



safetec

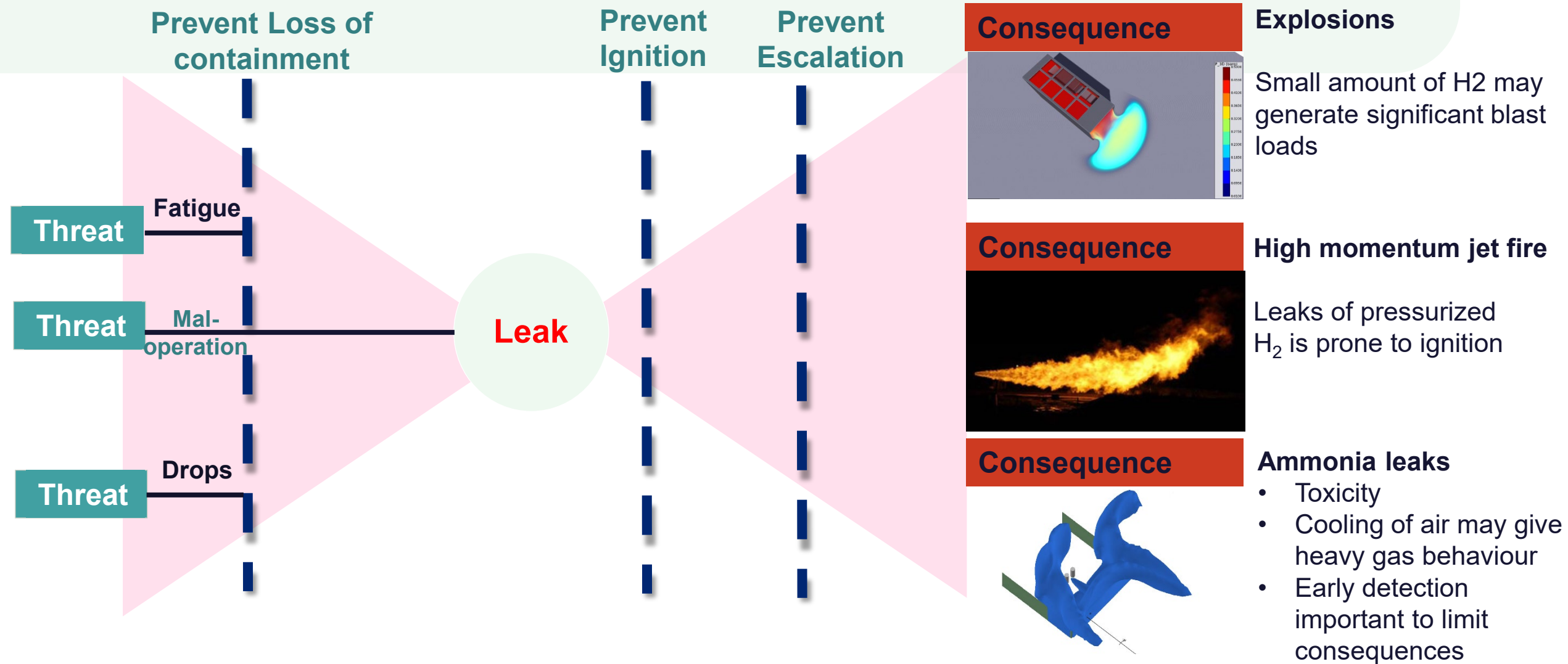
SAFEN, Safe Energy Carriers – nye metoder for risikovurdering av hydrogen- og ammoniakkanlegg

