32th Annual European AIChE / DPA Seminar

‘Safe start-up of chemical plants’

25 years lessons learned start-up and non-routine operation of a cracker plant

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Sponsored by Jos Vankevelaer & Rombout Keldermans

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BASF Antwerp Steamcracker

Capacity
Increase 2007
(furnace12)

Capacity
increase 1996
(furnace 10)

Construction
in 1993
+ start up

Capacity increase from

Introduction

- The process safety concept of a plant is determined during the engineering phase of a project.
- Once the process is started this safety concept will be validated during the life cycle of the plant, based on operational experience and lessons learned from incidents.

  MOC’s, if applicable, need to be incorporated in the safety concept

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Life cycle BASF A'pen Steamcracker

- Engineering & construction from 1990 till 1993
- Start up in 1993
- First shutdown in 1999
- Revamp in 2007
- Since start up - in total > 5000 MOC's

Slide 4

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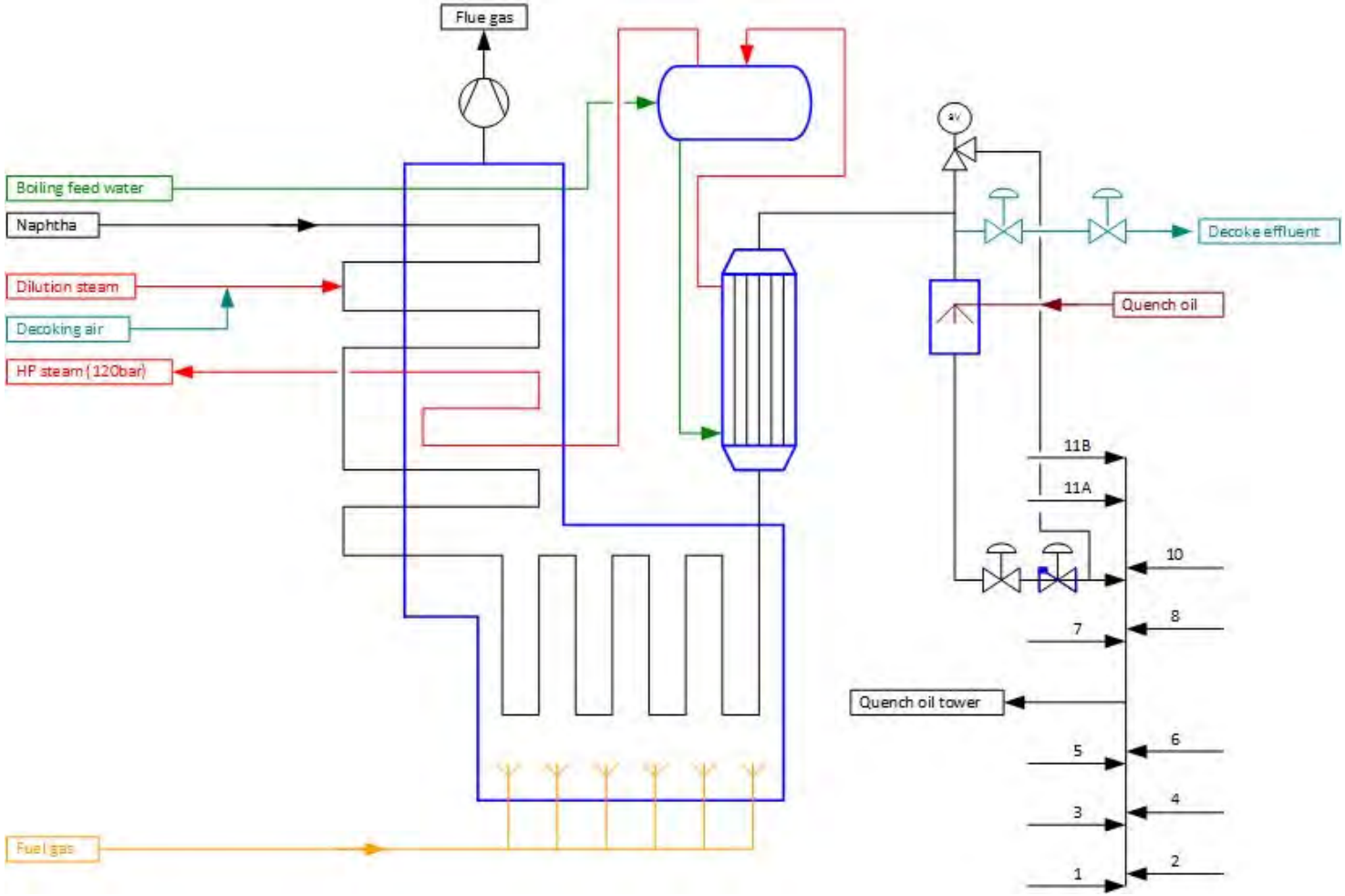
Incident 1 - 2001

