RispEX

ESRA

Jens Johansson Garstad and Sjur Helland

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Agenda

Context and objective

What is RispEx and what is it used for

How does it work

Validity and benchmarking

Summary

Explosion analysis for oil and gas development projects – context

- Identified challenges:
  - Complex probabilistic explosion models with many user-influenced input parameters
  - Input with the right level of detail not available when the DeALs need to be specified
  - Still, late in detail engineering or even when asset is going into operations:
    - There is uncertainty in the input to the analysis
    - There is uncertainty in results due to complexity in model
- Experienced consequences:
  - Significant cost and weight impact on project
  - Late design changes due to significant uncertainty in DeAL
  - Significant resources spent on explosion analyses in detail engineering with limited effect on design

Road to RispEx

An explosion load model that

- provide the required decision support when needed
- is transparent and traceable
- is based on the best industry knowledge

RispEx

RispEx development:

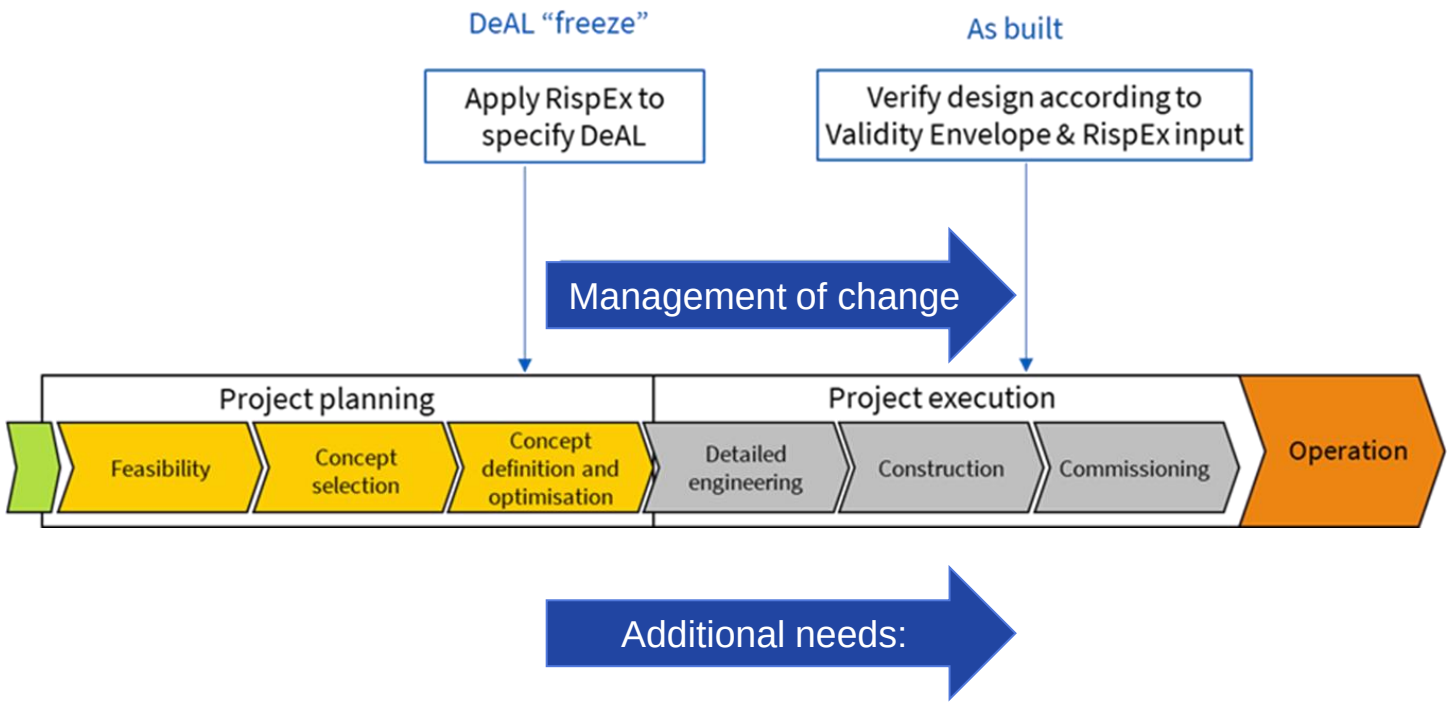
- Separate project initially performed by DNV and Aker Solutions
- Further development DNV
- Project owner has been RISP steering committee

2018	Risk management & Decision process
2019	**Explosions (several)**
	Fires
	Other accidents
	Regulatory Framework
2019-2020	**RispEx Model development (AKSO & DNV)**
2022-2023	**RispEx model improvement (DNV)**

Overall objective RispEx tool

- The objective is to make a **digitalised "look-up approach"** based on known risk profiles
- Based on few input parameters, all known before DG2, the tool shall provide:
  - Recommended **Design Explosion Loads** for a design/module
  - Typical **accidental scenarios** to be used in Risk Management context (design optimization, ALARP, management of change)
- The **same safety level** shall be achieved when using RispEx vs. traditional methods
- Validity shall be clearly defined with a **"validity envelope"**
- Shall be available through **an internet portal**

