GAS DISPERSION AROUND A DUAL-FUEL HARBOUR TUG

Mariusz Przybylski
Wartsila Ship Design

Presentation content

1. Few words about Wartsila Ship Design
2. Gas dispersion study: challenge, approach and results
3. Summary and questions

WARTSILA SHIP DESIGN

…a few words

WÄRTSILÄ

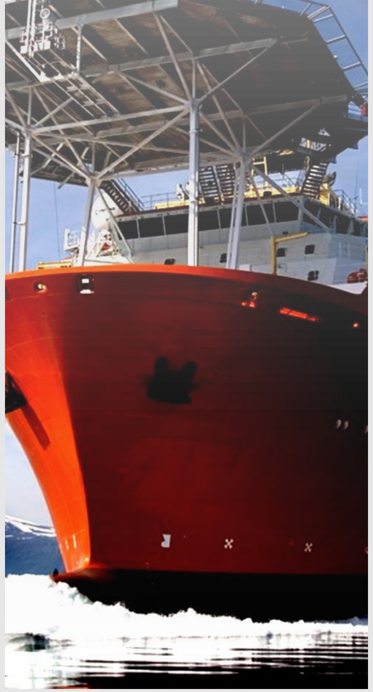
Norway
Singapore
Poland
China

  INTERNAL

WÄRTSILÄ

Offshore

- PSV
- AHTS
- OCV
- ROV / Subsea / DSV

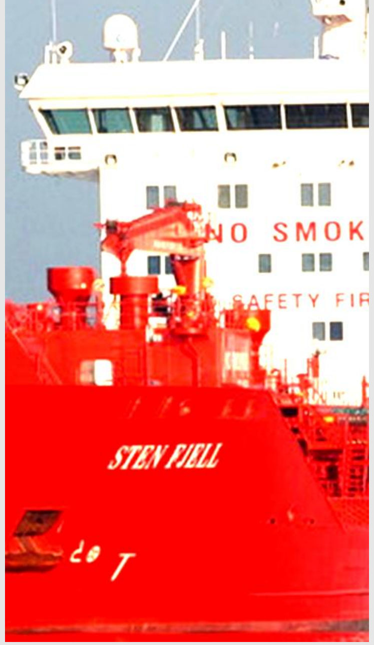


Special Vessel

- Fishing
- Ice-breaking
- Research / Seismic
- Accomodation

Merchant

- Tanker
- Bulk carriers
- Chemical tanker
- Container vessel



Cruise & Ferry

- Battery operated ferries

Navy

- Patrol Vessels

GAS DISPERSION STUDY

Challenge, approach and results

WSD 50MT BP:
Storage tank vent mast challenge

A 28.8m dual-fuel harbour tug equipped with a LNGPac: Wärtsilä's complete system for LNG fueled ships.

