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HySchool Webinar

28 Jan 2025

Protecting your
people, operations
and reputation

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Agenda

- ✓ About Gexcon
- ✓ Hydrogen Safety Fundamentals
- ✓ Hydrogen Safety in Buildings
- ✓ Safety design practises
- ✓ Verification by safety studies
- ✓ Public approval and stakeholder interaction

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Gexcon's mission

Chemical substances in industrial processes may take the form of liquids, powders or gases. They may be flammable or toxic. Consequently, they may pose risks to life, the environment and capital assets.

Gexcon assists clients to prevent releases of hazardous substances, to understand causal mechanisms and consequences so that effective mitigation measures can be established in the event of inadvertent releases.

How do we do this?
Gexcon applies physics, chemistry and mathematics to build numerical models for dispersion, fires and explosions. The models are implemented in software products which are used to predict the outcomes of releases of hazardous substances, providing crucial knowledge into the design and operation of industrial facilities.

The models and analytical approach is constantly updated to cater for new technologies, materials and methods in the industries we serve.

At Gexcon, we commit to protect people, the environment and minimize the risk of financial loss.

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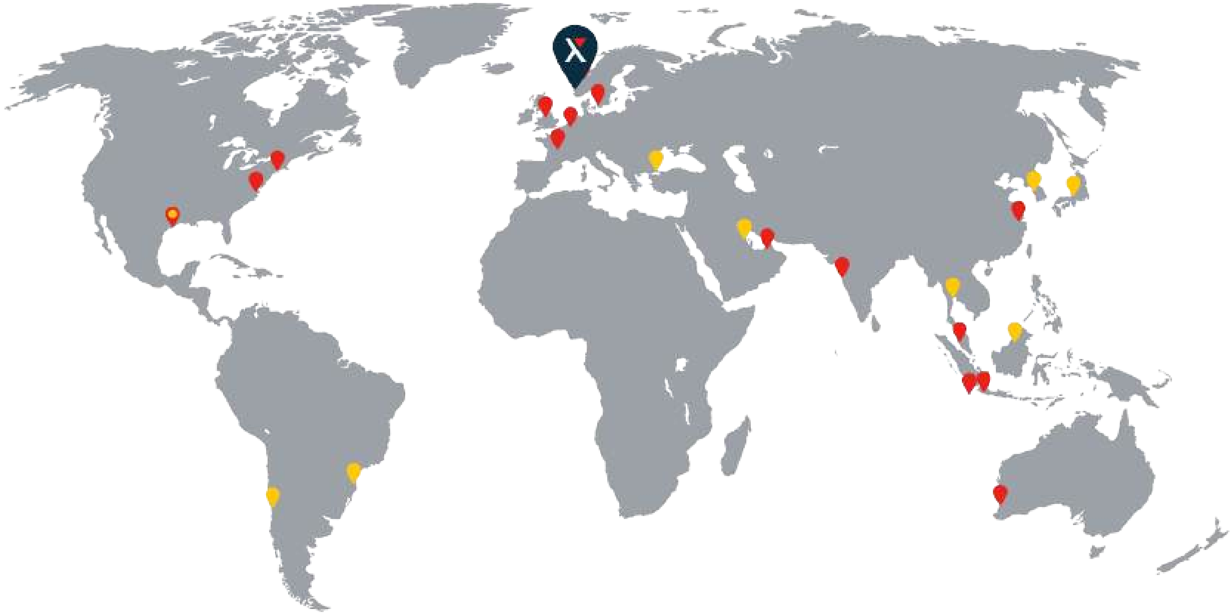

Global expertise with local understanding

Located across the globe, our teams can support your project anywhere in the world.