Explosion risk decision support in different phases



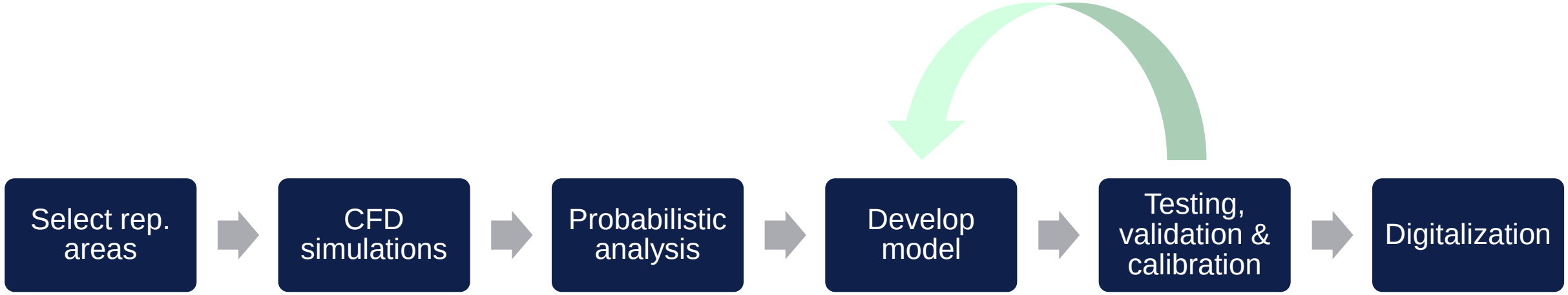
- Detailing of explosion loads and other design input
- Sensitivities for ALARP and design optimisation
- Understanding the risk picture

- Project planning phase:
  - Evaluate if RispEx can be used
  - Sensitivity analysis
  - Specify DeAL

- Project Execution
  - Follow-up input / basis for DeAL
  - Use "Accidental scenarios" for Risk management purpose

Some assessments might require more detailed analysis in addition – therefore developed scenarios to be used for MoC and optimisation

Main steps in development



- 26 process areas fixed platforms
- 7 wellhead areas
- 5 FPSO process areas

-> 38 areas in total

- Ventilation
- Gas dispersion
- Explosion

- Express
- Develop predefined risk curves

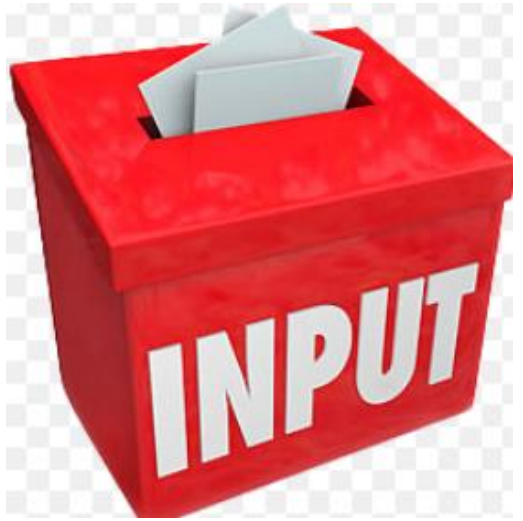
- Interpolation logic
- Validity envelope

- Validation
- Comparison with PLOFAM2/ MISOF2 analysis

- Digitalized tool
- User manual

Input and output of the model

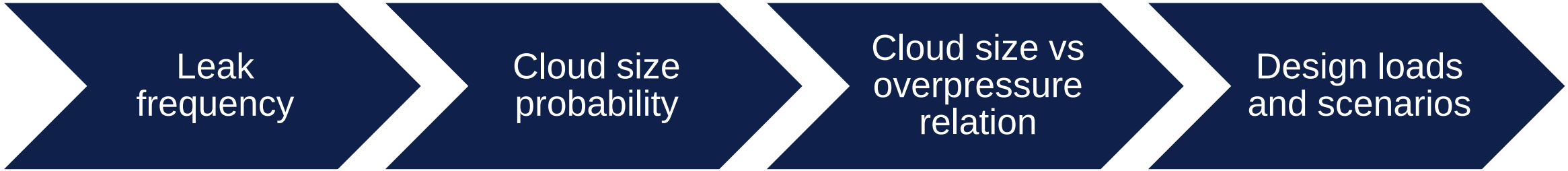
- Type of concept (jacket platform, FPSO)
- Type of area (process area, wellhead area)
- Area specific input
  - Wellhead area: number of wells, Representative blowout rate category
  - Process area: Function (gas process, separation, oil process)
- Dimensions of area (provides both size and shape)
- Openness per side (provides confinement degree / explosion relief / natural ventilation conditions)
- Effect of specific strong ignition sources
- RispEx is available here: RispEx