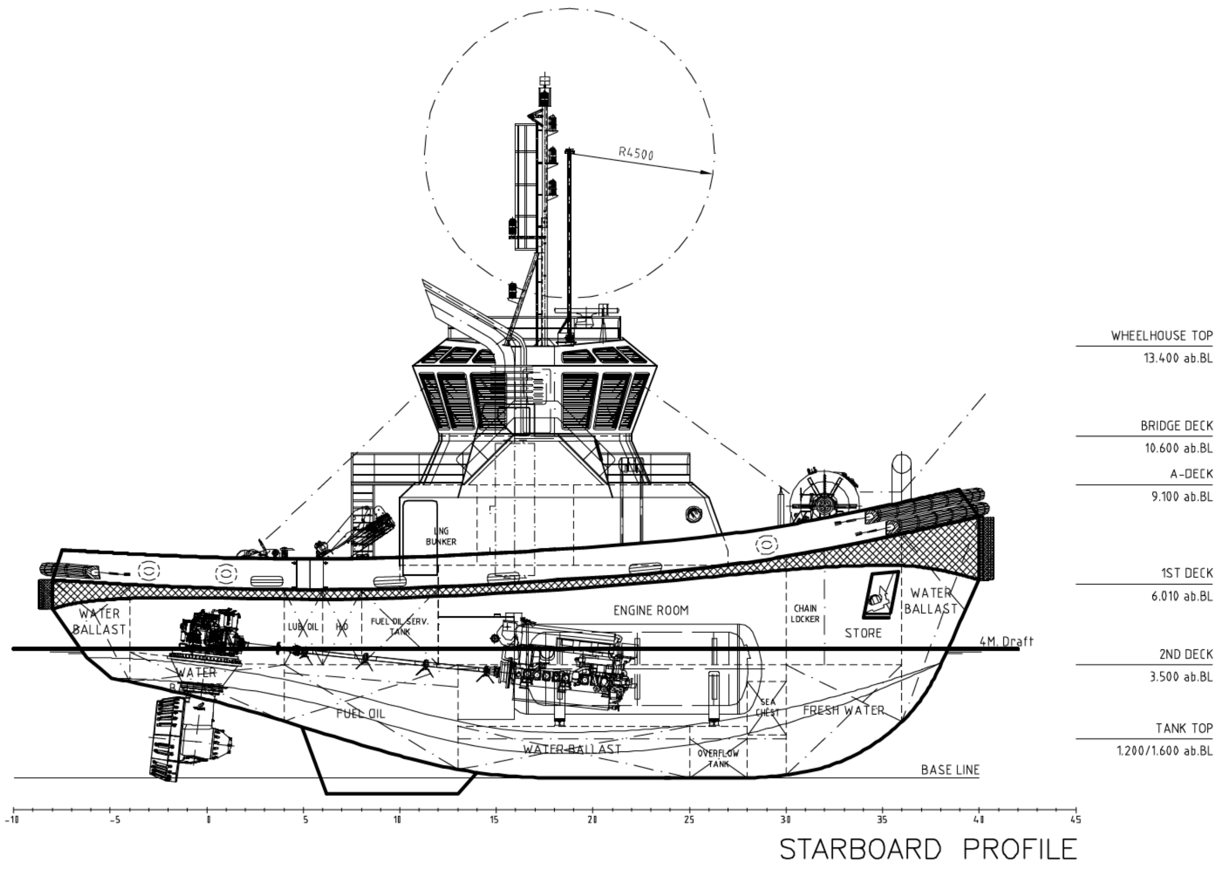
Guide for Propulsion and Auxiliary Systems for Gas Fueled Ships, American Bureau of Shipping, Houston 2016, Section 3.V, Gas Fuel Storage. LNG Storage Tanks:

"[…] The outlets from the pressure relief valves are

normally to be ***located at least 10 m from the nearest:***

1. *Air intake, air outlet or opening to accommodation, service or control spaces, or other non-hazardous spaces; and*
2. *Exhaust outlet from machinery or from furnace installation"*

