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SYMPOSIUM 2022

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Stamicarbon 75 YEARS

Risk based approach in the replacement of HP cigar type scrubbers

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Jaarbeurs, Utrecht

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Introduction

- Stamicarbon symposium 2000: “Explosion risks in urea plants”
- Hydrogen is the dominant component contributing to an explosion in a urea plant.

Explosion

Deflagration:

- *Flammable mixture which burns at subsonic speeds driven by the transfer of heat.* In Ammonia/air mixtures, over the entire concentration range, flame speeds are low, resulting in a deflagration.

Detonation:

- *Supersonic shockwave developing very high pressures within an enclosure.* Gas mixtures containing NH3/H2 and oxygen enriched air (40 mol% O2 / 60 mol-% N2) may result in a violent detonation.
- Oxygen enrichment shall be avoided at all times!

Effect of an explosion

- Rupture and fragmentation of equipment form a threat to people in the direct vicinity.
- Rupture of equipment results in a release of the hazardous chemicals.

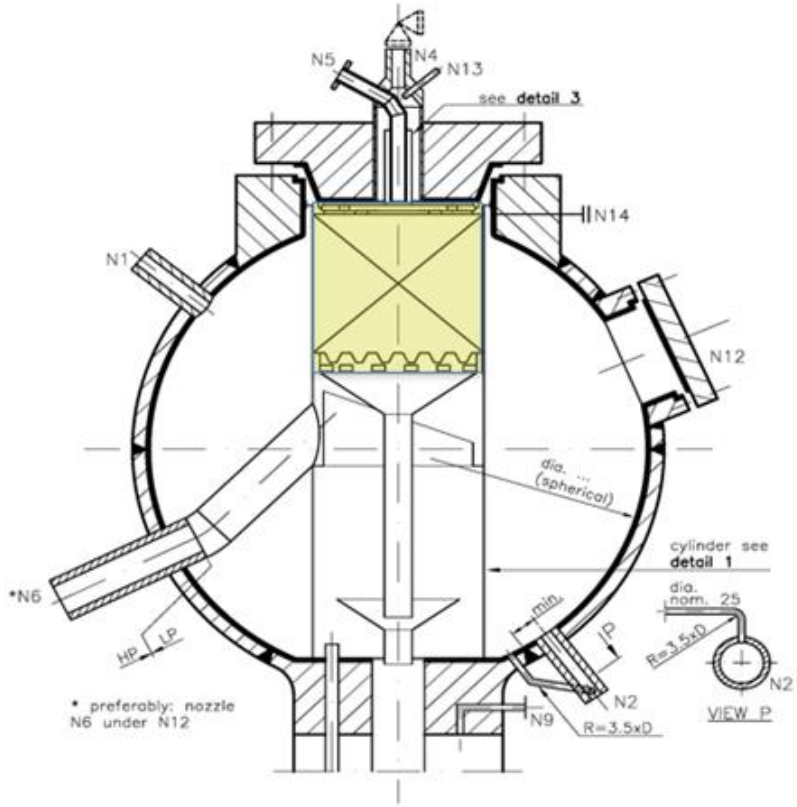
Design philosophy history

70's Partial condensation:

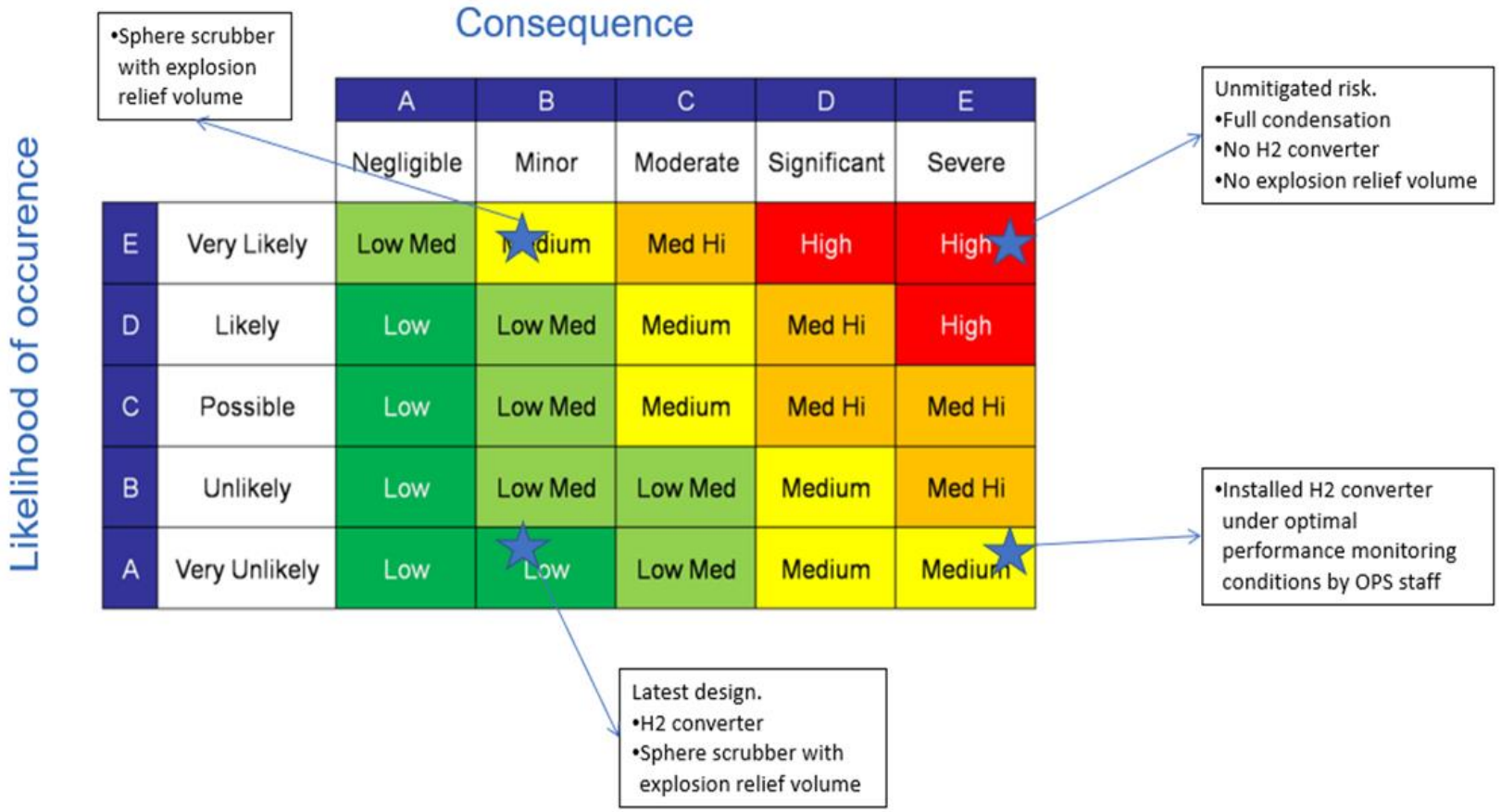
- Changing the total condensation of inert vapor in the urea synthesis in a partial condensation including the required sufficiently large pressure relief volume.
- Adding a hydrogen combustion in the carbon dioxide feed.

80's Total condensation:

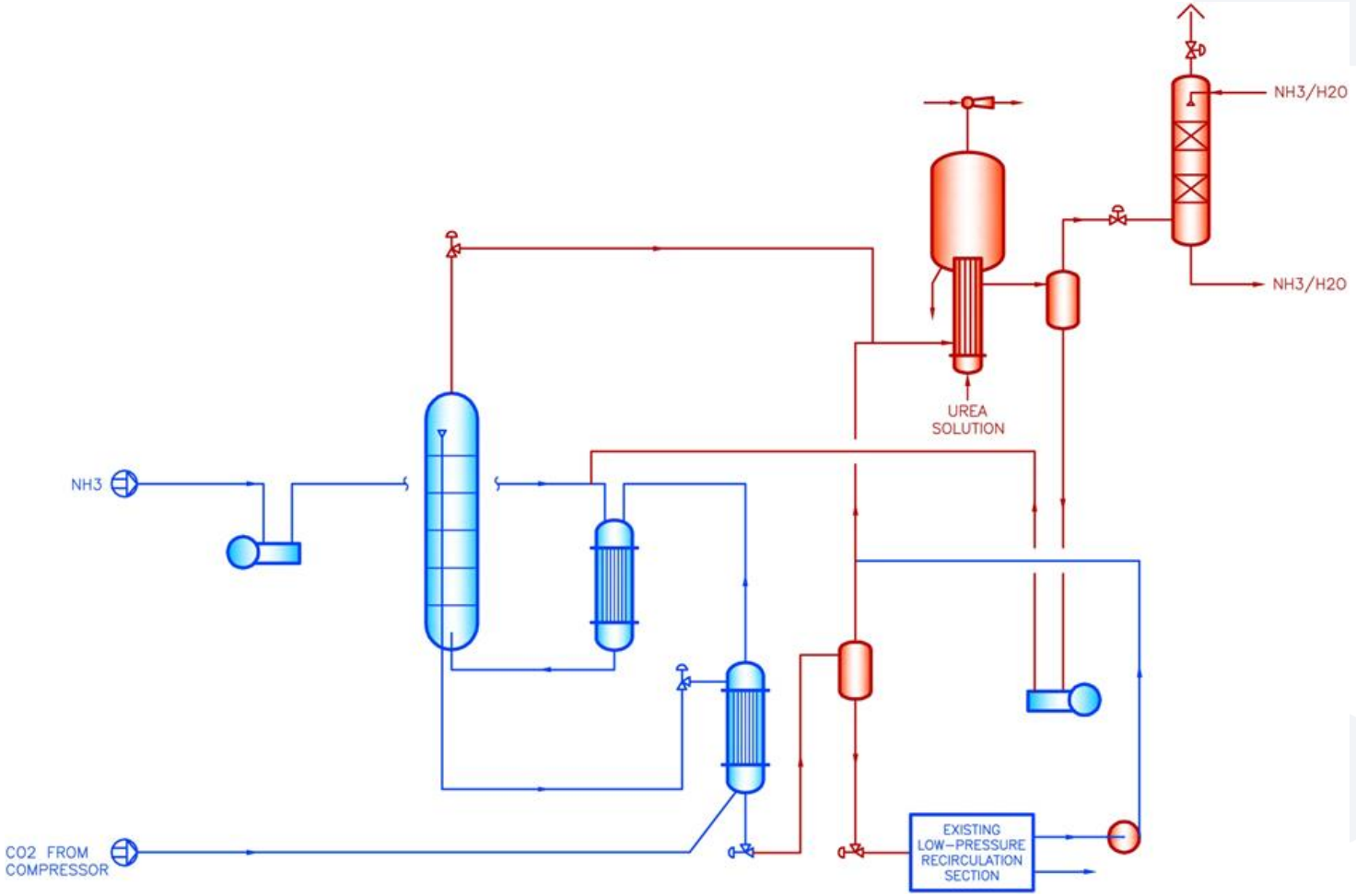
- Subsequently this resulted in the
- sphere type of high pressure scrubber
- which still today represents Stamicarbon's
- latest standard design.



Design philosophy grass roots plants: Hydrogen converter and sphere type HP scrubber



Latest Design philosophy grass roots plants: Adiabatic flash melt plant design



Internal deflagration
Mitigating the consequence

- “Dome area” constructions
- Rupture discs
- Deflagration proof equipment
- Adiabatic flash revamp concept

Internal deflagration
Mitigating the probability

- Hydrogen converter
- Dose oxygen in the form of air
- Monitor hydrogen concentrations on a regular basis
- Continuous monitoring of the hydrogen converter performance
- Equipment to be grounded and protected against direct hit by lightning