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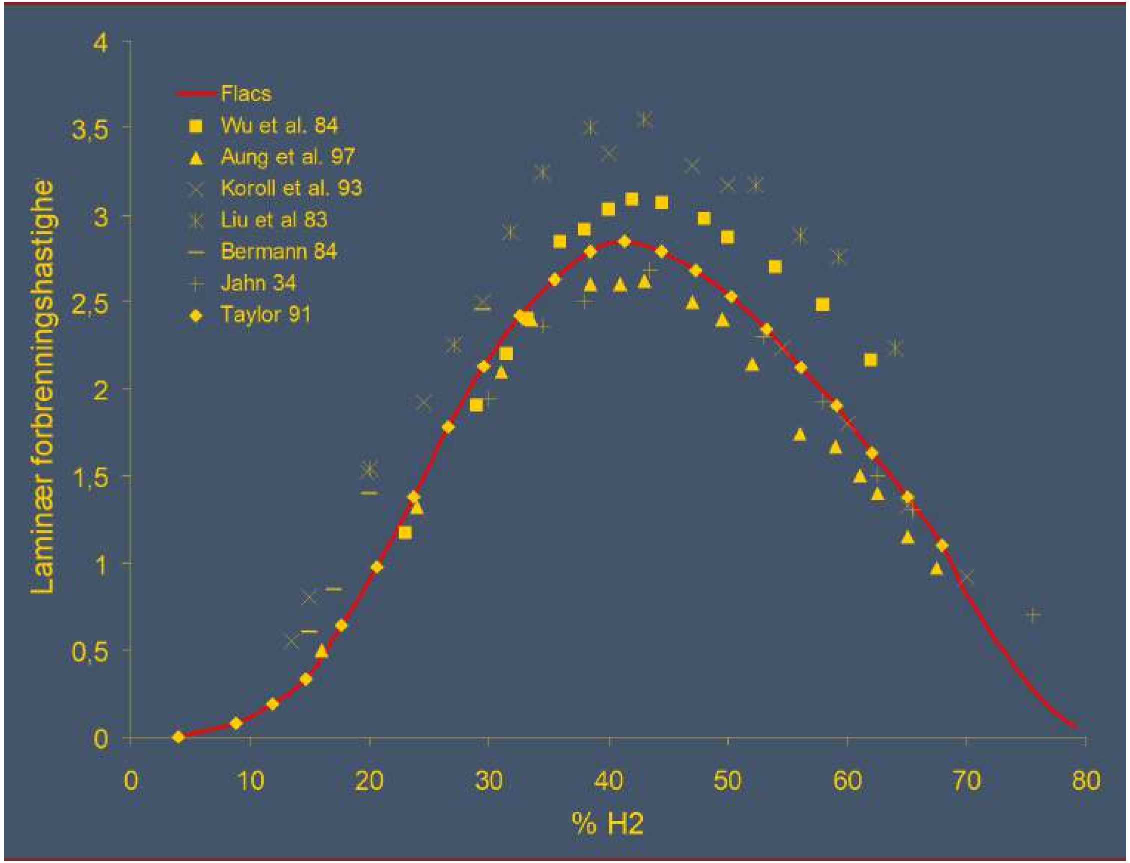
Hydrogen at a glance

Extremely buoyant:

- 14 times lighter than air
- Rises 6 times faster than natural gas
- Odourless and non-toxic
- Wide flammability range: 4 -75 %
- Very small molecules – leaks easily
- Laminar burning velocity about 3 m/s, which is 6 times faster than hydrocarbon gases
- Low ignition energy: 0.02 mJ which is about 10% of the ignition energy for hydrocarbon gases
- Negative Joule-Thompson effect and tendency for auto-ignition of leakages from high pressure



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Hydrogen safety in buildings

Hydro Herøya, 1985
Explosion with 10-20 kg hydrogen
2 fatalities

Full Scale test - confined

- 24 vol% H_2
- No vent devices
- Internal pressure approximately 1.1 bar

Full Scale test - vented

- 21 vol% H_2
- Plastic foil vent devices in ceiling
- Very low overpressure

Hydrogen Concentration Sensitivity

Identical Set-up, 12 vol% Hydrogen (left), 15 vol% Hydrogen (right)

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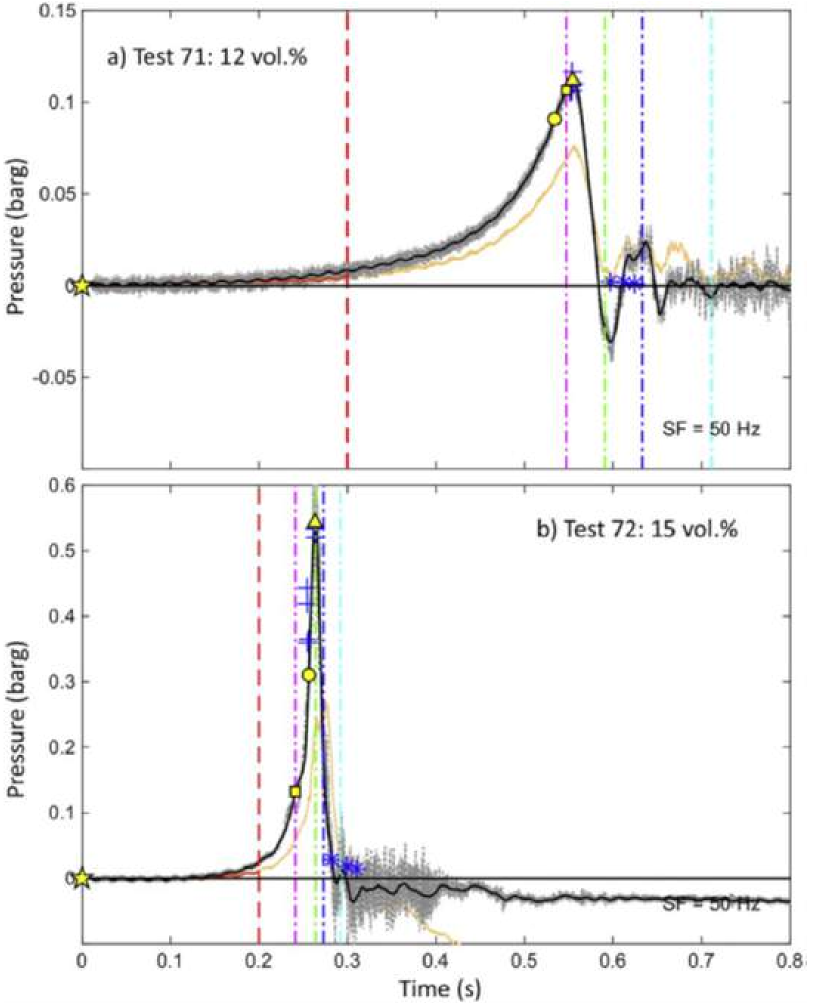
The effect of Hydrogen concentration