Output

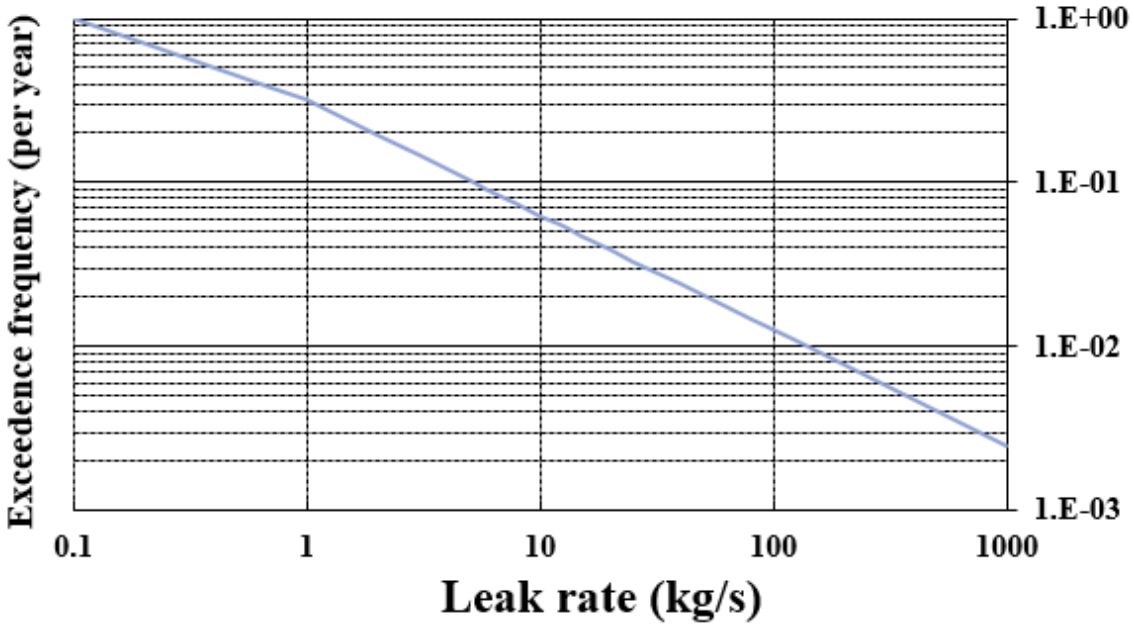
- Explosion DeAL
- Scenarios for MoC
- Frequency vs cloud/overpressure relations