- Presented at EEPC conference in 2001
- Loss of naphtha feed leading to a trip of all furnaces and subsequently Cracker
- Fire in furnace 1 due to leaking quench oil

Incident 1 – PFD Furnace



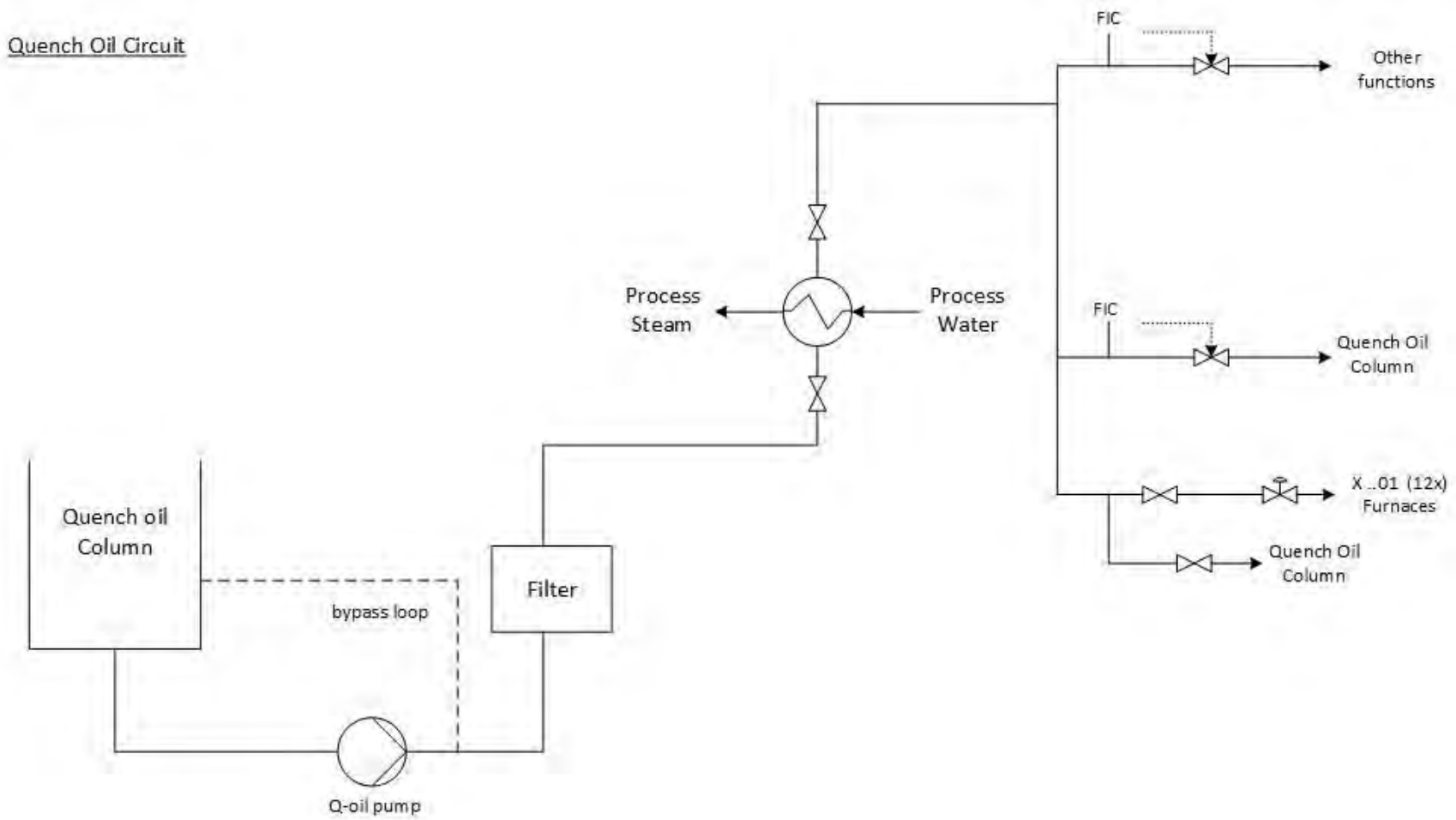
Incident 1 – What happened

- Description of incident
  - *Trip of furnace : close of feed + close Quench oil injection via control valve*
  - *Isolation of furnace from crack gas header*
  - *Small leakage through Quench oil control valve leads towards gradually filling of outlet line furnace*
  - *Through leakage of coil, quench oil comes into furnace and fire starts*
  - *Fire only stops when quench oil is extra closed by a hand valve*

Incident 1 – Corrective measures

- How to stop Q oil leaking:
  - *Primary function of Q-oil is to cool down gas outlet stream of furnace (direct quenching)*
  - *Secondary function of Q-oil is to generate process steam by heat transfer in a train of heat exchangers*
  - *Trip of Q-oil pump is not a solution*
  - *Additional on/off valve is placed*