- Even a small difference in hydrogen concentration has a significant effect on explosion pressure
- The two graphs on the right shows pressure-time histories of experiments with 12 and 15 vol% hydrogen, respectively
- Rate of pressure rise in the two experiments
    - 0.1 bar across 0.25 seconds – 0,4 bar/s
    - 0.5 bar across 0.07 seconds – 7,2 bar/s – 18 times faster
- This may be what separates explosions which can be vented effectively, and those which can not.



Implemented in Software

- 21 vol% H_2
- Commercially available pressure relief panels
- Very good agreement with experiment
- Can be used for preditions and support design.

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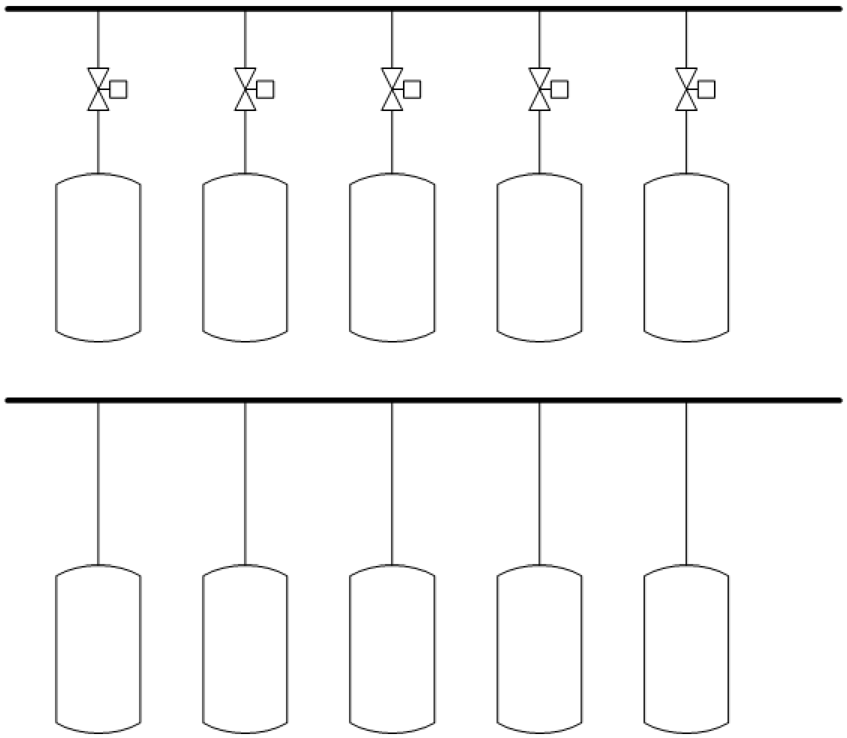
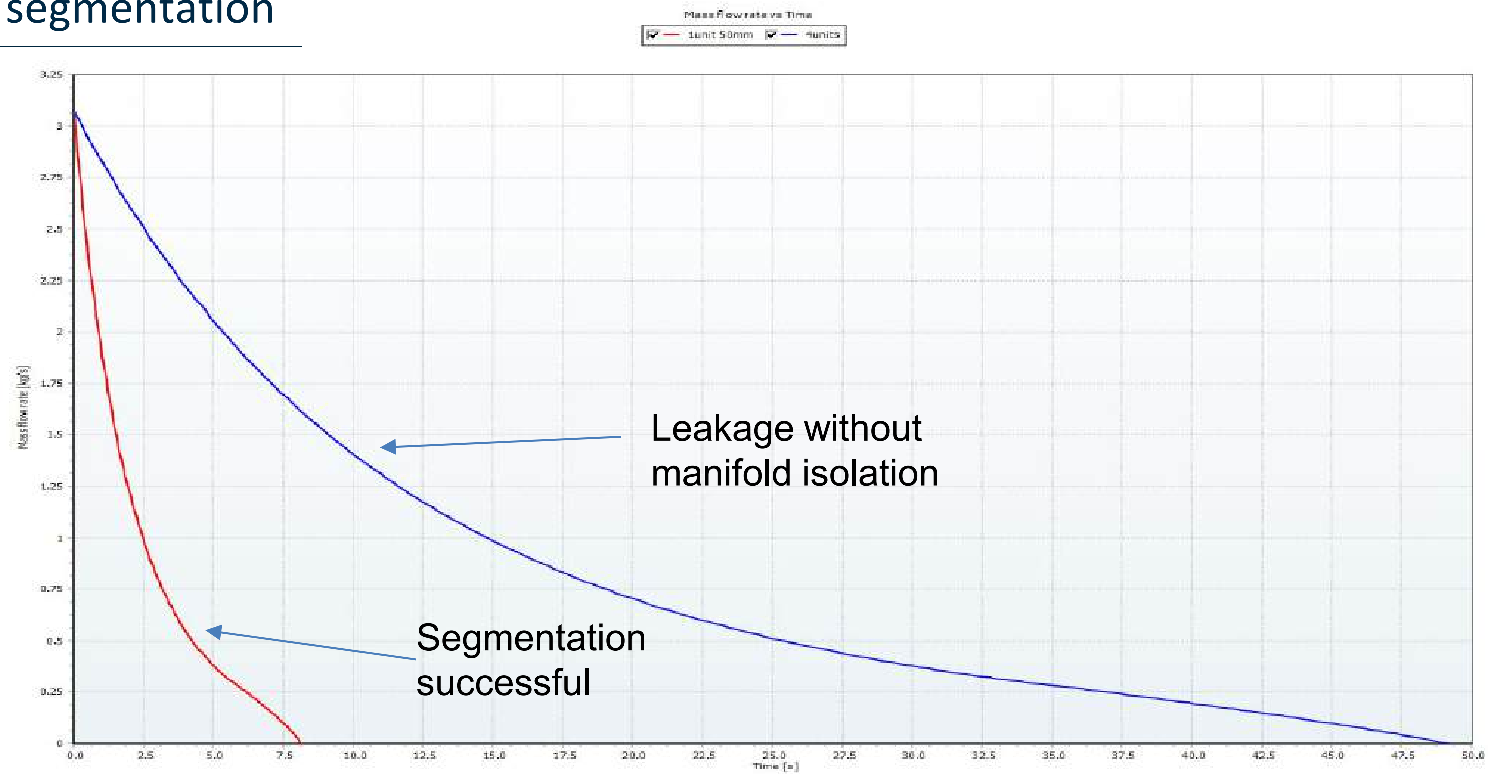
Segmentation