Overall calculation flow

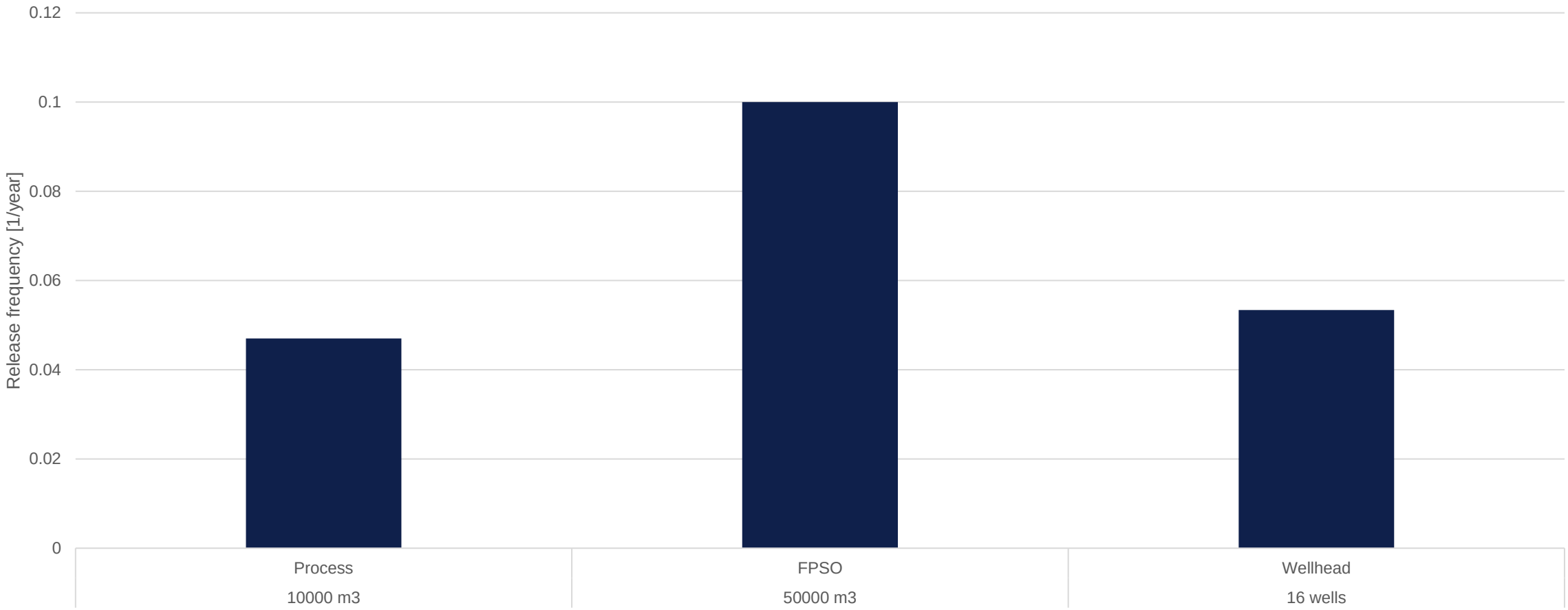


Leak frequency model

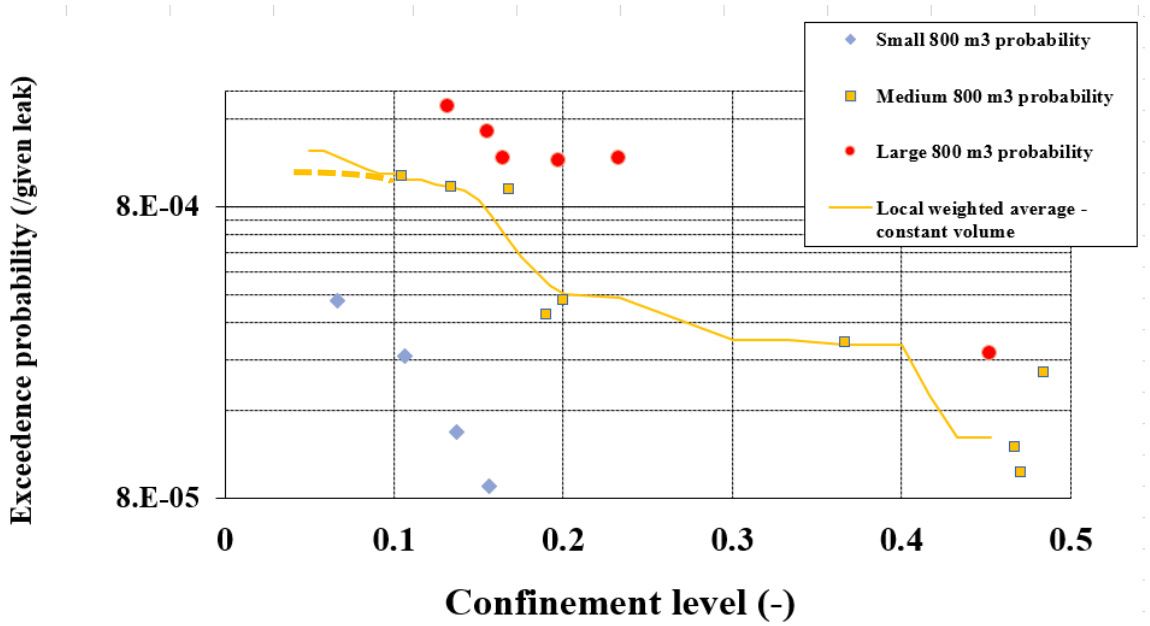
- RispEx uses a simplified leak frequency model. The total leak frequency is estimated as:
  - Proportional to the area size for process areas
  - Linearly dependent of the number of wells for wellhead areas
- For process areas the leak frequency per cube meter is applied from MISOF2 report
- For wellhead areas and FPSO process areas scaling parameters are found based on correlation with existing PLOFAM2 leak frequency analysis