Sjøsikkerhetskonferansen 27.-28 september 2023

Linda Fløttum, Spesialistrådgiver Safetec

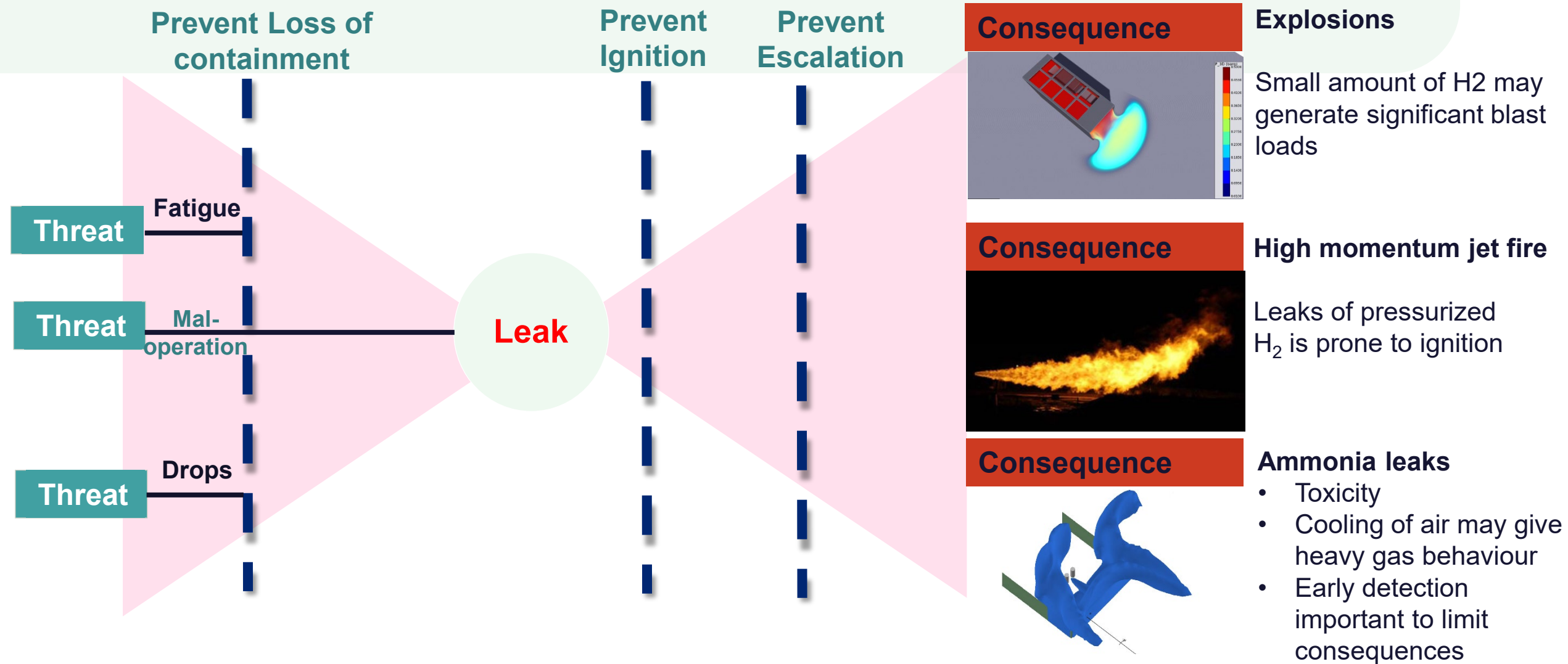


The well-proven risk management principles apply also for hydrogen- and ammonia facilities ..



...avoiding leaks even more important due severe consequences

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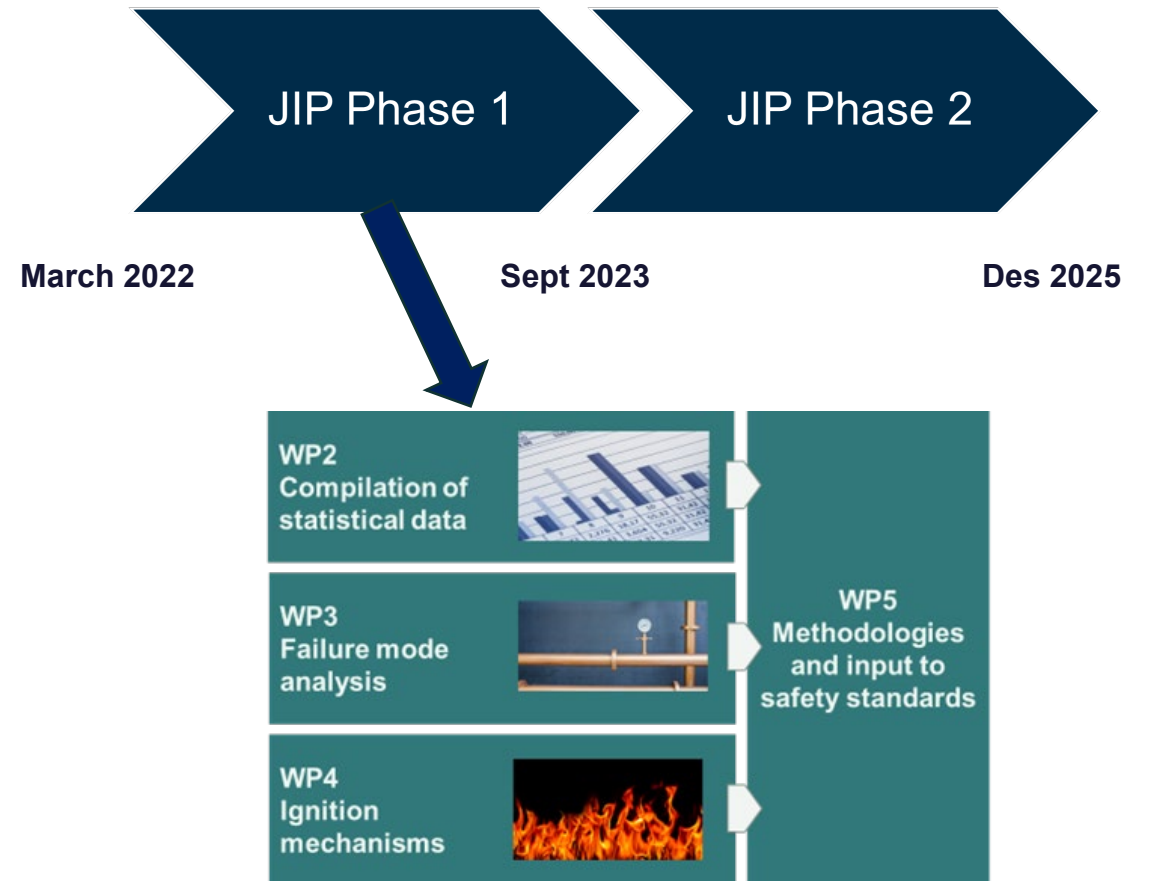
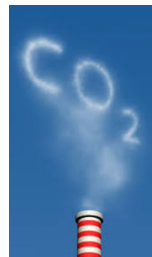