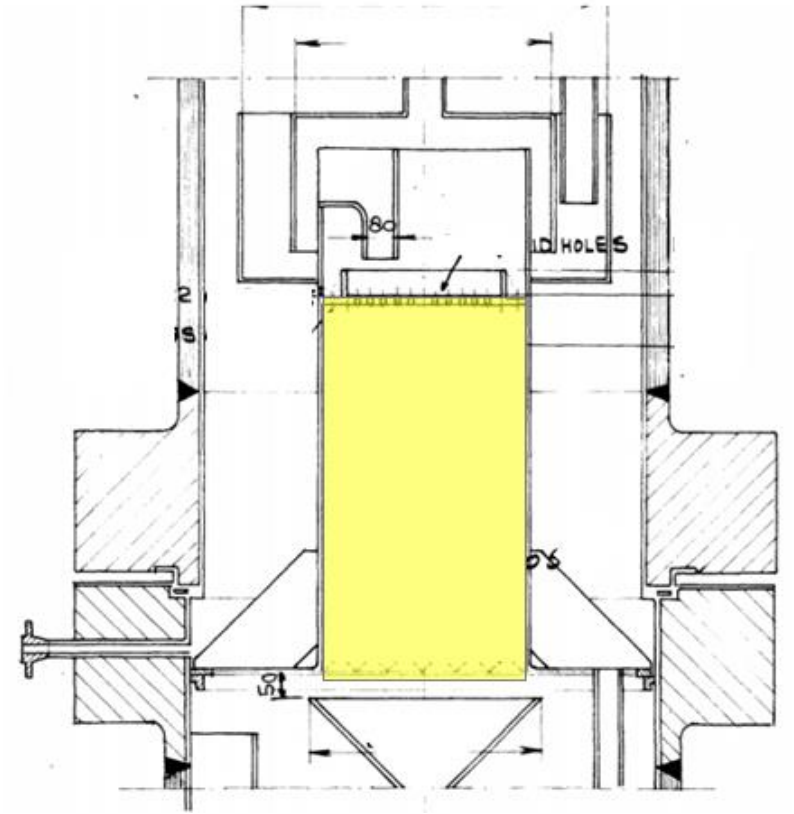
Risk based decision making

- Customers who decide that replacement of a high-pressure scrubber is due (end of lifetime) might have a strong preference to plan for a “replacement in kind”.
- Perfectly acceptable for Cigar type scrubber of partial condensation with a sufficiently large pressure relief volume.

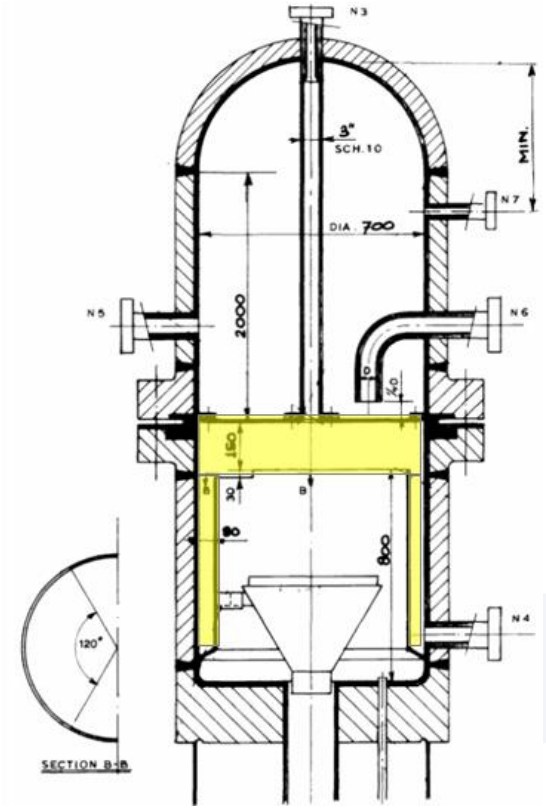
- Cigar type scrubbers on the principle of total condensation do not meet current safety design criteria
- In those cases, it is preferred to install a sphere type scrubber or transform the plant into an Evolve Melt Flash Design.