Incident 1 – Corrective measures

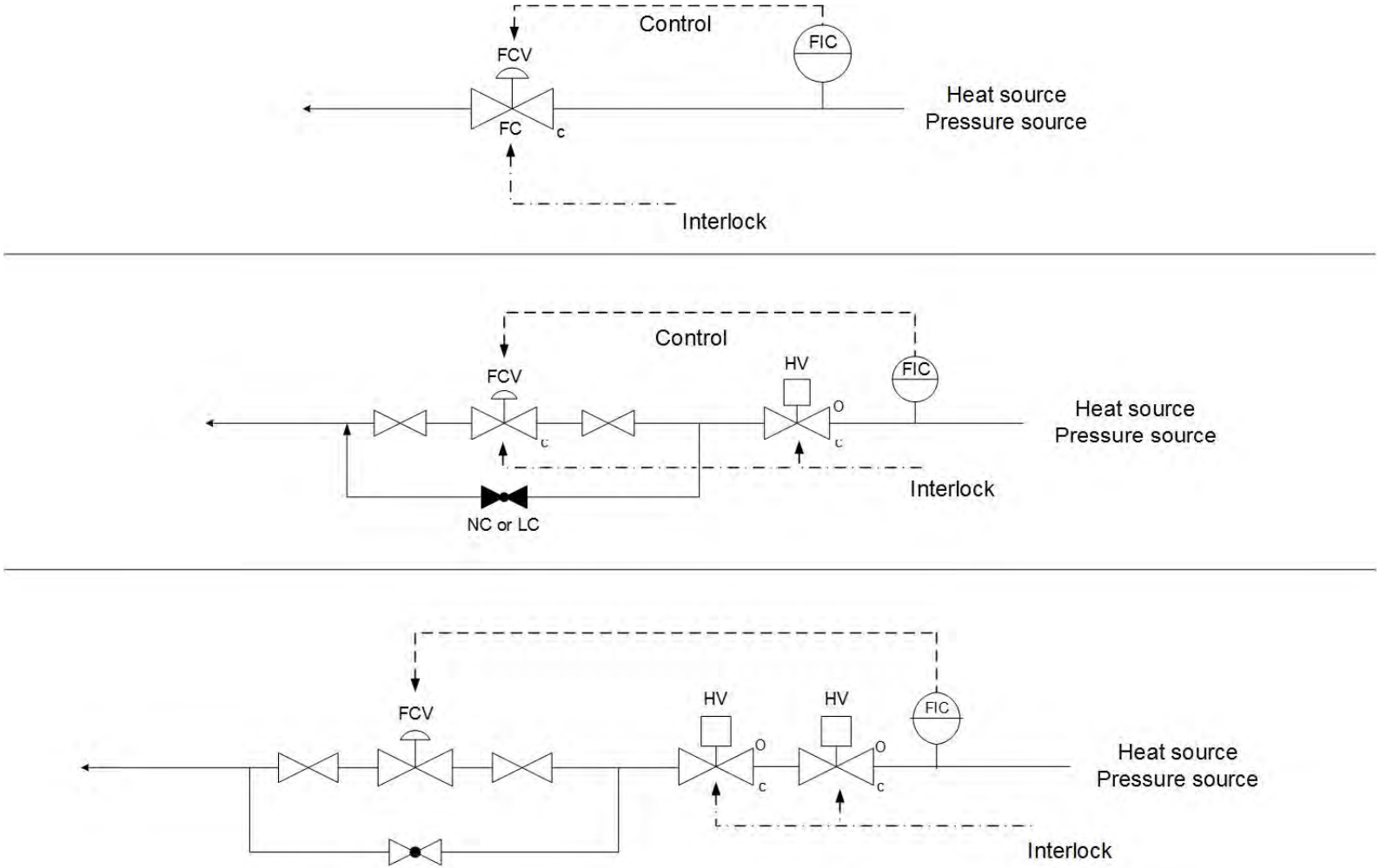


Incident 1 – Corrective measures

- Integration of safety instrumented functions in safety concept

- Different possibilities to close the feed

Incident 1 – Corrective measures



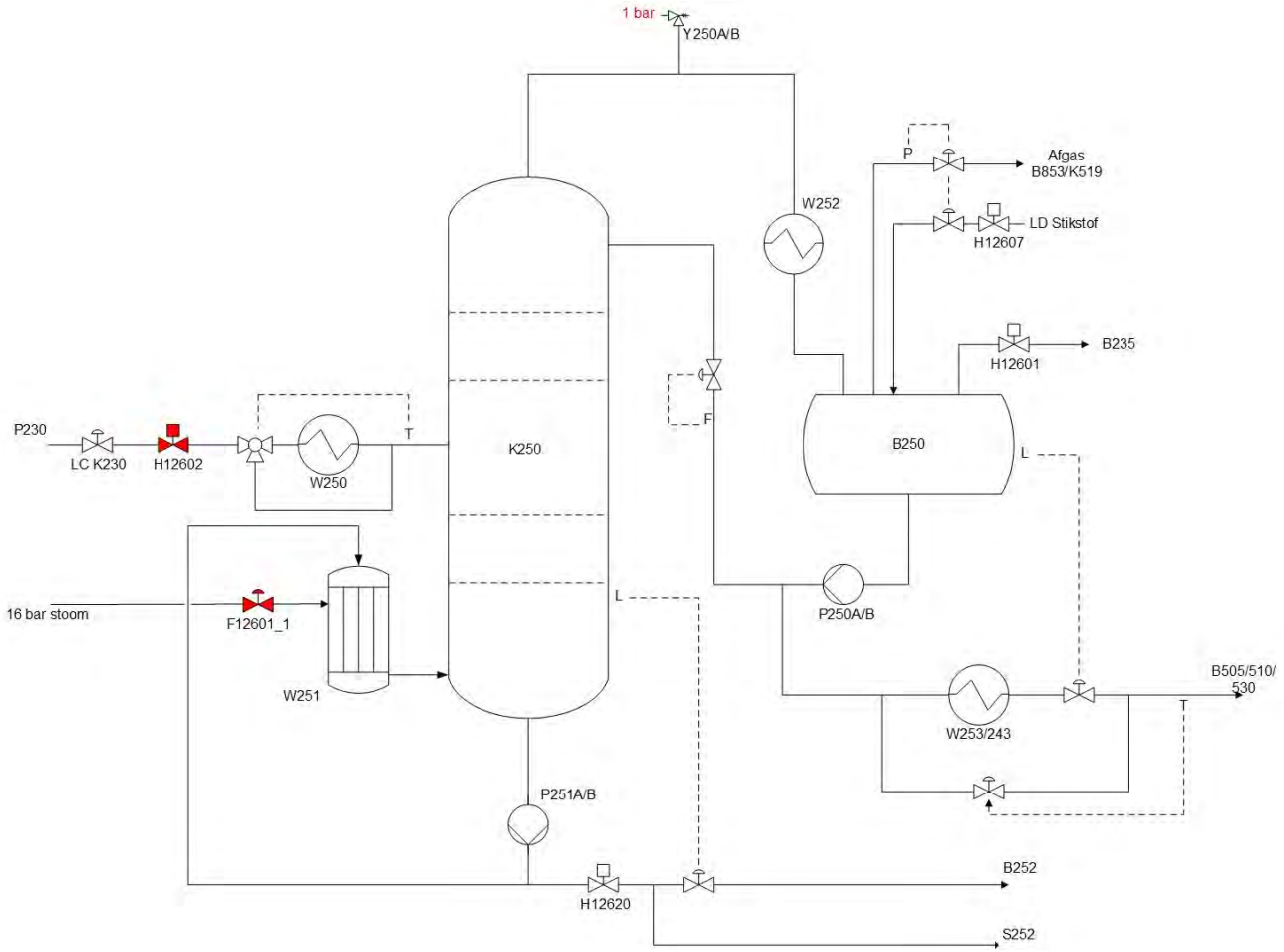
Incident 1 – Similar incidents

- Lessons learned from other incidents
  - *Unwanted error – failure of instrument air on/off valve*
  - *Sequence of releasing valves after trip*
  - *Other similar incidents*

Incident 1 – Similar incidents

- Other similar incidents:
  - *Operator mistake – forgot to start pump with a reboiler with forced circulation (often with a vacuum column)*
  - *Steam was already lined up – heating up a non-flowed reboiler – getting hot*
  - *When pump was effectively started – a quenching of the preheated reboiler occurred and activated the relief valve*