- Limiting inventories which may be released in a leakage event is crucial to safety
- Manifolded equipment should be isolated individually towards the manifold to limit the duration and overall volume of leakages
- The result is smaller clouds with lower hydrogen concentration



Effect of segmentation



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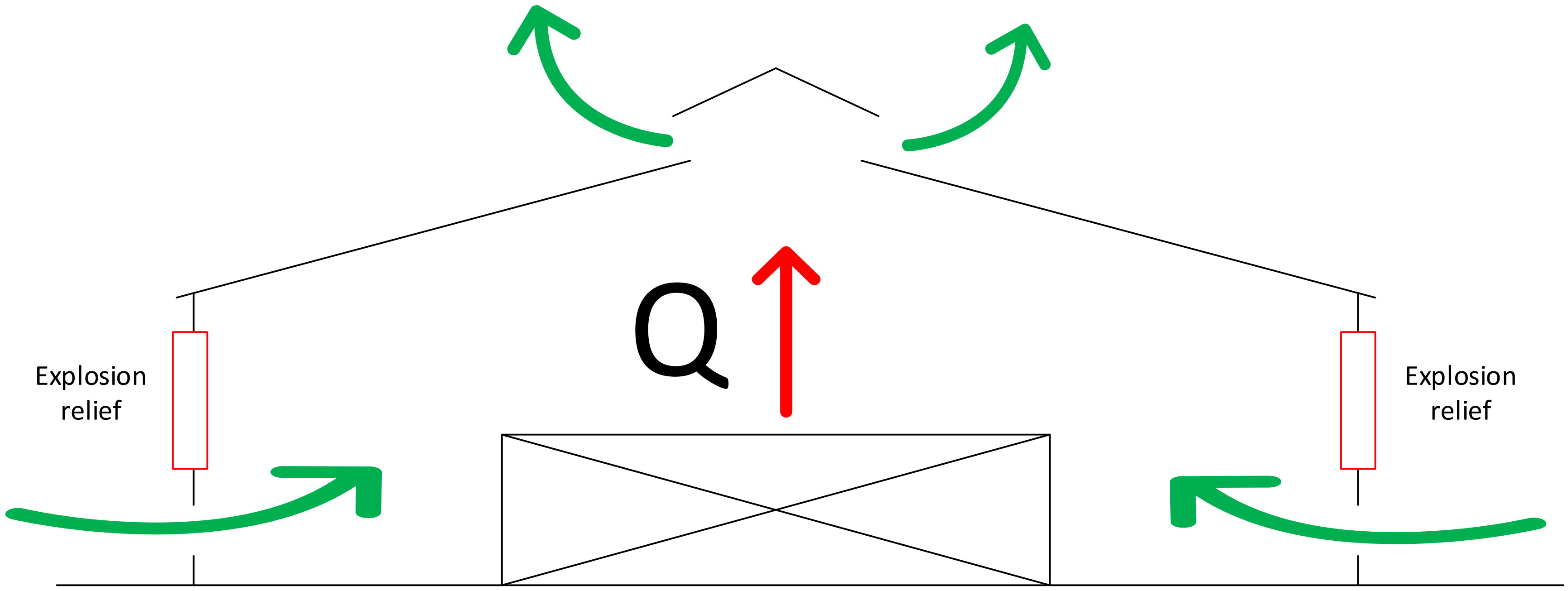
Building design