Modification of existing plant configurations

Total condensation

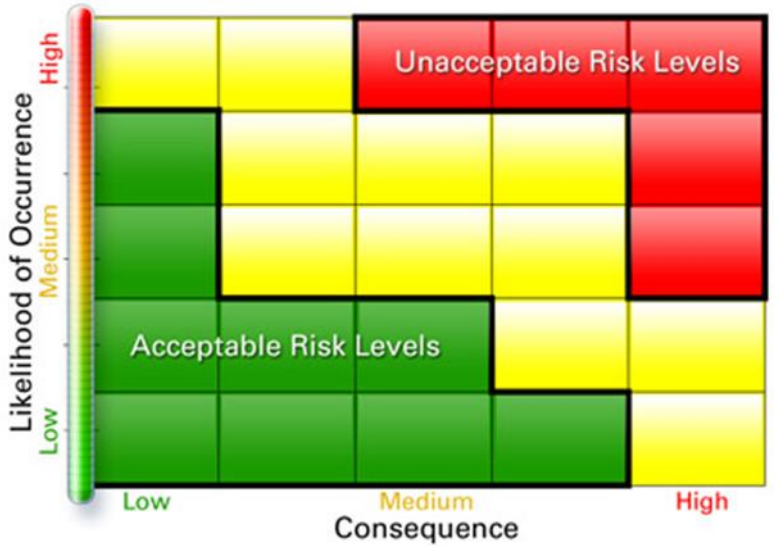


Partial condensation

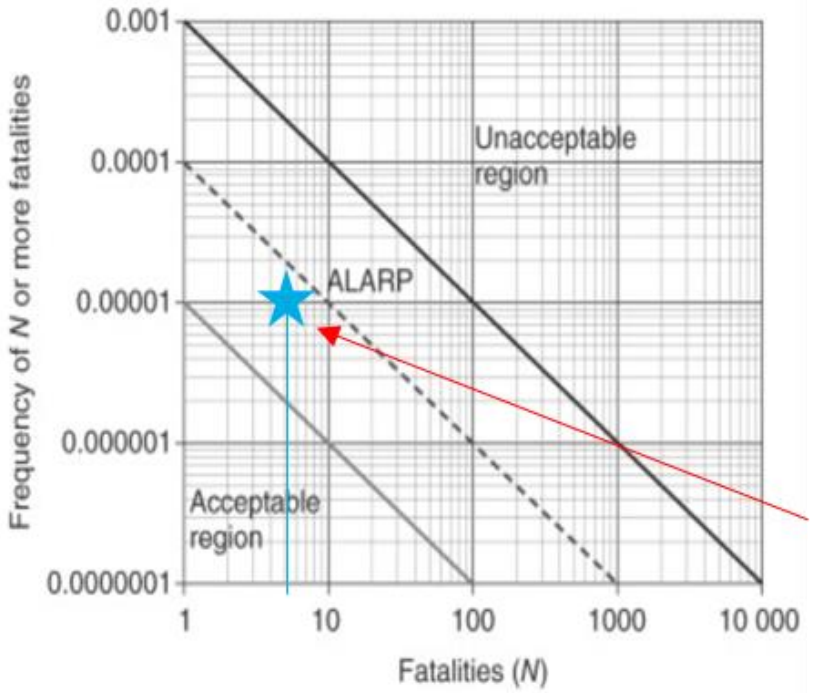


Risk based decision making

- In case the customer persists in a replacement in kind, the actual risk of such a configuration needs to be carefully evaluated against (inter)nationally recognized Risk Acceptance Criteria (RAC).

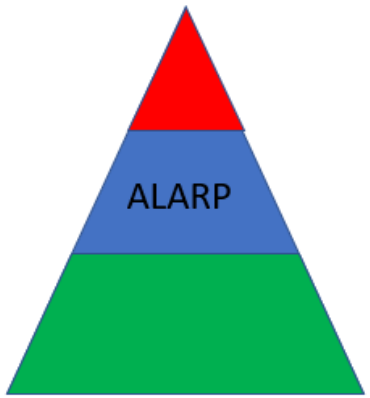


Risk acceptance criteria



HP scrubber fragmentation scenario (2-10 fatalities)

In general the **individual** risk of **plant population** is considered acceptable at a value below 10^{-5} per year.



>10^{-3} Unacceptable

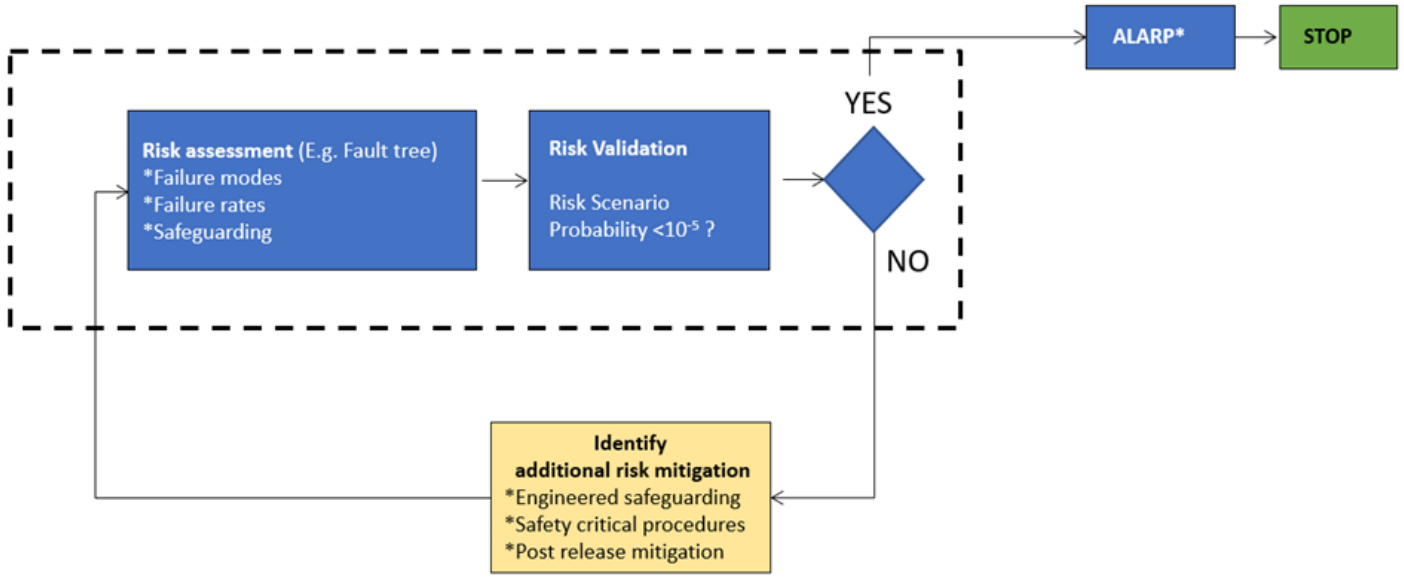
ALARP* demonstration (Tolerable region)