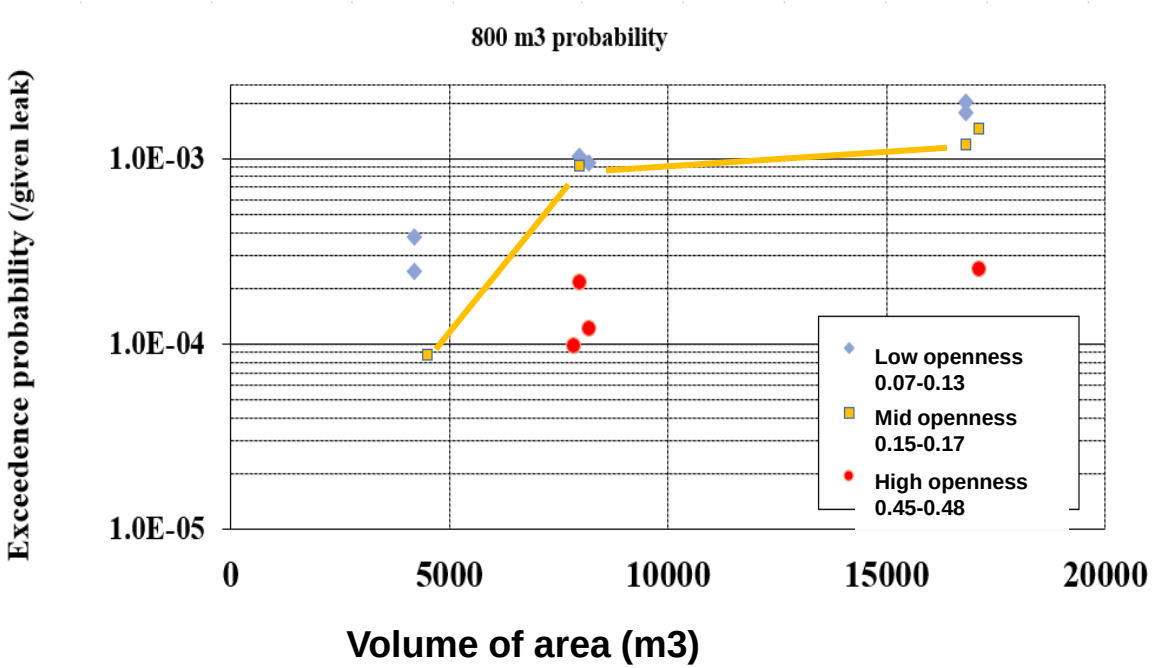


Leak frequency model



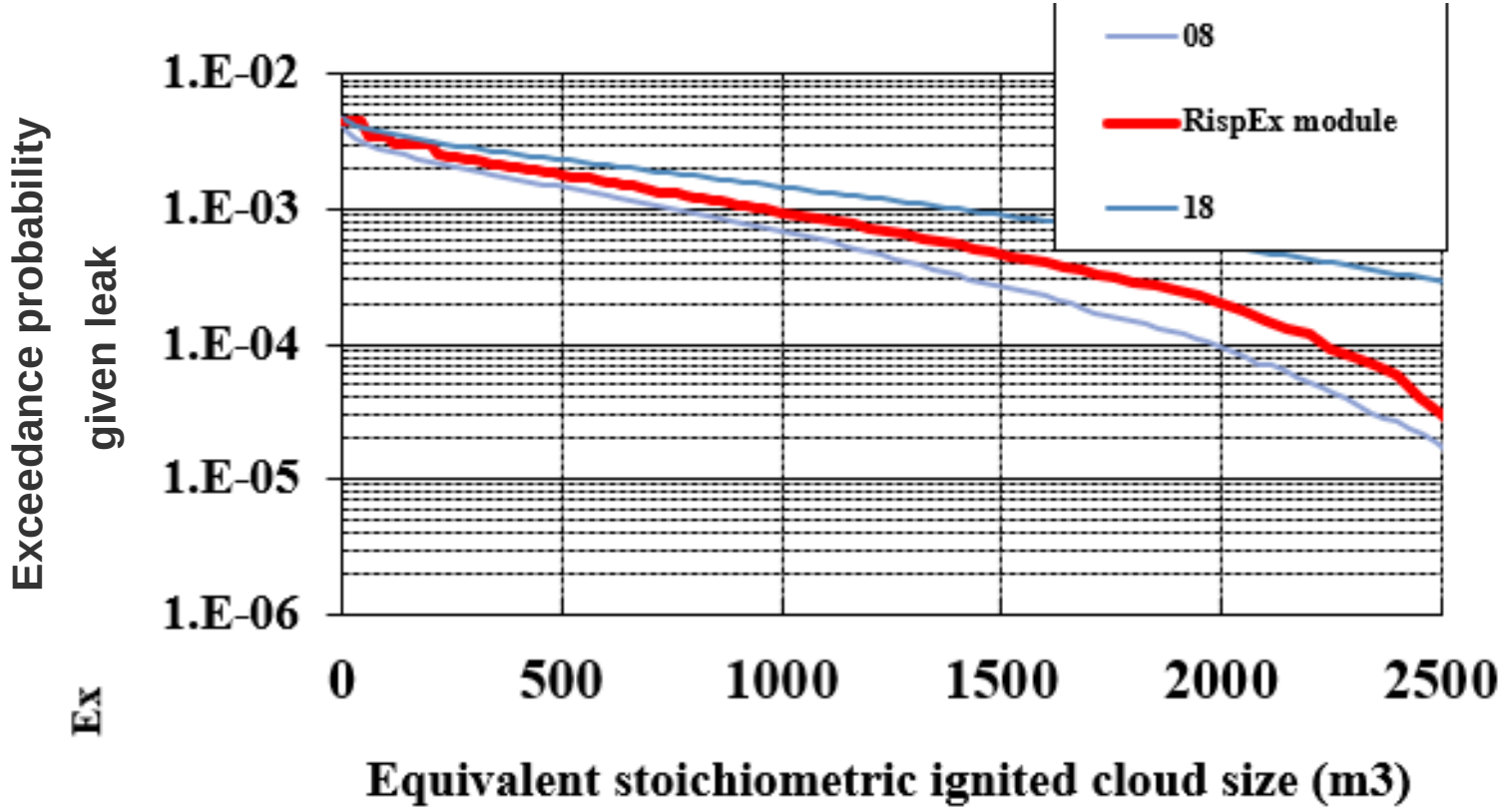
Interpolation schemes
Probability of exceeding 800 m3 illustrated





Probability vs cloud size curve

- Interpolation on volume and openness is performed to all points on the probability vs cloud size curve
- Two dimensional interpolation scheme, interpolating based on openness and volume of area