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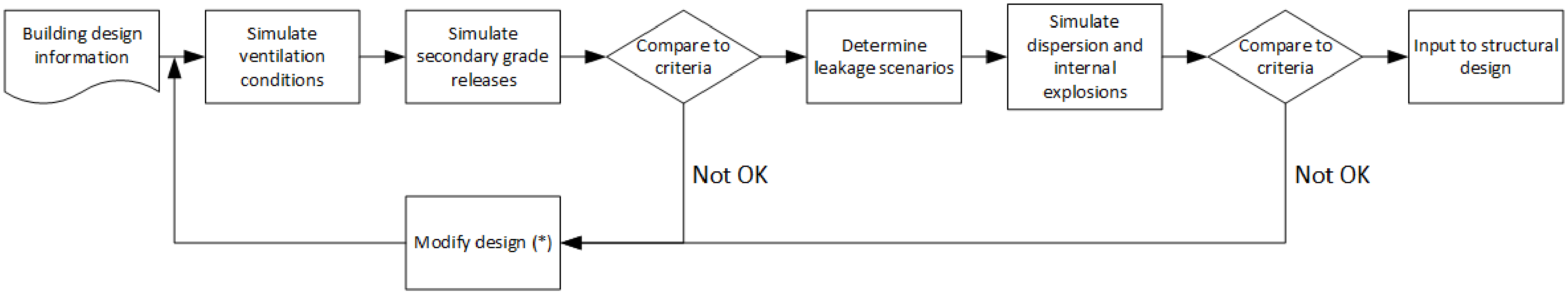
Design development and verification

Two main criteria to fulfil

- Dilution of secondary grade releases in accordance with IEC 60079-10
- Determine size and position of explosion relief panes so that
    - Internal explosion pressure does not jeopardise structural integrity
    - Explosion pressure waves are directed away from vulnerable areas



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Other good safety practises

- Natural ventilation where possible
- Avoid possibility for accumulation of buoyant gas
- Limit size of isolatable process segments
- Limit potential leakage sources
- Fully paved areas under pressurised systems
- Avoid asphalt paving under cryogenic systems
- Ignition source control ATEX ‘IIC’ or ‘IIB + Hydrogen’
- Management of change
- Develop and enforce suitable maintenance and inspection procedures
- Training of personnel

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Verification by Safety Studies

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Fire, explosions & toxic clouds cause disasters

Industrial disasters may occur upon release of hazardous substances, failure of safety systems, or human error, as seen in numerous chemical accidents over the years.

Fires can cause extensive damage to facilities and pose significant threats to workers and surrounding communities.

Explosions can destroy infrastructure, causing fatalities, and lead to secondary fires or toxic releases.

Toxic clouds can expose people to harmful substances, leading to respiratory issues, long-term health problems, or even death.