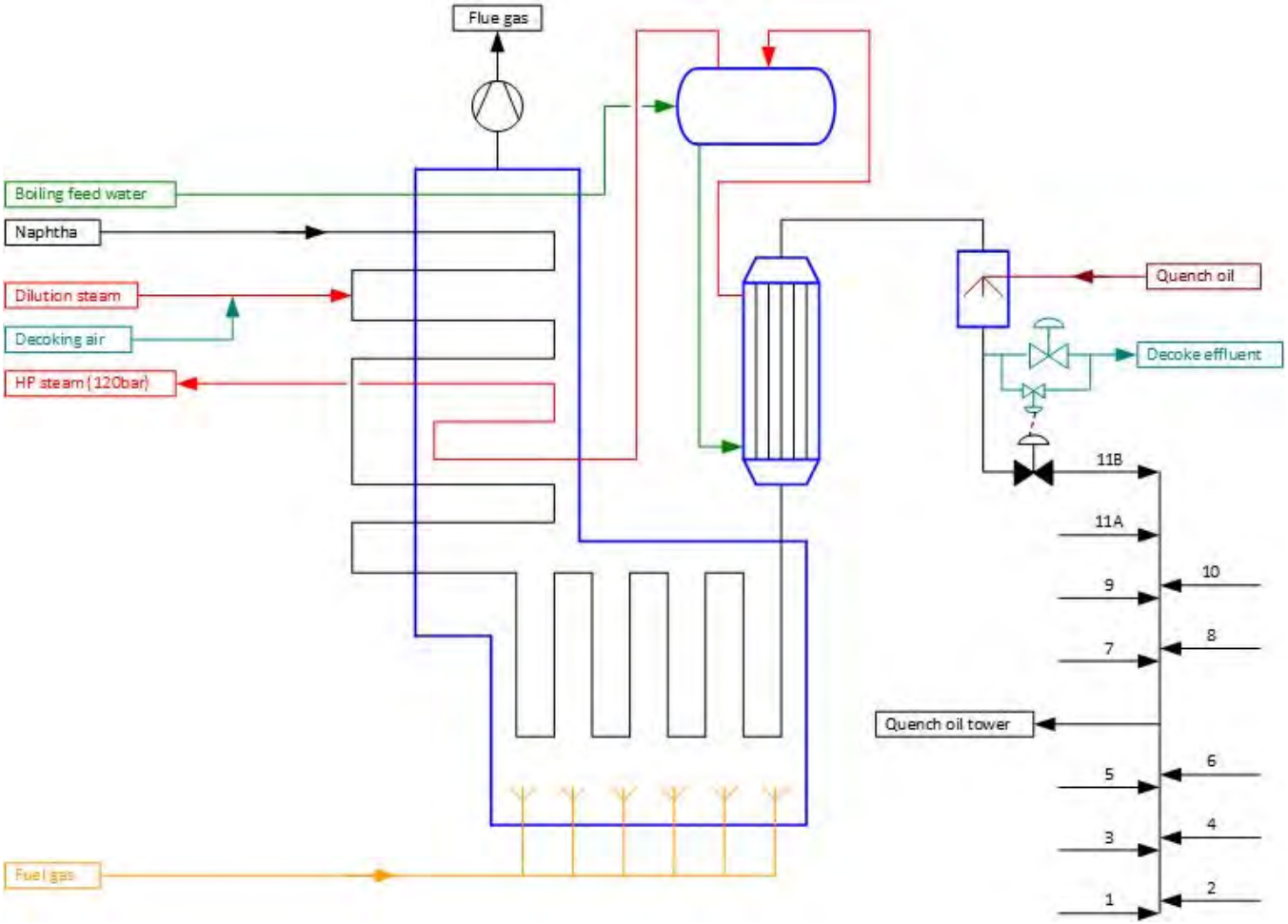
Incident – Wrong sequence of start up reboiler



Incident 2 - 2004

- Presented at EEPC conference in 2004
- Unexpected trip of furnace 11
- Explosion in fire box due to backflow of cracked gas

Incident 2 - 2004



Incident 2 – Critical items

- Critical items concerning incident
  - *Opening of peep holes, due to the explosion*
  - *Complexity of switch over to decoke procedure*
  - *Coil rupture detection*

Incident 2 – Corrective measures

- Work group within EEPC where operators and licensors participated focusing on:
  - *Detection of coil rupture*
  - *Detection and protection against Crack gas backflow*
  - *Protection against explosion*
  - *Quality and Design of Crack gas valves*

Incident 2 – Corrective measures

- Conclusions of work group were included in BASF internal guideline “Process Safety Concept for a Cracker furnace”