<10^{-5} Widely acceptable For new facilities *or* when latest standards can be applied to existing units with "reasonable "efforts (technically & financially)

***A**s Low **A**s Reasonably **P**racticable

Visualizing risk and mitigation opportunities

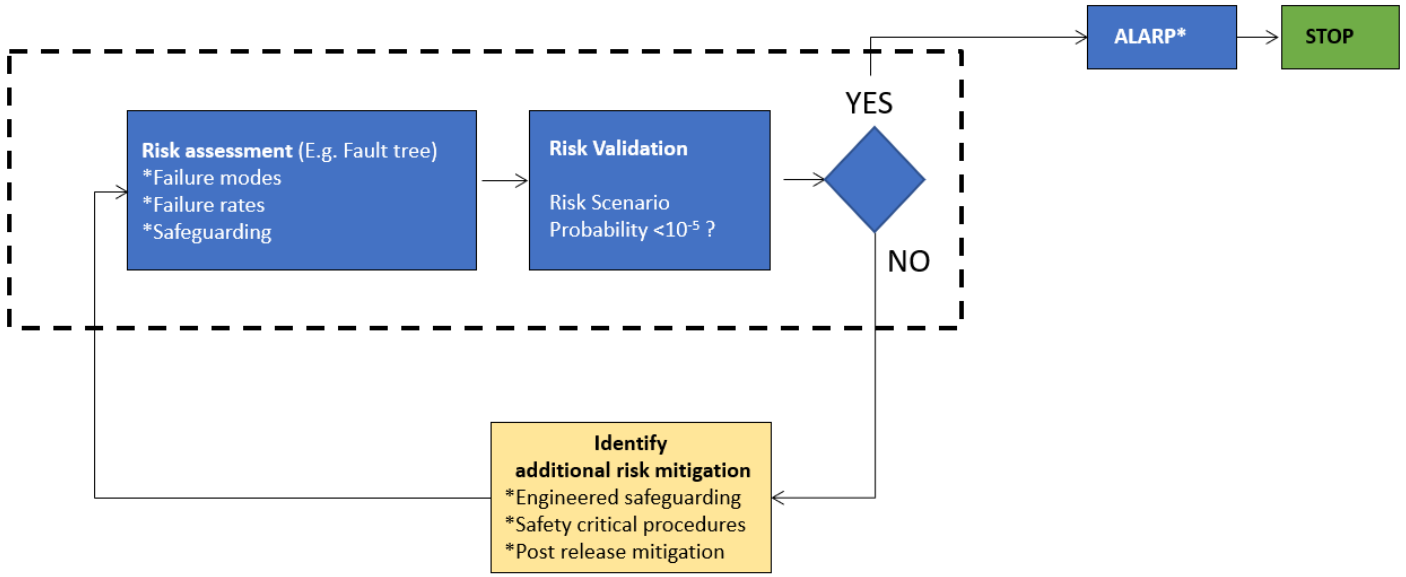
- Stamicarbon can facilitate a risk assessment by proposing an internationally accepted methodology and drafting the parameters determining the actual risk level.
- Providing the actual process conditions and details around already implemented safeguarding remains however the responsibility of the plant operator.