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Historical context

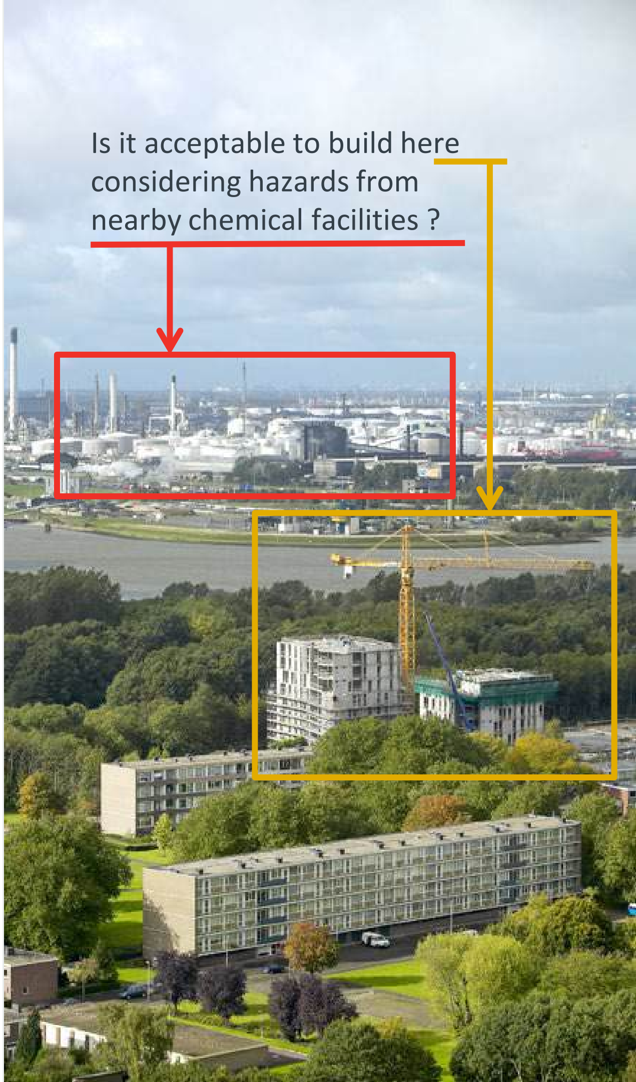
Densely populated areas close to industrial sites require strict regulation on public safety.

Catastrophic chemical industry accidents in the 1970s, led to the implementation of **Seveso Directive.**

These directives mandate companies to develop safety reports (including QRAs) to comply with government safety requirements.

National authorities have developed local regulations on the basis of the Seveso Directive. (Norway: Storulykkeforskriften)

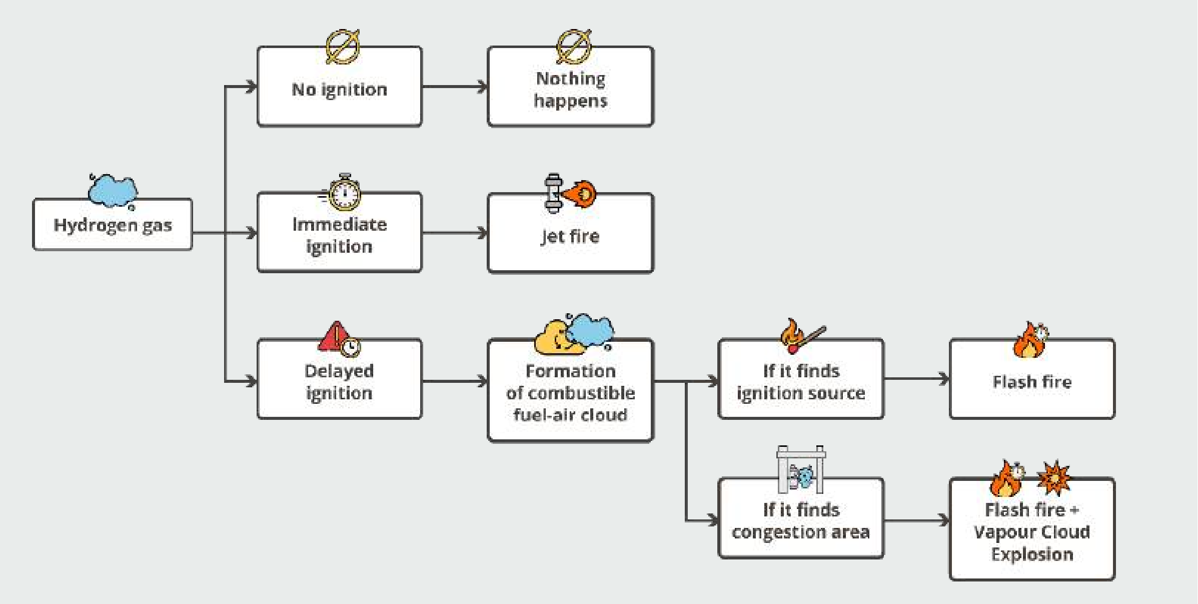
Today, risk criteria are used during land use planning.



How to ensure process safety?

It all starts with loss of containment.

- Awareness starts with realising what might happen upon a “Loss of Containment” (LoC)
- Consequence from LoC depends on chemical, storage conditions and release scenario.