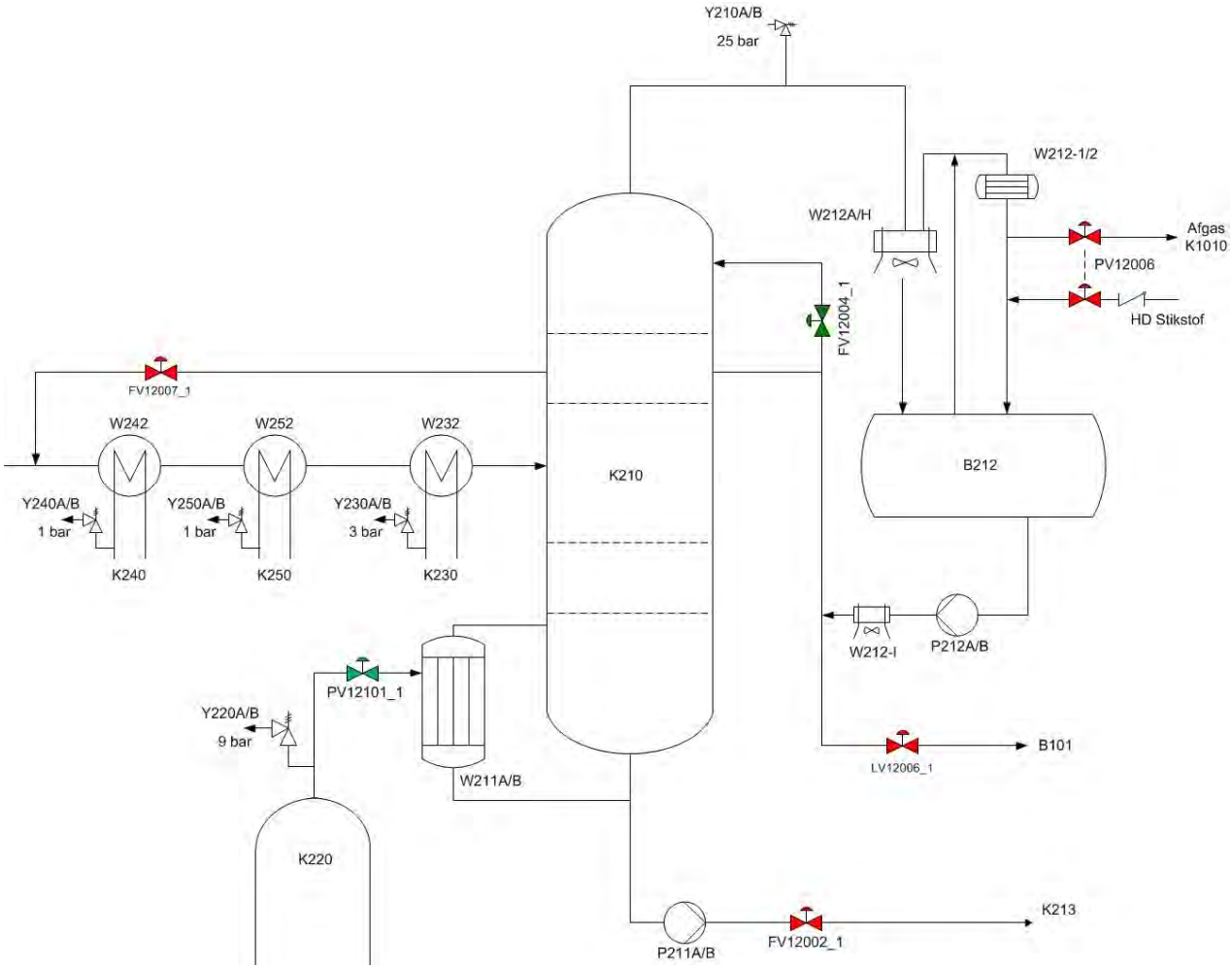
- One recommendation will be highlighted: the installation of valve with a check valve incorporated

Incident 2 – Corrective measures

Incident 2 - 2004

- Other similar incidents:
  - *Energy integration with other columns*
  - *Leakage in condenser can lead to pressure build up in columns*
  - *Scenario is included in calculation relief valve*
  - *Relief valve will be activated for a long time as complete column system will depressurize via backflow over leakage*

