Integrity management in HF Alkylation

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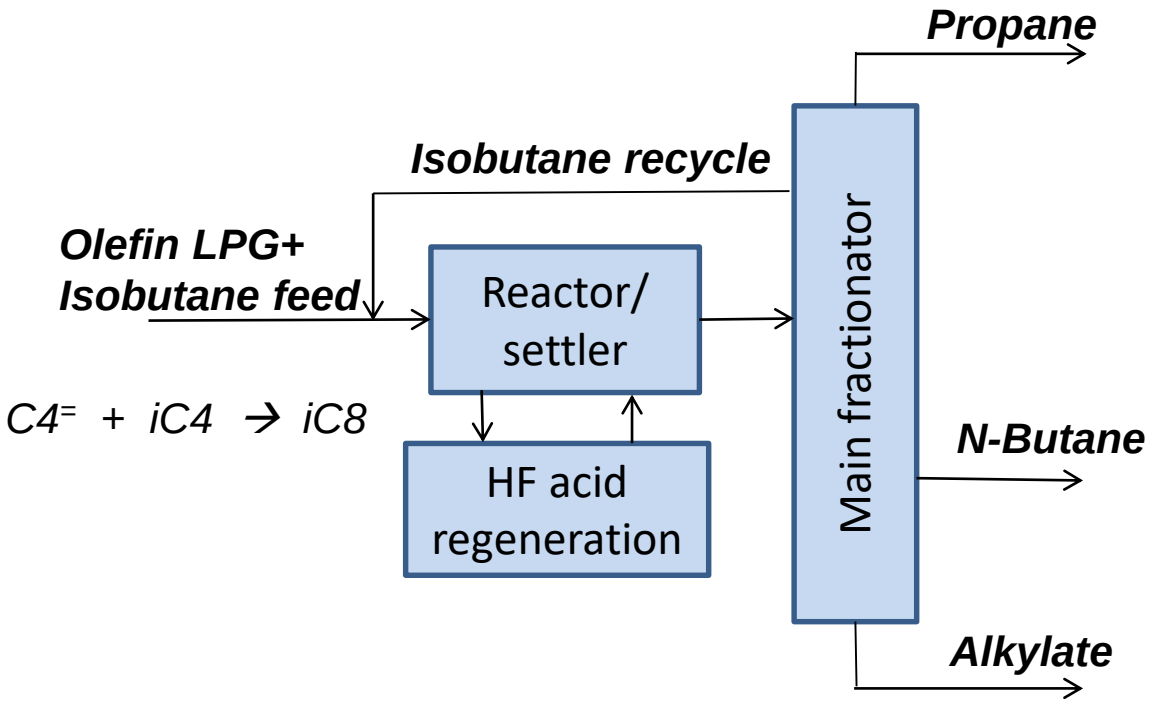
HF Alkylation units

- Refinery process unit to upgrade LPG into alkylate
- Typical upgrading margin 330 (summer) and 135 (winter) $/Ton alkylate
- Worldwide about 130 operating HFA units



Safety issues HFA units

- Generally HFA units have the highest risk profile in the refinery due to presence of a large inventory of LPG and HF
- High risk profile for people outside the refinery fence was demonstrated in 1987 following an accidental release of 24 Ton of HF:
  - 4000 people had to be evacuated
  - 1000 people reported to hospital
- Despite a very large R&D effort during the last 25 years by numerous reputed companies, no breakthrough alternative for HF acid has become commercially available

Today's common practice

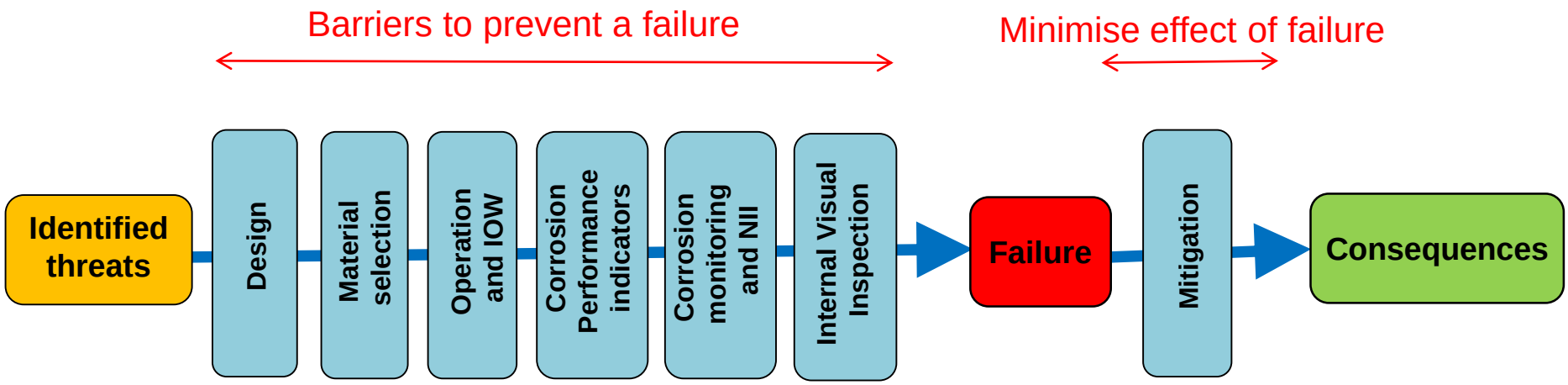
Today's common practice to manage the risk of HF Alkylation units is:

- Ensure compliance with the API-751 Recommended Practice "Safe operation of HF Alkylation units"
- Assess the residual risk of the HFA unit by for example QRA
- Apply new technologies to reduce the risk profile to target level

BUT:

- API-751 is a list of proven practices, not necessarily the best
- Nearly all technology developments attempt to **mitigate** the consequences rather than **pervent** a failure

Bowtie concept in HF Alkylation



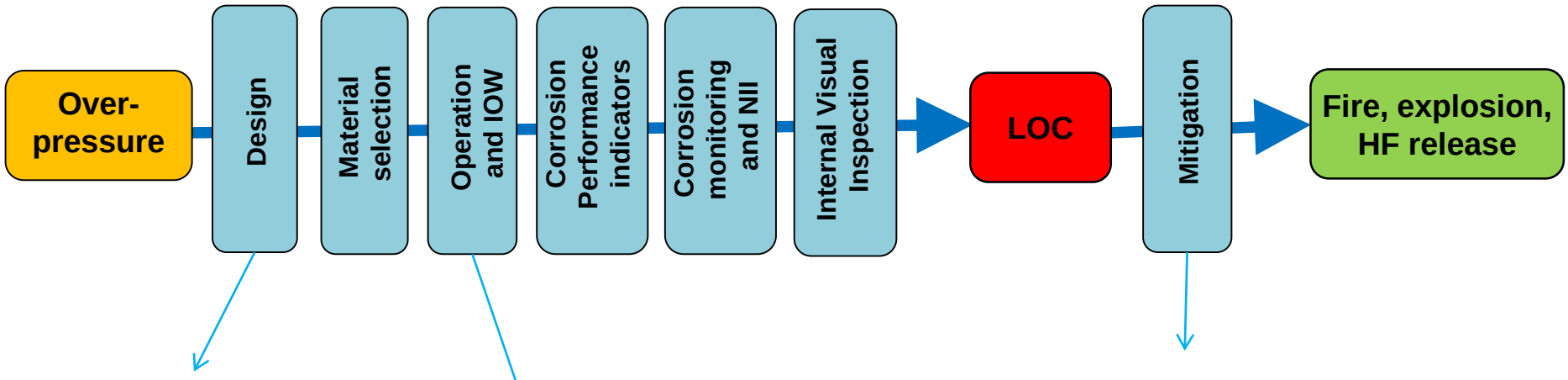
Example of threats:
- Overpressure
- Pump seal failure
- Internal corrosion