RAC criterium at ALARP midpoint arbitrarily set at 10^{-5} for the risk scenario (2-10 fatalities)

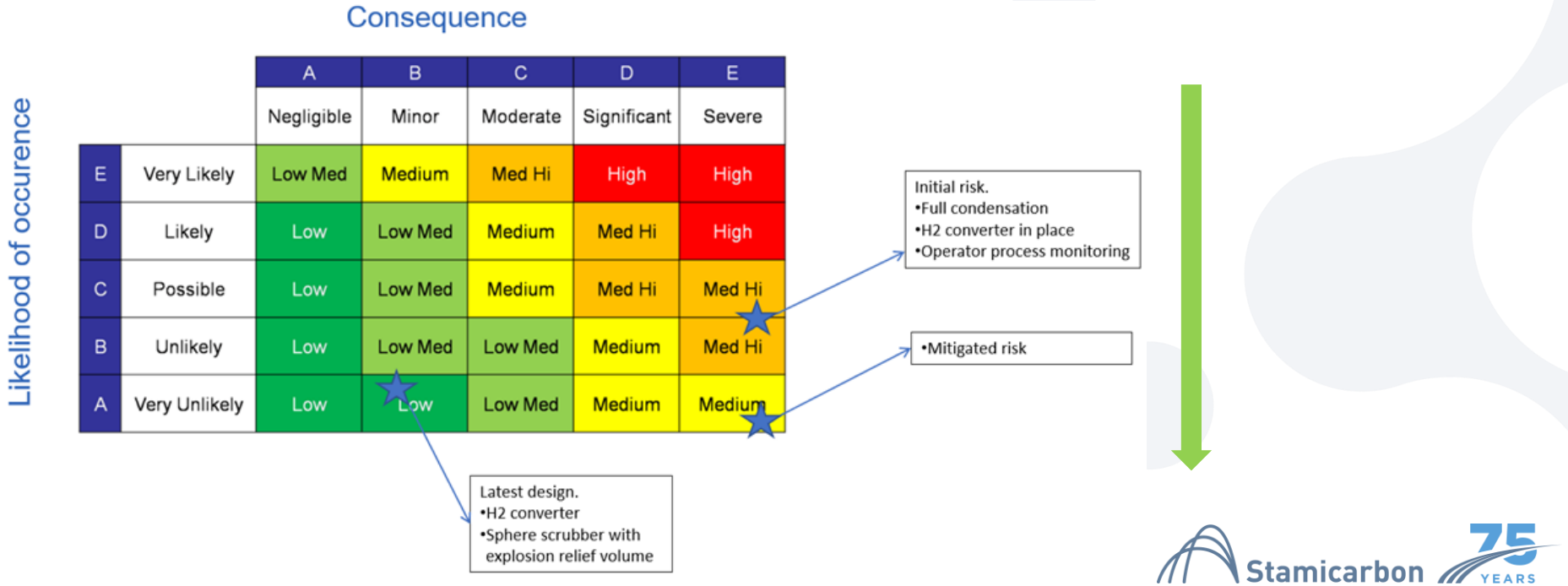
Visualizing risk and mitigation opportunities

- As the “disproportional cost” criterium is arbitrarily, ALARP demonstration in relation to the replacement of existing cigar type HP scrubbers may be difficult to defend towards legislators as affordable technical alternatives are readily available.



Visualizing risk and mitigation opportunities

- The high pressure cigar type scrubber with total condensation may not withstand an internal deflagration. The residual risk (Probability x Consequence) when operating these type of scrubbers can only be lowered by reducing the probability parameter; lowering the probability of the presence of an explosive atmosphere internally of the scrubber.



Probability mitigation

- Provide hydrogen converter with a ΔT measurement and 2003 SIL2 interlock to monitor its effective combustion process.
- Provide the discharge of the hydrogen converter with a continuous analyzer with a safety critical high hydrogen concentration alarm (Stami digital process Monitor).
- Lower Probability of Failure on Demand (PFD) of H2 analyzer by more frequent calibration.
- Prevent instantaneous failure of the hydrogen converter (catalyst poisoning by Sulphur and catalyst ineffectiveness by lubrication oil).
- NH3 feedstock preferably to be supplied from a refrigerated storage tank or flash section.
- Analyze NH3 feedstock periodically to verify that H2 content is sufficiently low.

