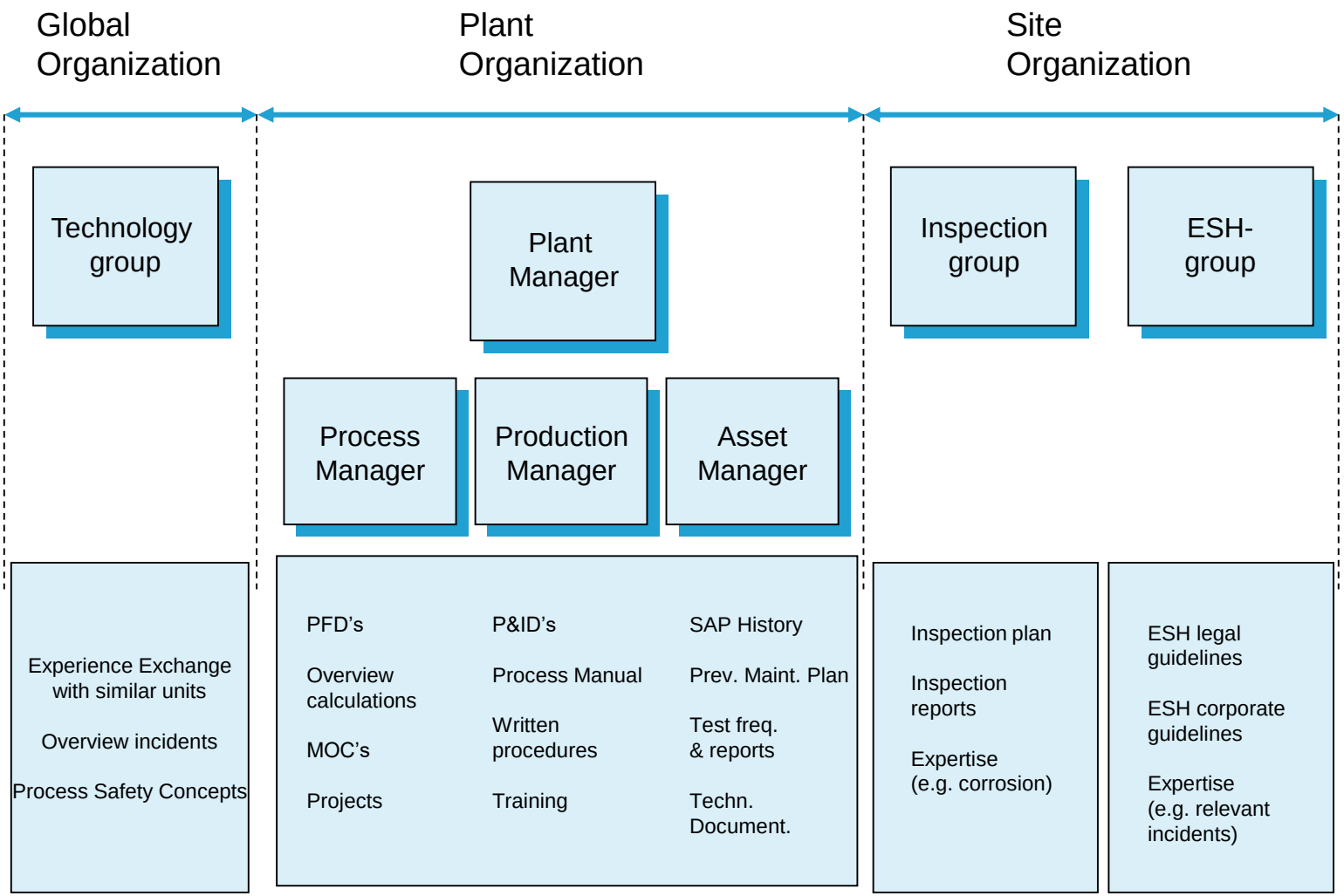


# Know How & Competence
# Deliverables from the organization



# Conclusions

- Recent incidents shows further need to focus on know how and competence.
- During revalidation of process safety study important incidents need to be incorporated in safety concept (“Lessons Learned”).
- Many have to do with start up or non-routine activities – new tools are under development to support Operations & Maintenance.
- “Keep the memory alive”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that makes questions love
answers.
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