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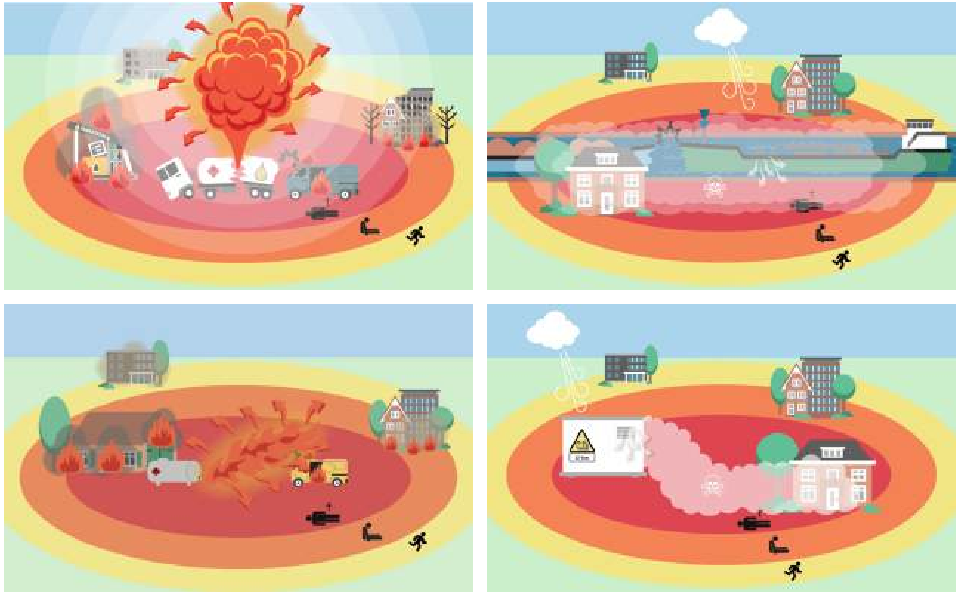
Consequence modelling

- Predict the consequences of an accidental release of a hazardous material
- Calculate the consequences that a fire, explosion or dispersion scenario have on surrounding population and structures.
- Understand these consequences to design and operate safe facilities (i.e., implementing prevention and mitigation measures).



Risk modelling

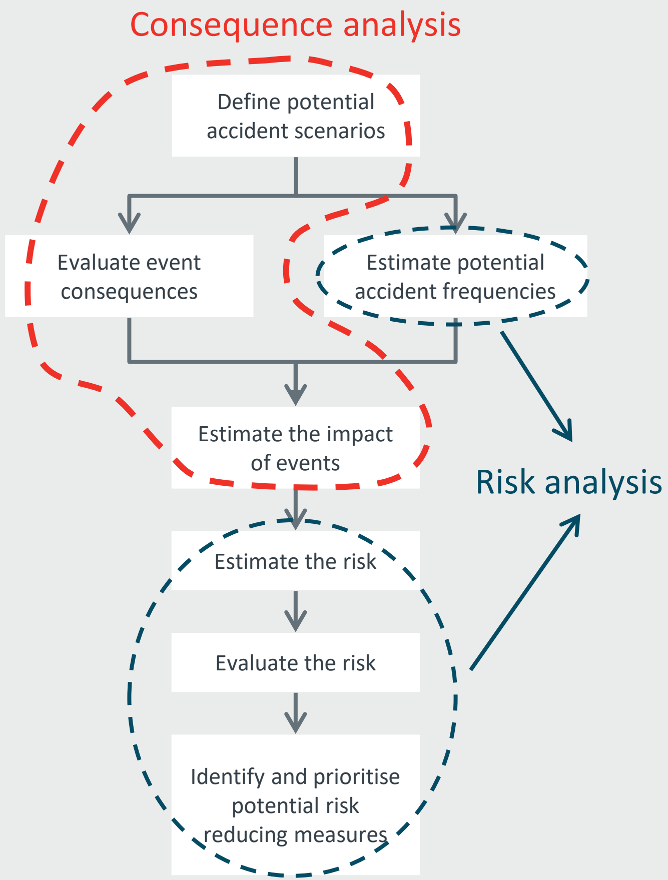
Consequence modelling

- To calculate the consequences
  - What could happen? (including external events)
  - If it happens, how dangerous is it?
- Part of Quantitative Risk Assessment (QRA)

Risk modelling

- Risk = Likelihood * Consequence
- Uses failure frequencies & weather statistics
- Uses risk criteria: quantified values to determine "**acceptability of risk**"

QRA



Public approval and stakeholder interaction

Major Hazard Facilities – Public approval

- Hydrogen facilities in Norway with total inventory exceeding 5000 kg will be subject to the Major Accident Regulation (Storulykkeforskriften). This means that the site owner must apply to DSB for a consent to operate.
- As part of that process, a Quantitative Risk Analysis (QRA) must be developed in accordance with applicable guidelines.
- Methods and acceptance criteria for 3rd party risk are defined in these documents
- Similar principle in several other countries, but with differences in acceptance criteria and documentation requirements.