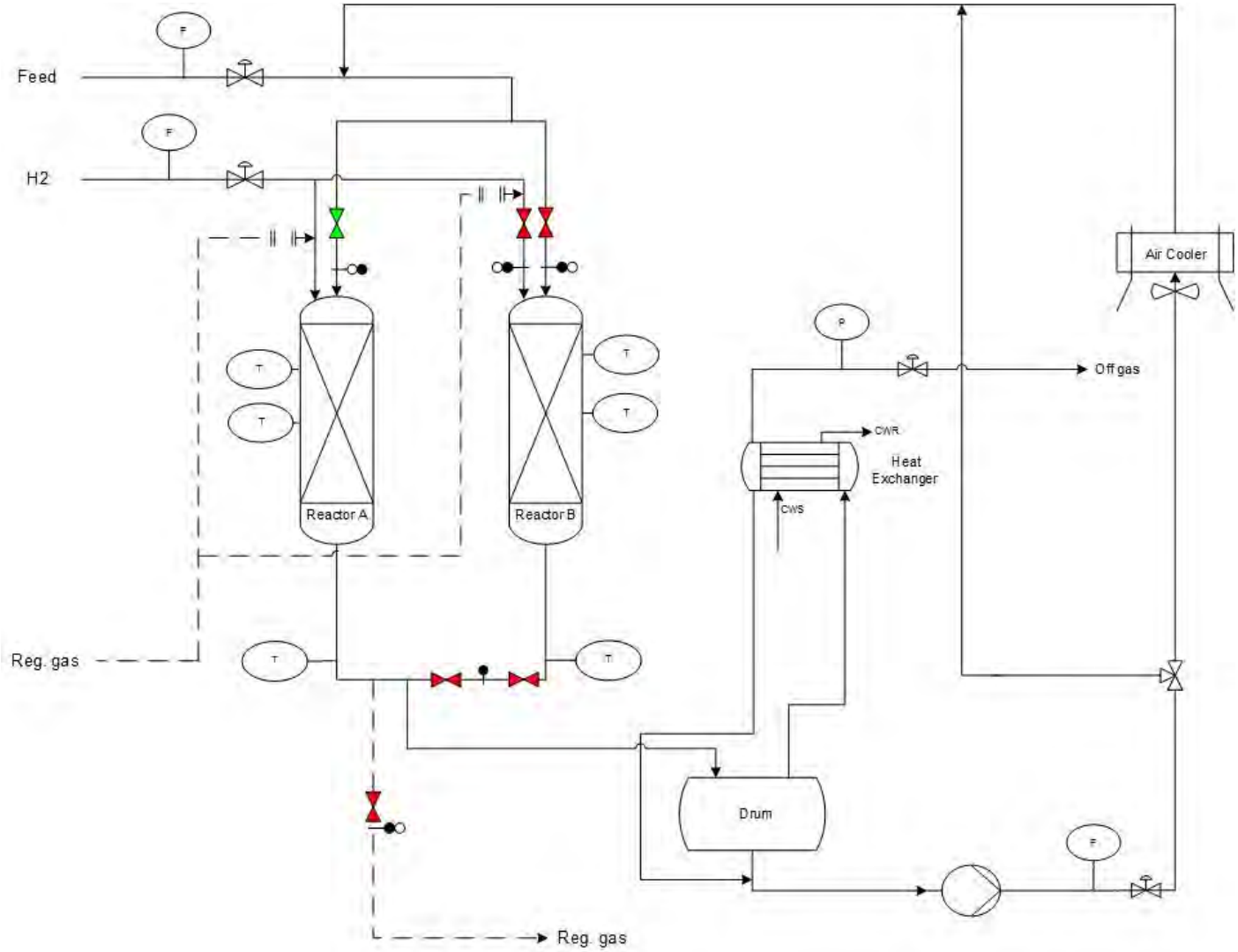
Special design – pressure rating condenser vs column



Incident 3 – Description

- Start up of Hydrogenation unit after catalyst exchange
- High temperature noticed at liquid collector drum during plant tour
- Unexpected reaction at gas/liquid interface

Incident 3 – Process Flow Diagram



Incident 3 - Description

Incident 3 – Corrective measures

- Precommissioning and commissioning have been revised – prevent dust entrainment to adjacent equipment

- Pressure control of drum was adjusted from hydrogen to nitrogen

Incident 3 – Other similar incidents

- Selection of catalyst incidents out of the BASF incident database
- Some examples :
  - Start up of new catalyst in slightly different conditions
    Due to unexpected decomposition reaction pressure build up in adjacent column
  - Temperature hot spot during regeneration
  - Temperature increase during start up due to adsorption energy on a zeolite dryer

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Conclusions

- Need for incident database – important process safety management system
- During revalidation of process safety study important incidents need to be incorporated in safety concept
- Many have to do with start up or non-routine activities
- “Keep the memory alive”

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that makes questions love
answers.
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