Risk and mitigation opportunities

The downside of probability mitigation:

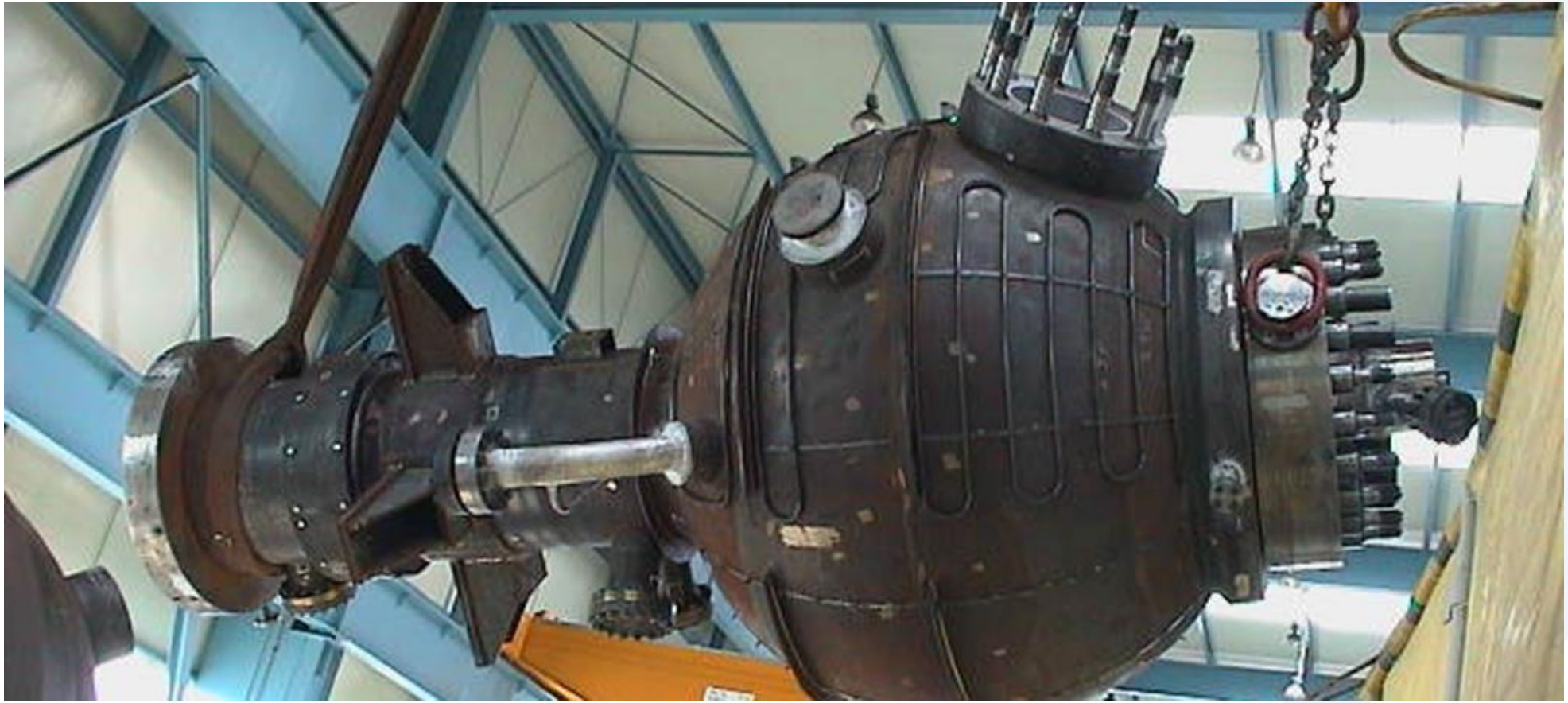
- To ensure the effectiveness of risk mitigation measures they need to be adequately maintained during the entire lifetime of the facility.

- Advantage of the sphere type HP scrubber:
  - It can manage an internal deflagration by design!

Prioritized Advice sequence

- Cigar type scrubbers of the partial condensation type are to be modified to accommodate an explosion dome volume as per latest standard.
- Cigar type scrubbers of the total condensation type are to be replaced by a sphere type scrubber with an explosion dome volume as per latest standard.
- Modify plant to the Evolve Melt Flash Design and elimination of HP scrubber
- Change scrubber to partial condensation type with sufficient explosion dome volume and adapt downstream section to handle additional ammonia vapors.
- In case the client persists to identically replace the high-pressure cigar scrubber of the total condensation type, a thorough safety study, under the responsibility of the client and by the approval of the (local) legislator, is needed. Stamicarbon can be of assistance to conduct such study.

Your next HP scrubber?



Thank you!

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