...avoiding leaks even more important due severe consequences

SAFEN Safe Energy Carriers

Closing knowledge gaps, sharing learnings and developing risk-based methodologies for hydrogen, ammonia and CCS facilities

- Status:** JIP project started up in Q1 2022, Phase 2 started in Q3 2023
- Schedule:** Phase 1 (1,5 years) + Phase 2 (2,5 years)
- Funding:** Industry partners and consultancies (in-kind)
- Budget:** 10 MNOK for Phase 1
approx. 22 MNOK for Phase 2
- Project owner:** Safetec
- Partners:** Consultancies, Authorities, Energy companies /Asset owners



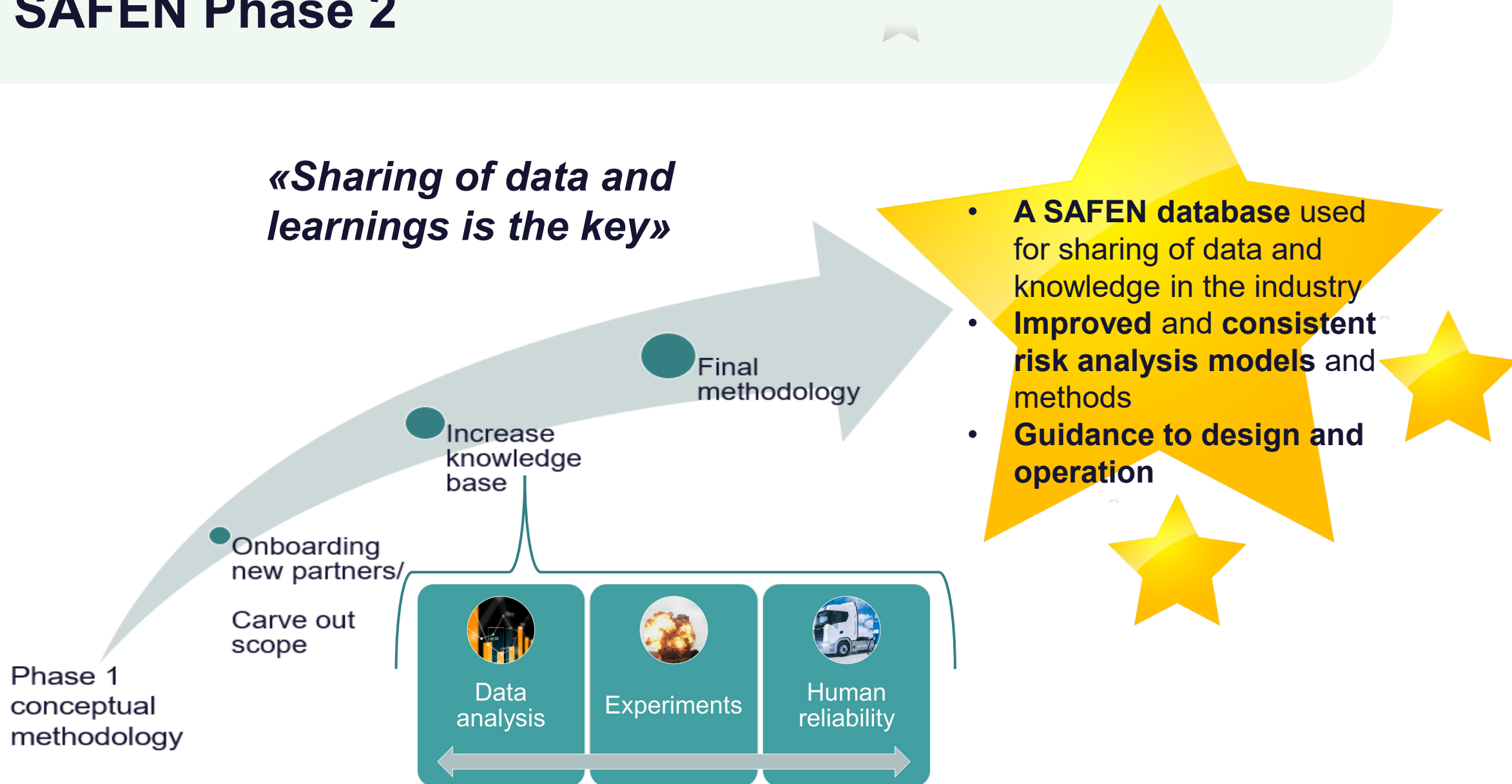
SAFEN partners

Project owner				
Partners (Contractors)				
Partners				2-4 add. new partners in Phase 2
				
Partners				
				