Example of failure:
- Loss Of Containment

Example consequence:
- Fire
- Explosion
- HF release to atmosphere

Example threat: overpressure

Example: overpressure in a fractionator column

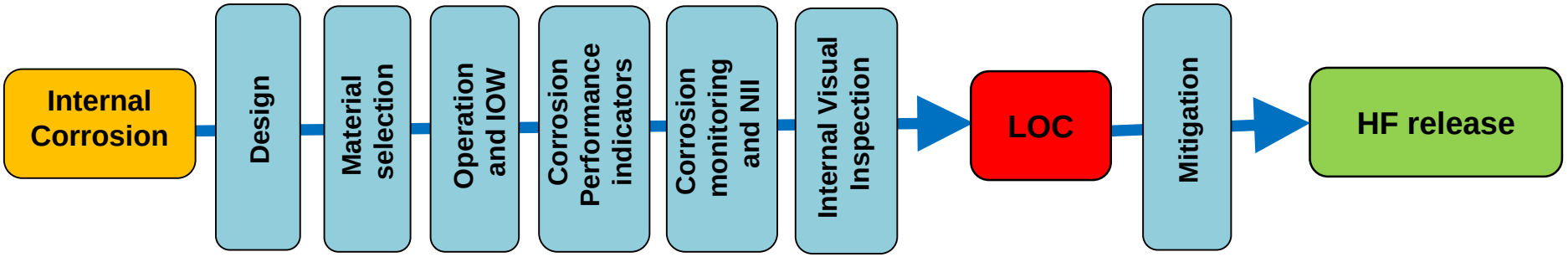


Correct design pressure
Pressure Relief system

High pressure alarm & operator action
High pressure automatic trip system

LEL detection
Fire water system
Emergency response
Equipment layout

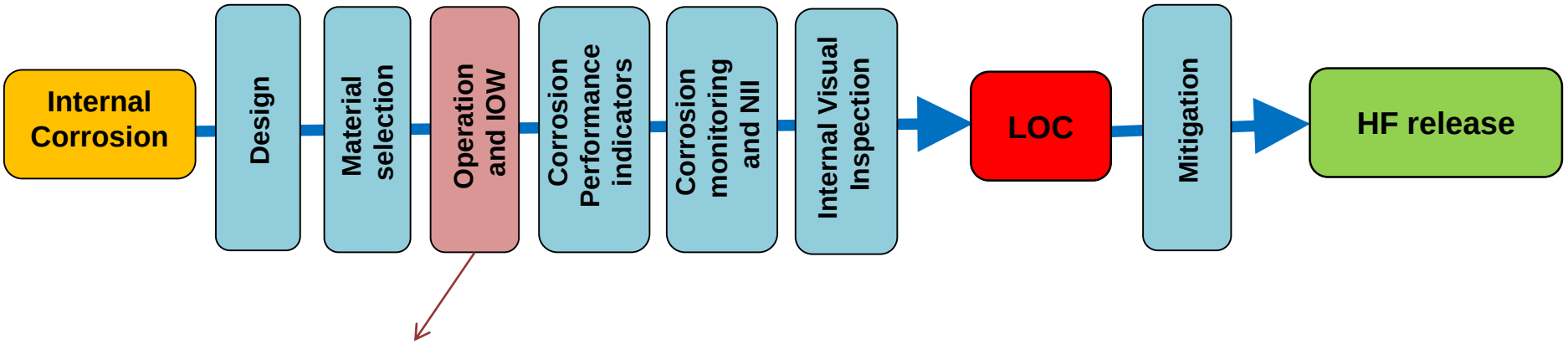
Example threat: corrosion



Internal corrosion is the integrity threat most difficult to manage because:

- Not all corrosion processes are well understood (effect of Residual Elements, Occluded Cell Corrosion)
- It relies on good workmanship and attention for HFA specific details during installation and maintenance
- Best inspection strategy is still not agreed upon

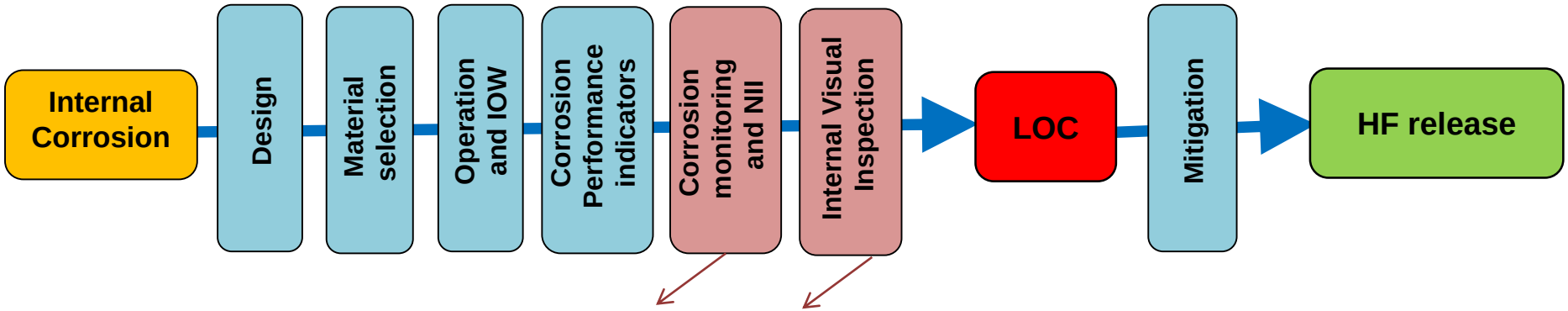
Barriers: Operation and IOW



Integrity Operating Window to include following critical parameters (examples):