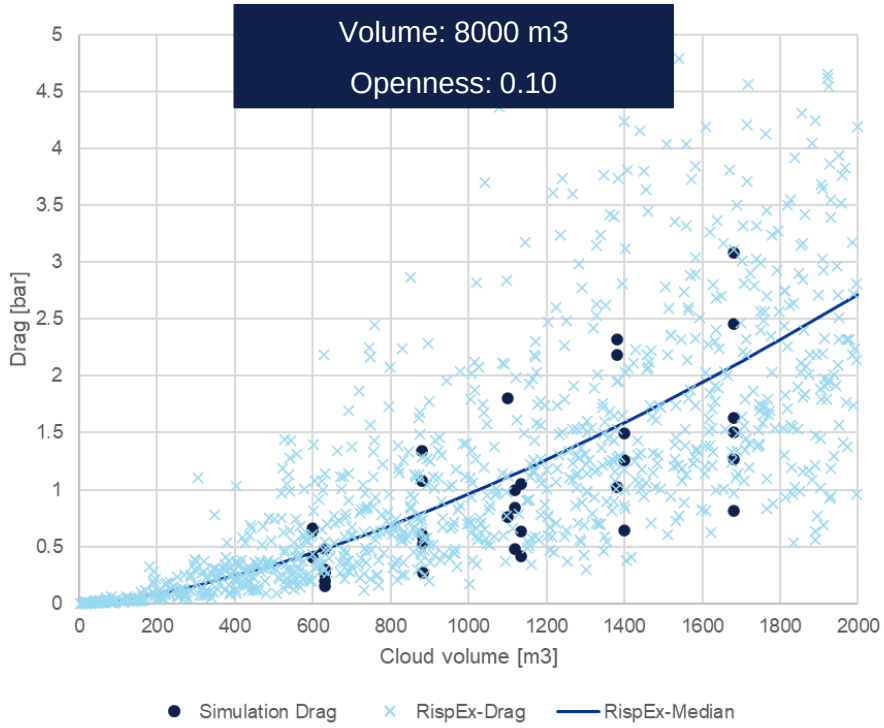


Explosion model

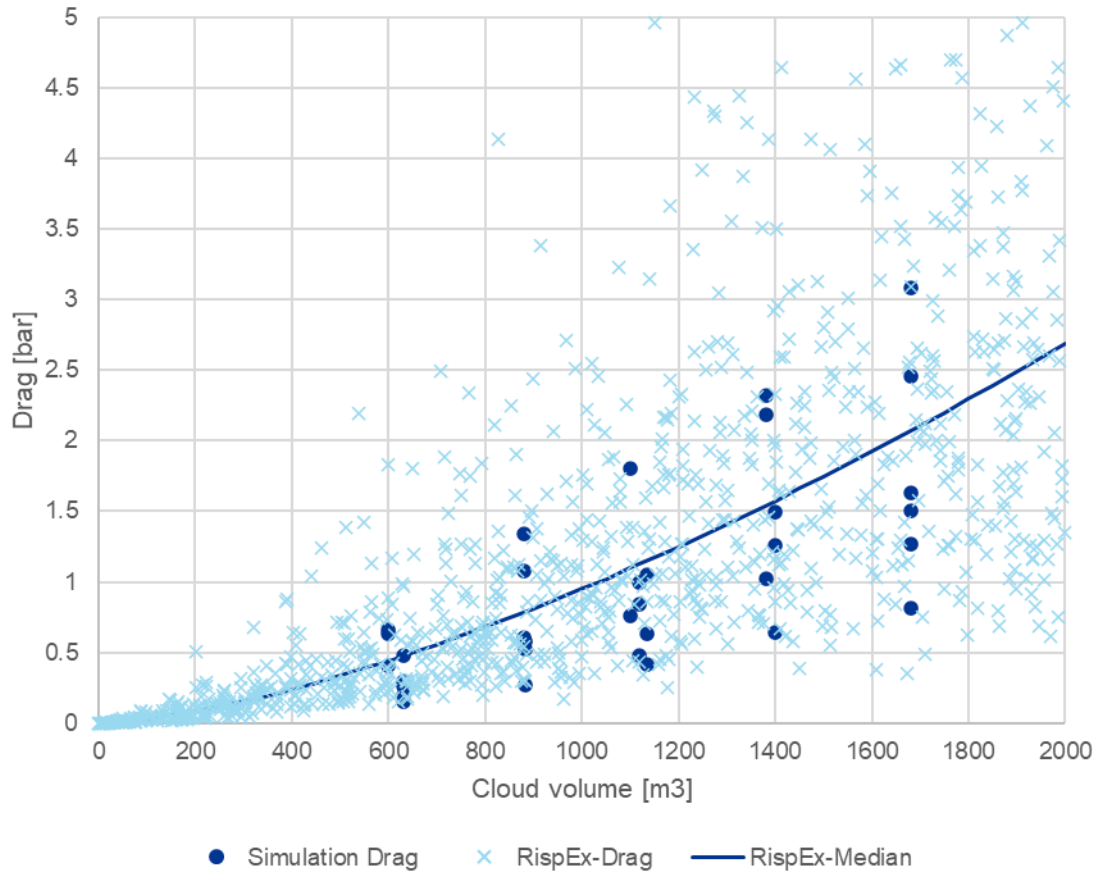
- The RispEx explosion model uses a simple function to predict an overpressure caused by an ignited cloud size, with log-normal distributed term to account for the variance in the explosion pressure
- It is developed and relation between K parameter for and the area volume and area openness based on curve fitting
- Separate K values are developed for:
  - Local wall pressure
  - Local deck pressure
  - Drag

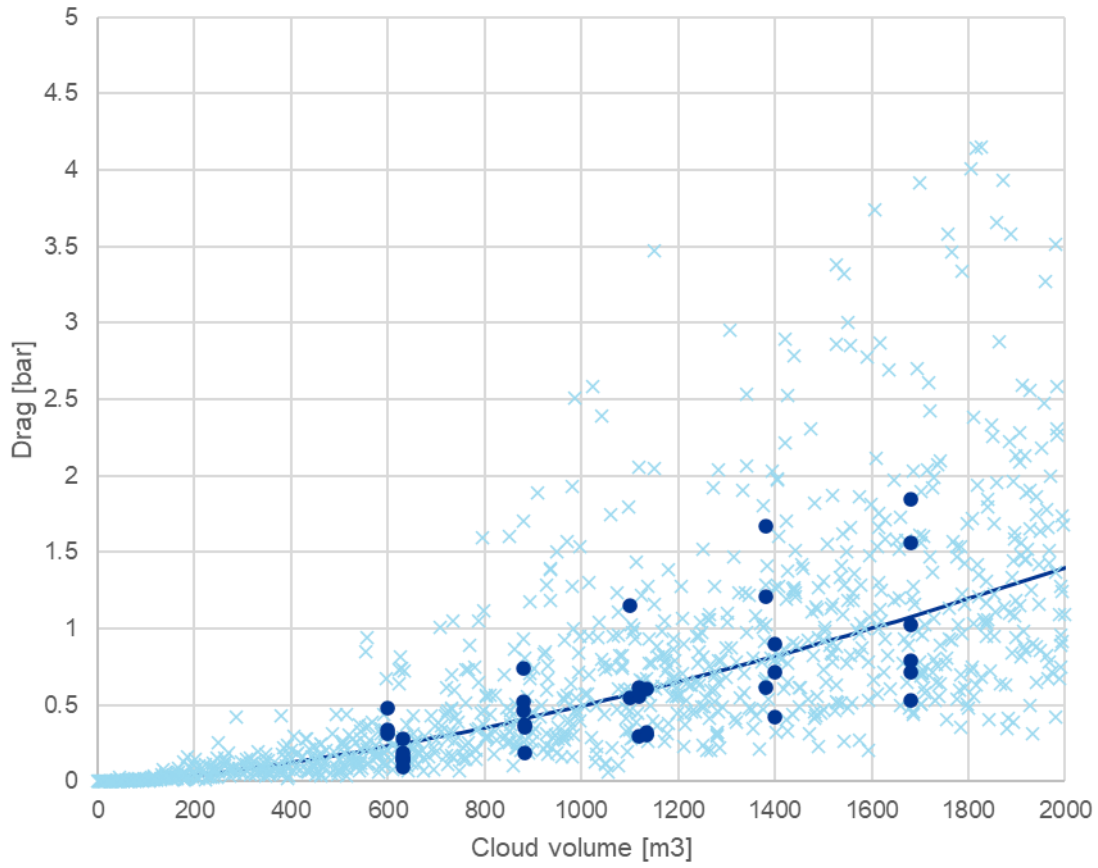
$$\frac{P_{Wall}}{P_0} = \Phi\, K\, V_f^{p_{eV}}$$