Authorities and associated members				



SAFEN Phase 2

«Sharing of data and learnings is the key»



Hydrogen & Ammonia in Maritime industry

Approval of alternative design according to IMO (MSC.1/Circ. 1455)

Safety
equivalence

Acceptable
total risk

- How do we make the comparison?
- How do we measure risk?
- Do we have sufficient risk analysis methods?

Maritime

Need to prove that alternative solution is as safe as conventional technology



Alternative



Conventional



Hydrogen in maritime – what are the risks?

Hydrogen as fuel



Photo: Norled

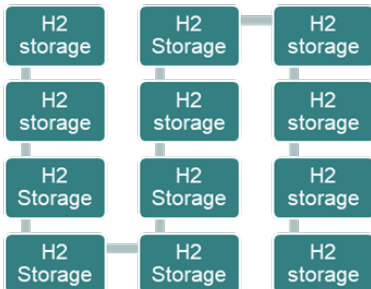
VS.

Hydrogen as cargo



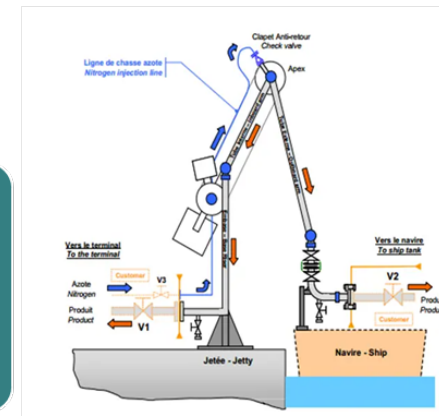
Picture: Gen2 Energy

Containerized storage



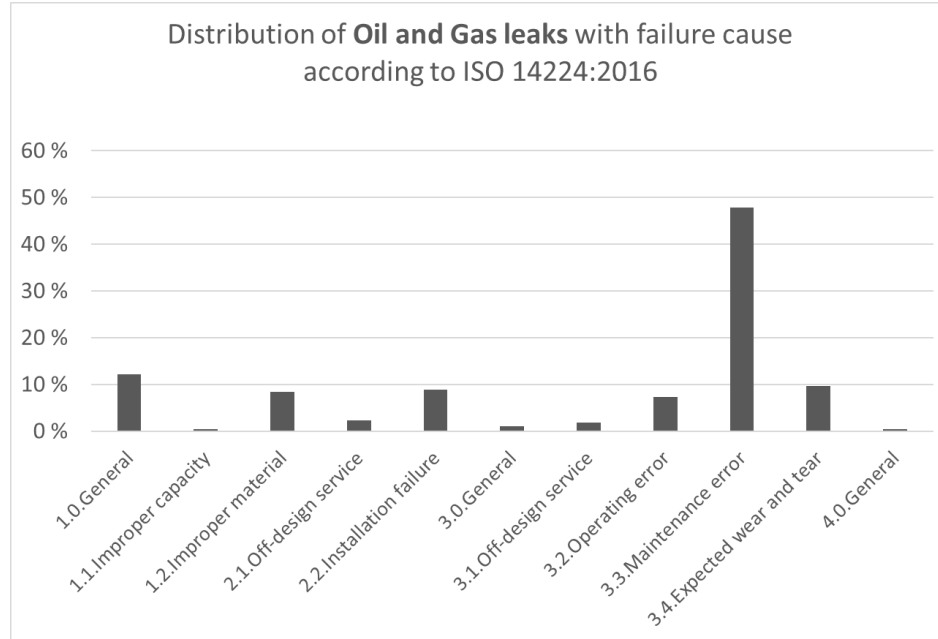
VS.