- On-line calculation of acid entrainment from settler
- Acid/HC interface level in acid boot Main Fract overhead vessel
- Continuous nitrogen purge of on-plot flare header

Barriers: Corrosion monitoring/inspection



Traditionally, during a shutdown, all HFA equipment if neutralised using an aqueous solution. Disadvantages are:

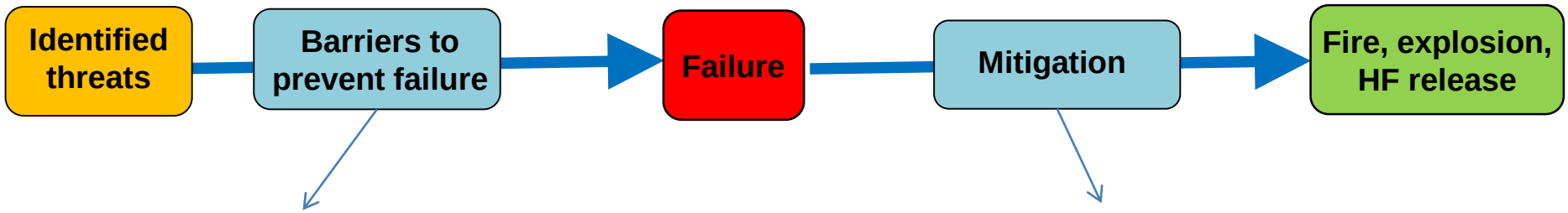
- Moisture (and oxygen) will destabilise the internal iron-fluoride layer
- Water left in any NNF lines will become highly corrosive after re-start

Examples of possible improvements:

- Consider more Non Intrusive Inspection instead of Internal Visual Inspection avoiding wet neutralisation
- Attach Ultrasonic Thickness monitoring probes in vital locations

Main risk reducing developments

The main technology developments that reduced the risk profile of an HFA unit in the last 25 years have been:

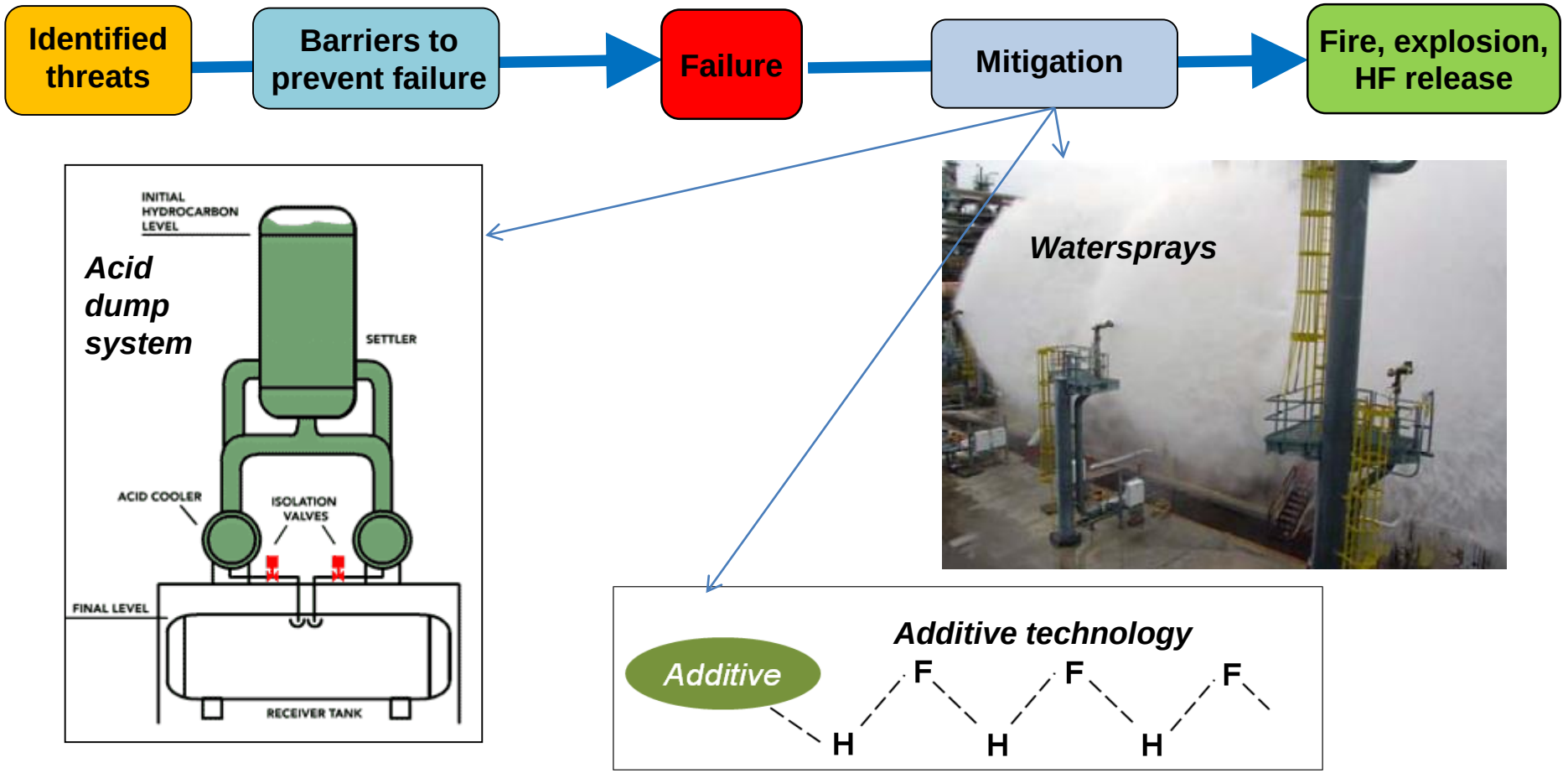


- Double seals on acid pumps (API610 plan 53)
- Process safeguarding Alumina and KOH treaters
- On-line acid analyser

- Minimum acid inventory
- Acid Inventory Management Systems
- Rapid acid dump systems
- HF-in-air detection
- Water spray systems
- Additive technology (modified HF)

Main risk reducing developments

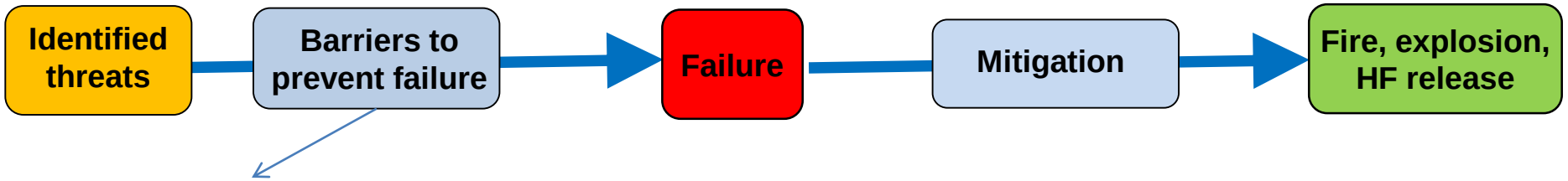
Nearly all developments have been in the „Mitigation“ area of the Bowtie



Investments costs are up to 10-20 million$/each

Risk reduction by prevention

More cost effective measures are on the „Prevention“ side of the Bowtie.



Examples:

- Apply best available process monitoring tools and Integrity Operating Windows
- Judicious upgrading of C-steel in critical service to Monel (specially piping)
- Replace Internal Visual Inspection (and wet neutralisation) by more Non-Intrusive Inspection where possible
- Rigourously eliminate piping in NNF service where possible
- Upgrade settler acid/HC interface level measurement to best available
- Use separate crew of well trained maintenance staff for the HFA unit

Examples of upgrading to monel

1. Photo of heavily fouled suction line of a Pressure Relief Valve, as quite frequently found during shutdowns, seriously jeopardizing the validity of the PRV as a barrier against overpressure.
Upgrading the line to monel elimiates this integrity threat.

2. Rapid corrosion and failures have occurred in C-steel feedlines to fractionators, caused by acid entrainment, high operating temperature and/or Residual Elements. Upgrading the last (hottest) part of this line to monel eliminates this integrity threat.

Conclusions

- Corrosion is poorly predictable and the most difficult integrity threat to manage for the HF Alkylation unit
- Some corrosion cases still lack a satisfactory explanation
- The Bowtie concept is an useful tool for integrity management by systematic review of threats and barriers
- Most risk reducing developments by licensors, refineries and suppliers have been in the “Mitigation” area. Options which prevent failures (left side of Bowtie) have been wrongfully neglected
- An up-to-date and comprehensive review of corrosion control and Integrity Management for HF Alkylation units is available (reference)

Reference

„Integrity management in HF Alkylation“ by H.Helle and A. van den Bosch – published April 2014