$\frac{P_{Wall}}{P_0}$ is the calculated median pressure on the firewall.
Φ is a lognormal stochastic variable
K is a fitted parameter based on volume and confinement
V_f is the volume of the stoichiometric cloud
p_{eV} is fitted a constant

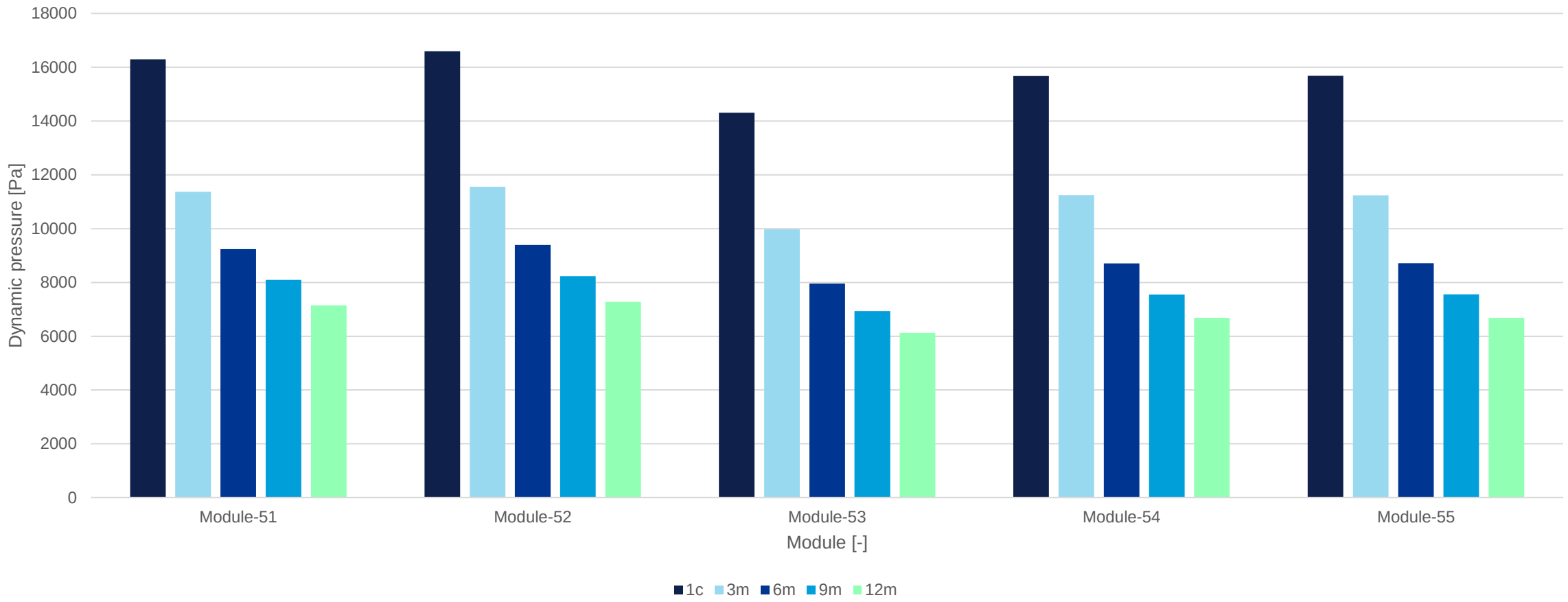


Drag model vs Simulation results 3m (Left) and 12 m (Right)





Drag load extent - FPSO



Design loads and scenario

- Design loads calculate from exceedance curves based on a default 7 x 10-5 criterion
- Criterion can be changed by changing “Design frequency scaling factor”
- Other parameters (duration and global loads) calculated based on design loads.
- Leak scenario calculated based on design cloud size and module size and confinement