Integrated storage on vessel

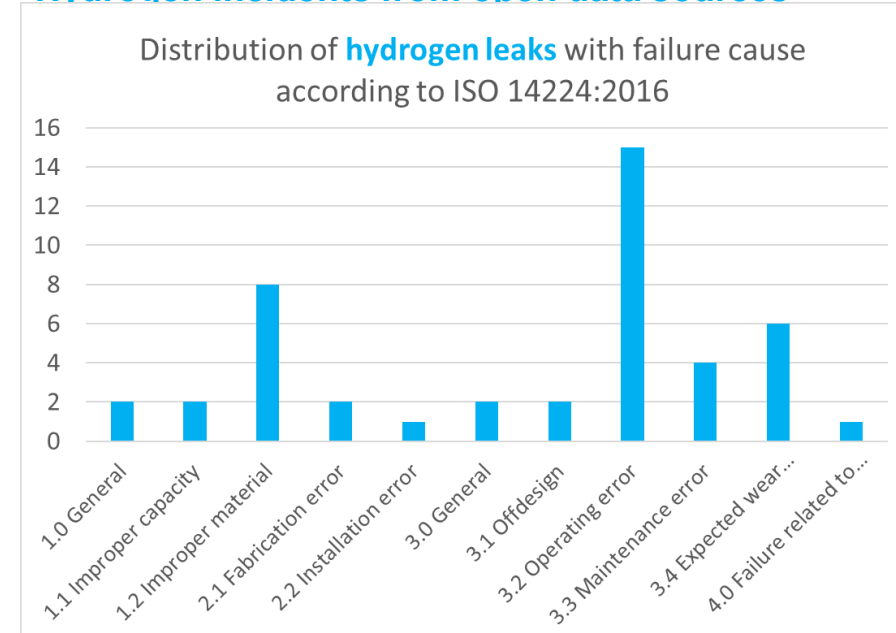


When are the errors introduced?

O&G: NCS and land-based plants processing oil and gas



Hydrogen incidents from open data sources



Release of hydrogen

- Tankhead consists of two pieces/caps each to be fastened by bolts with prescribed momentum
- Too weak momentum used for fastening bushing
- Initial leak through leak bore
- Secondary catastrophic leak potentially due to sudden failure of O-ring

GEXCON

The Sandvika incident in 2019 could be categorized as 2.2 Installation failure



Some recent hydrogen incidents



Ohio, february 2023



Hydrogen explosion in Austria | 'I live more than 3km away... and the blast made my windows shake'

Tank containing several hundred litres of H₂ explodes 'during testing' at valve manufacturer's premises

Austria, August 2023

SAFETY

Everfuel – Root Cause for Leaking Hydrogen Trailer Identified and Solution Campaign Have Been Initiated



Everfuel hydrogen leakage 2023



Engulfed in flames | Fuel cell bus in California destroyed after explosion during refuelling

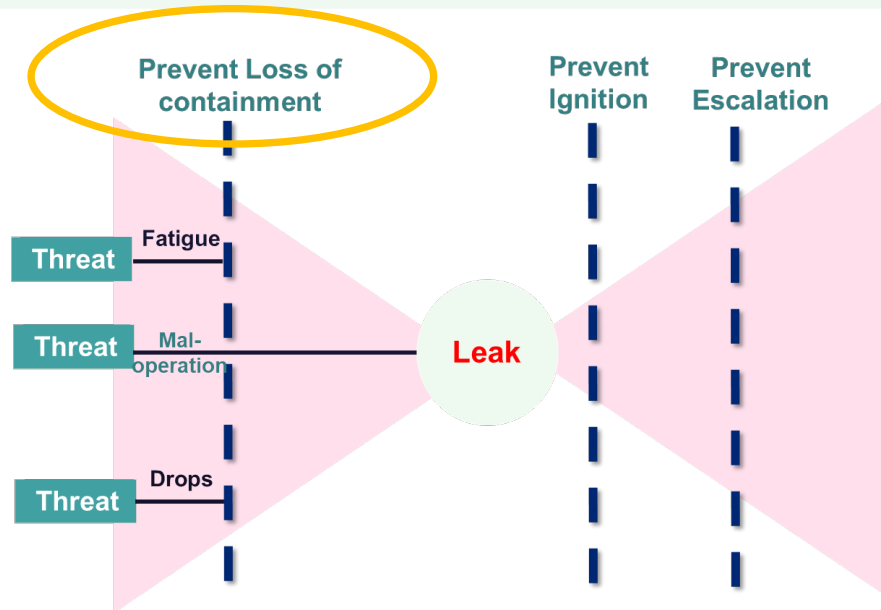
'Too early to speculate' on cause of fire, says bus company CEO

California, July 2023

What are the failure mechanisms?