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Influence zones

Zone	Description	Risk threshold (per annum)
Inner zone	This is usually the facility site itself. In addition, it can include areas used for agricultural purposes. Only short-term human presence is acceptable, such as people passing through on already established hiking trails.	1×10^{-5}
Middle zone	Public roads, railroads, docks and similar. Permanent places of work, such as industry or offices, is also acceptable in this zone. However, there shall be no hotels or residential buildings. Scattered residences may be accepted in some cases.	1×10^{-6}
Outer zone	Residential areas and areas with access for the general public may be inside the outer zone, including shops. Buildings with high occupancy such as schools, day care centres and hospitals, shall be located outside the outer zone.	1×10^{-7}

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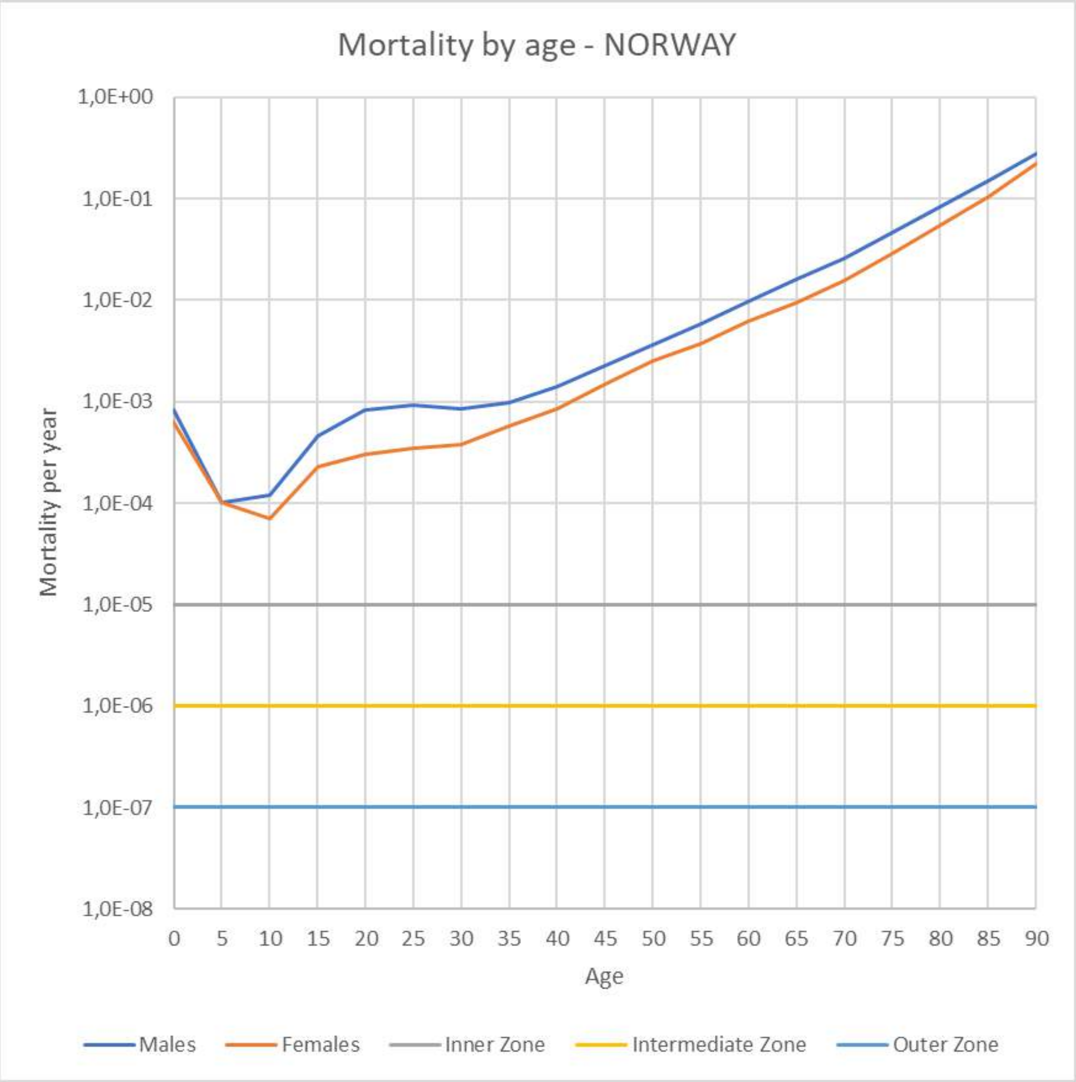
Societal lethality vs DSB limits

- Requirements for safety around major accident sites in Norway are generally very strict compared to general mortality in society



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Stakeholders to consider

- Local authorities, police, fire brigade etc.
- National authorities – typically for consent to operate Major Hazard Facilities
- Local community, including local press
- Neighbours
- NGOs

- Engage with stakeholders from an early stage of the project
    - State your intentions
    - Be visible – hold open meetings
    - Explain how safety is implemented and ensured throughout the project development
    - Use tangible examples
    - Be straightforward about potential impacts (both positive and negative)

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Thank you for your attention

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