Results

880 m^3	Design cloud size		
1 barg	Design overpressure Firewall (Local)	80 ms	Design duration
0.7 barg	Design overpressure Firewall (Global)	110 ms	Design duration
1.2 barg	Design overpressure Deck (Local)	80 ms	Design duration
0.9 barg	Design overpressure Deck (Global)	110 ms	Design duration
0.4 barg	Design drag	50 ms	Design duration
0.058	Leak frequency per year		

Leak scenario corresponding to design explosion load

Leak rate	**9 kg/s**
Leak direction	**South**
Leak location	**Mid module**
Wind speed	**6 m/s**
Wind direction	**West**
Design frequency scaling factor	**1**

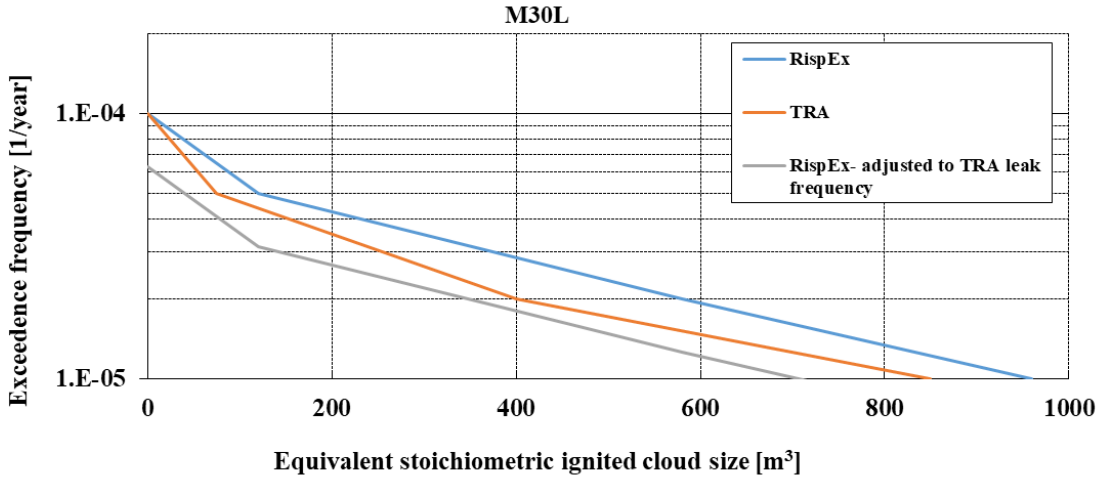
What can it be used for

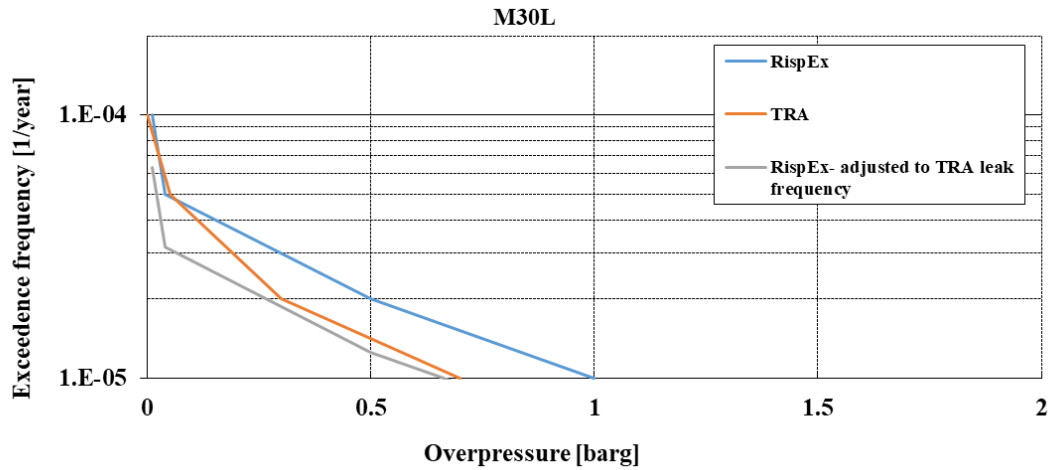
- Within the validity envelope, RispEx shall in principle be able to replace traditional (NORSOK Z-013) explosion analysis for determining design accidental loads.
- Explosion analysis will still be required for other aspects (e.g. MOC, input to QRA and to demonstrate ALARP)

- Validity envelope consists of multiple parts:
  - Overall concept and design, e.g:
    - Design according to PSA requirements and NORSOK S-001
    - Naturally ventilated areas
    - Wind speed distribution similar to Norwegian Continental Shelf (typical)
  - RispEx user input parameters, e.g:
    - Area length, width, height.
    - Wall and deck openness
  - RispEx fixed input parameters, e.g:
    - Maximum blowdown time; 15 min to 6.9 barg
    - Max closing time ESD valves: 30 sec

Benchmarking

- Formal benchmarking was performed as part of the initial development of RispEx.
- Further benchmarking has been performed by DNV as part of ongoing studies and the RispEx development.
- Relatively more benchmarking performed for process areas on fixed facilities compared with FPSOs.





Summary

- Many aspects of explosion risk well understood despite complex nature
- Challenges wrt to our methods from a decision support point of view
- RispEx is developed as a digitalised “look-up approach” based on the best industry knowledge
- Aim to provide explosion DeAL and other explosion risk based decision support when needed
- Simple tool with well defined input available in FEED available in an internet portal
- Output includes scenarios to be used for MoC and optimisation
- RispEx is available and can be used now

Questions?

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