How can the risk be reduced?



Understanding the failure mechanisms is the key!

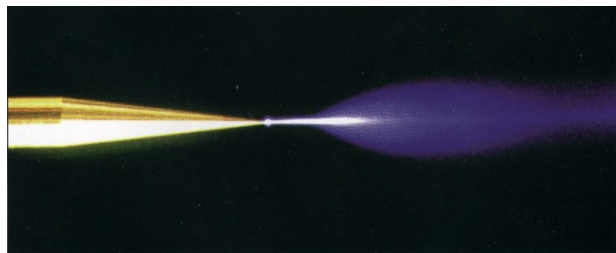
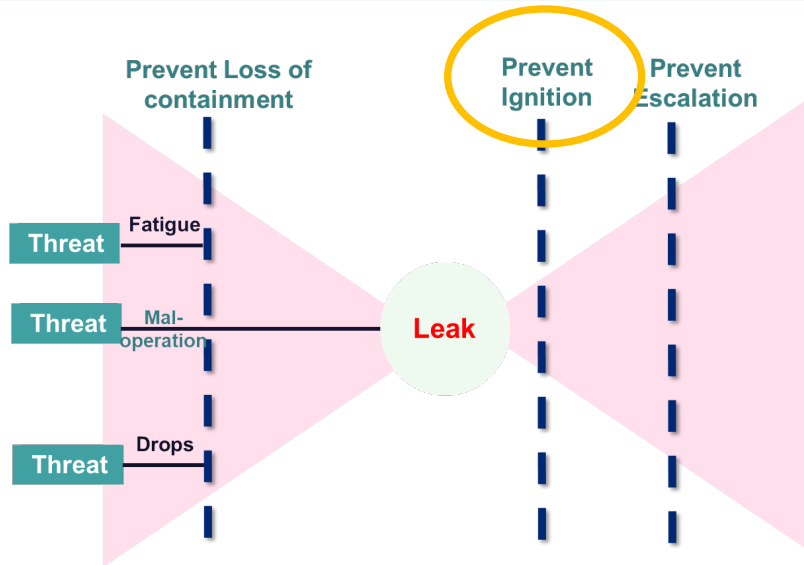
- The leak frequency is not only a function of the number of leak sources
- The human aspect should not be underestimated

Examples:

- Design to minimize risk for human errors during operation
- Operation & Maintenance strategy
 - shut down and depressurize before maintenance
 - Automation instead of manual operations
- Design to minimize leak potential (number of leak sources & scenarios)
- Avoid exposure to external impact (or protect)
- Ensure high quality during fabrication & installation
- Risk management & safety culture in operation!!



How can the risk be reduced?



Corona discharge



Mechanically generated sources

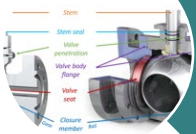
- Limit hydrogen gas cloud build-up
 - Utilize strong buoyancy (GH2)
 - Good ventilation
 - Locate high risk equipment/storage above deck
 - Reduce inventories
 - Rapid shutdown & isolation
 - ...
- Understanding the specific ignition mechanisms for hydrogen
 - => Suitable ignition source control, e.g.
 - ATEX equipment
 - Earthing philosophy
 - Vents – avoid sharp edges
 - ...



SAFEN models & methods



Catastrophic tank rupture



LoC model - Process equipment



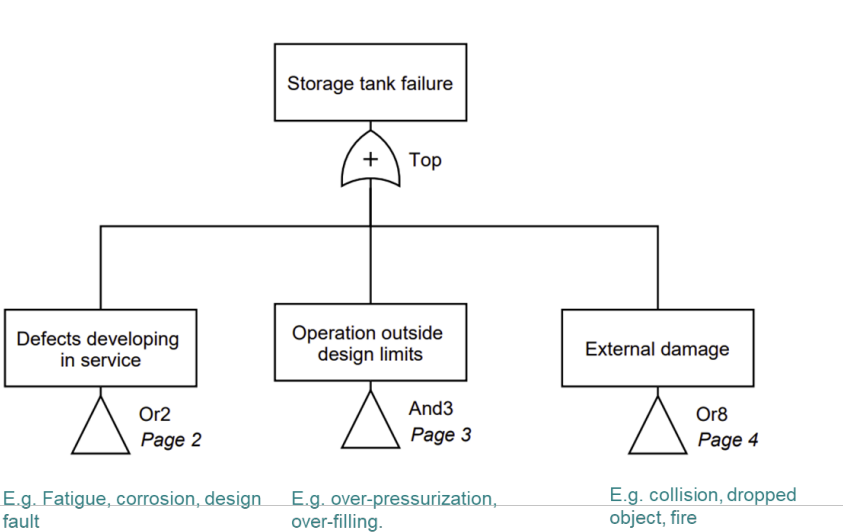
LoC model - Loading operations



Ignition probability model – hydrogen



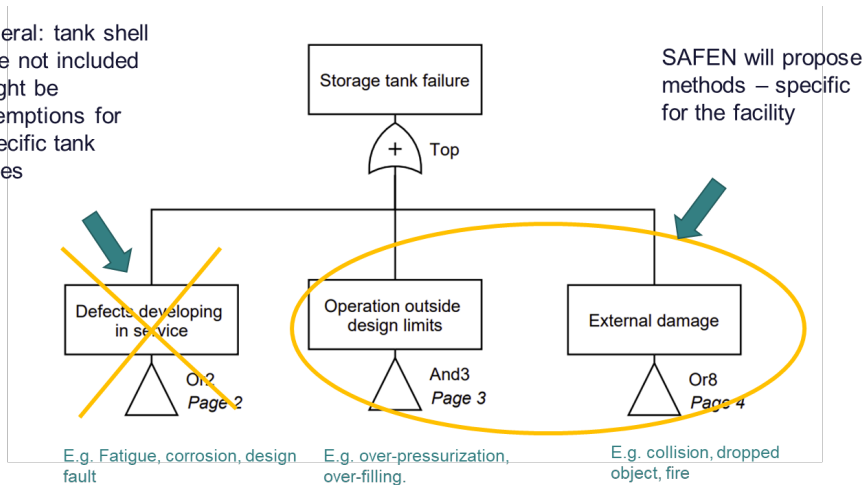
Storage tank failure – SAFEN approach (preliminary)



Storage tank failure – SAFEN approach (preliminary)

In general: tank shell rupture not included

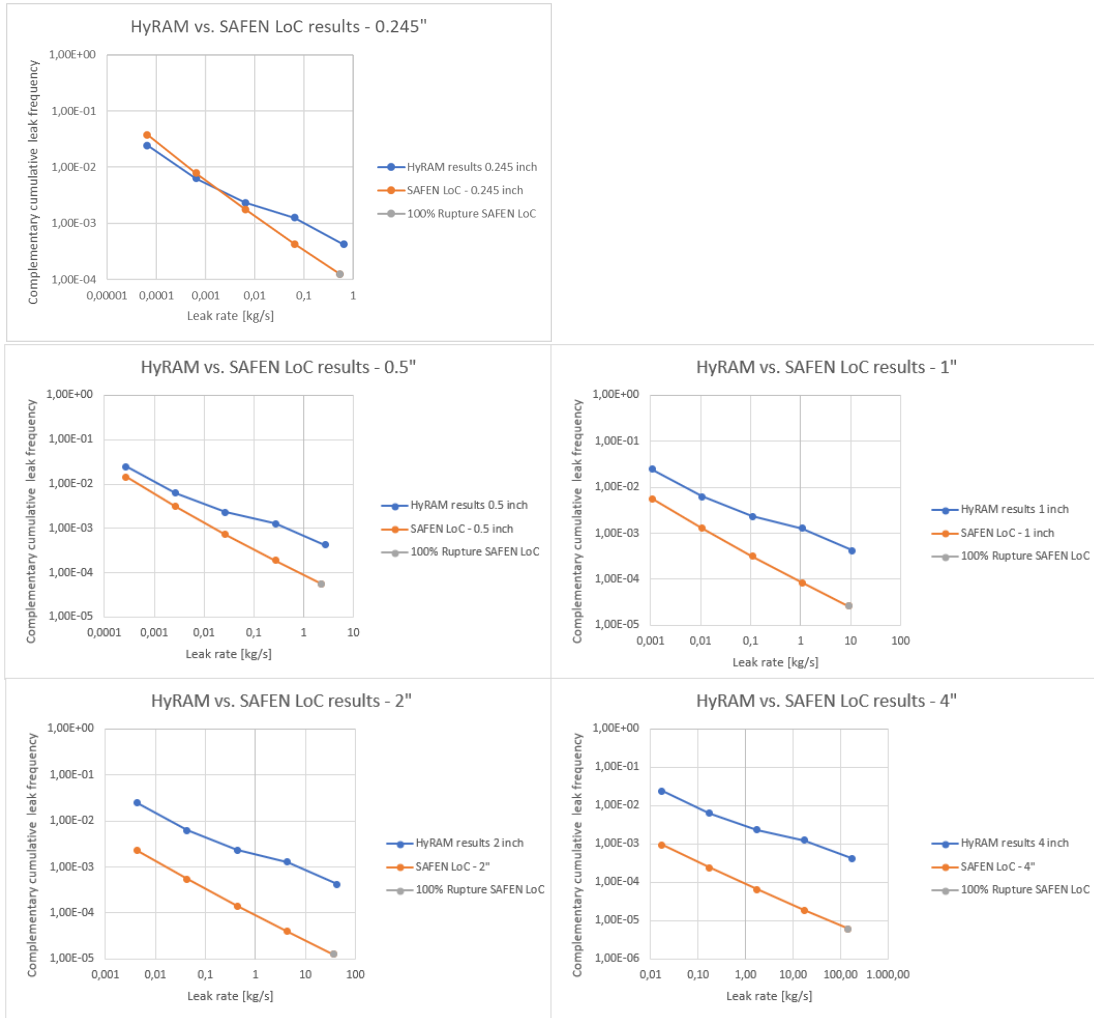
- Might be exemptions for specific tank types



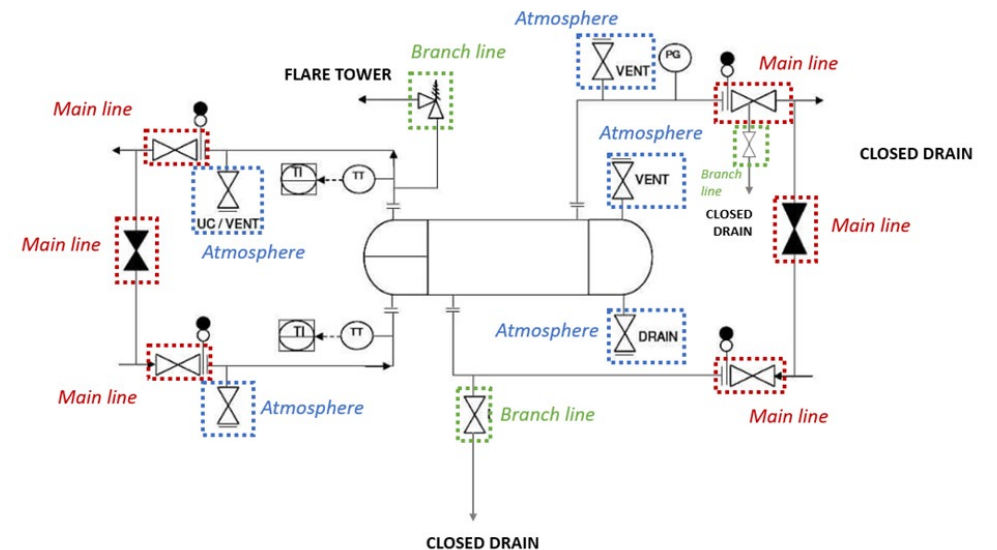
- «Defect developing in service»
 - In general: tank shell rupture not included
 - Minimum requirements to safety design and barriers
 - Leaks from tank nozzle and storage system valves & connections included – to be further evaluated in Phase 2
- SAFEN Phase 2 to further evaluate how to aggregate frequency for many identical items



SAFEN LoC model Process equipment (prelim)



- The model cover the following aspects
 - Valve role
 - Atmosphere
 - Branch line
 - Main line
 - ESD
 - # couplings
 - # of instruments
 - Pipe-in-pipe
 - Pressure/heat source (heat exchanger, pump, compressor)



Comparison SAFEN and HyRAM LoC model (HyRAM case example)



Thank you!



The SAFEN team, October 2022

Do you want to learn more about SAFEN?

Interested in joining?



TECHNICAL MEETING | LOSS OF CONTAINMENT AND IGNITION MODELLING FOR RENEWABLE TECHNOLOGIES INVOLVING HYDROGEN, AMMONIA AND CCS

[ADD TO CALENDAR](#)

London, United Kingdom From: 18 October 2023 09:30 (BST) To: 19 October 2023 16:00 (BST)



Contact info:



Linda Fløttum

Specialist adviser

📞 930 34 767

✉ linda.flottum@safetec.no