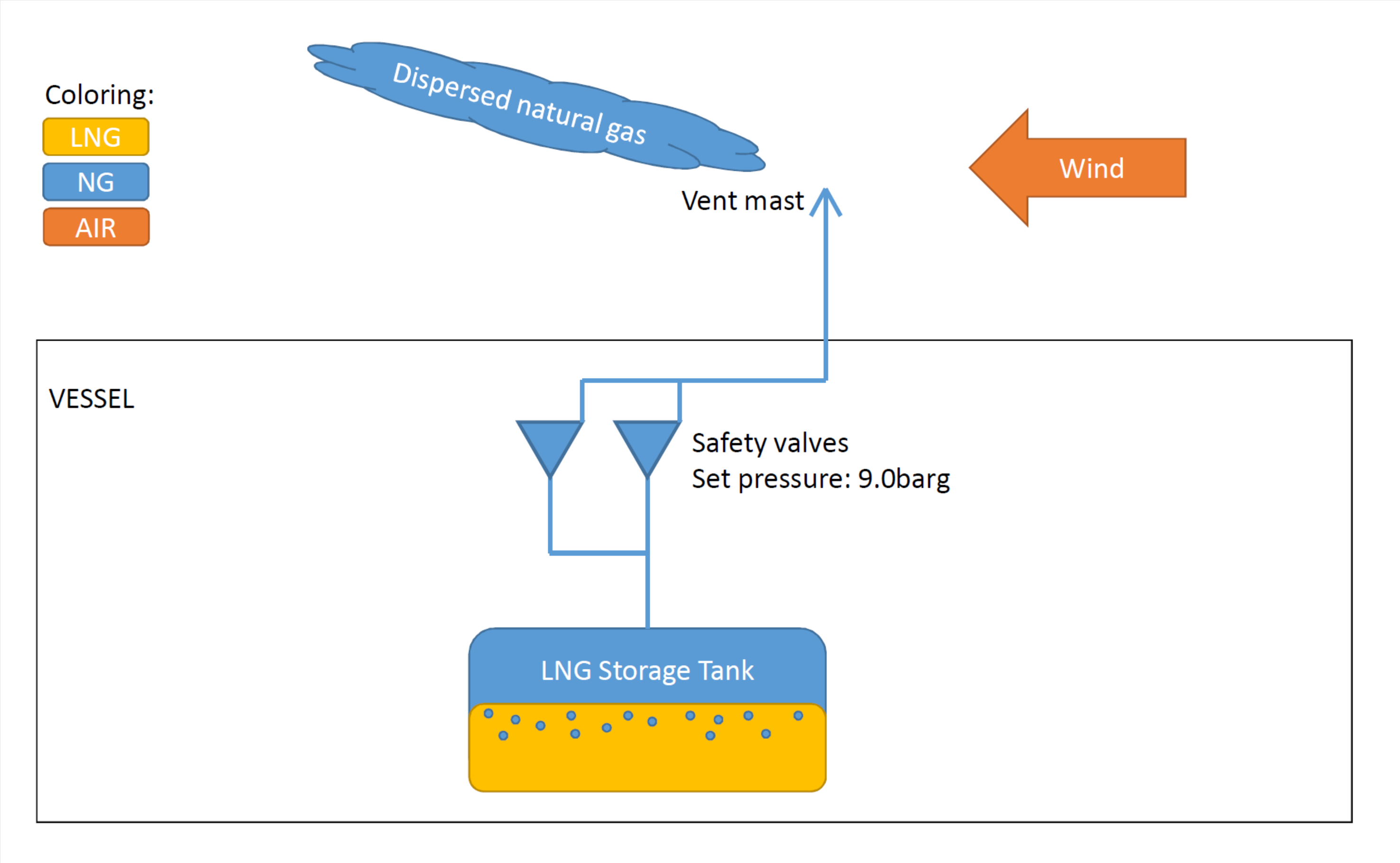
Storage tank vent mast challenge: a way out!



However same rules allow for proposals to be made with regards to the alternative pressure relief valve outlet positions:

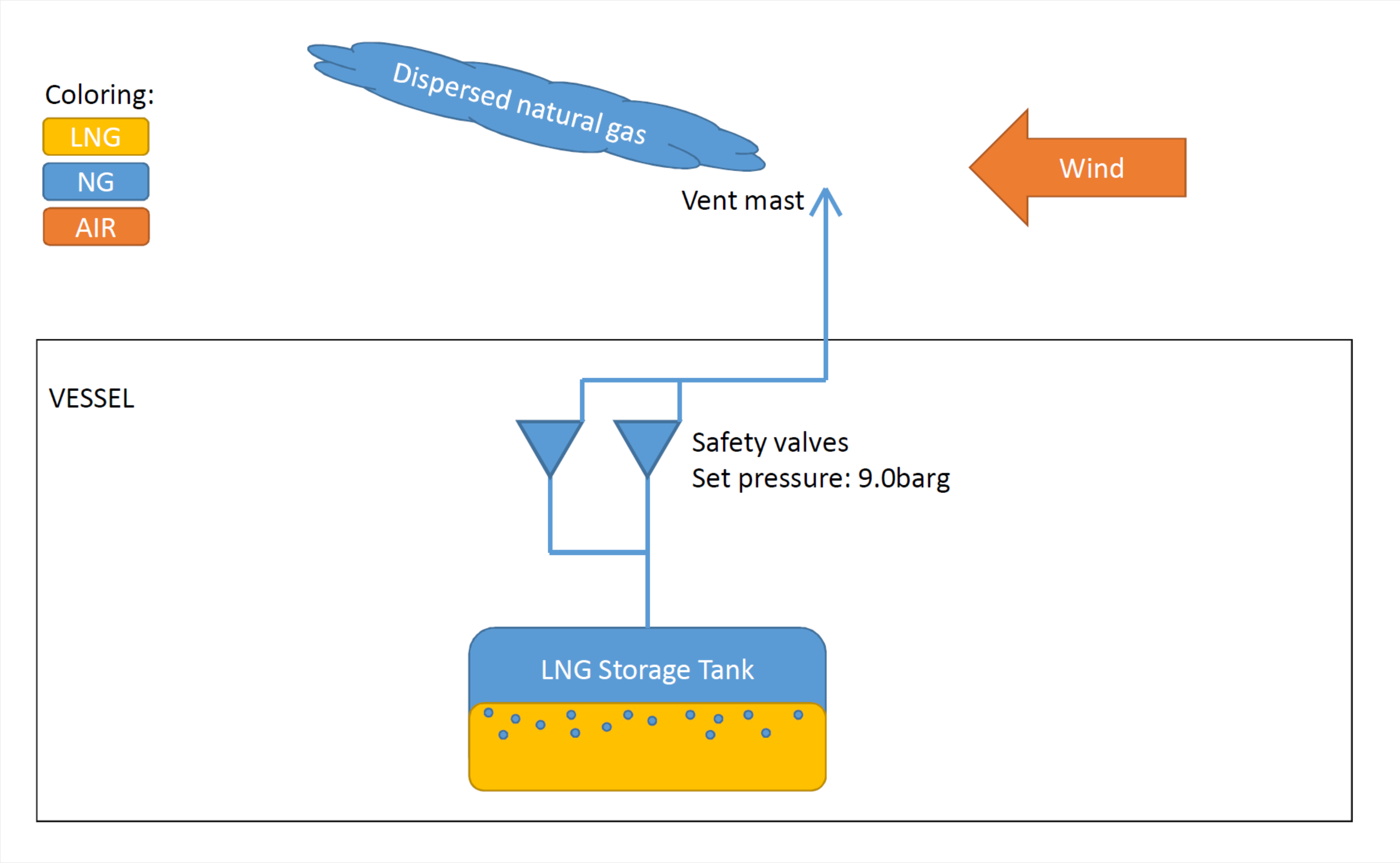
- "*Proposals for alternative pressure relief valve outlet positions will be considered on a case-by-case basis and subject to the submission of an appropriate safety case.* ***Such a safety case could be based on a vessel specific gas dispersion analysis.*** *In that case the air intake is to be provided with a gas detection system which will activate visual and audible alarms when the gas concentration reaches 20% of LEL.* ***However in no case are air intakes to be located less than 4.5 m from a relief valve outlet."***

“[…]Such a safety case could be based on a vessel specific gas dispersion analysis[…]” … ok (?)



Due to the unavoidable thermal leaks the tank with its contents slowly warms up and the pressure inside increases. This increase is normally stabilized by drawing the evaporated gas from the gas space of the tank volume through the main gas evaporator to the engines. In case this consumption is too low the automation system will regulate the pressure and keep it below 8barg by releasing small quantities of gas to the atmosphere through vent mast.

“[…]Such a safety case could be based on a vessel specific gas dispersion analysis[…]” … ok (?)

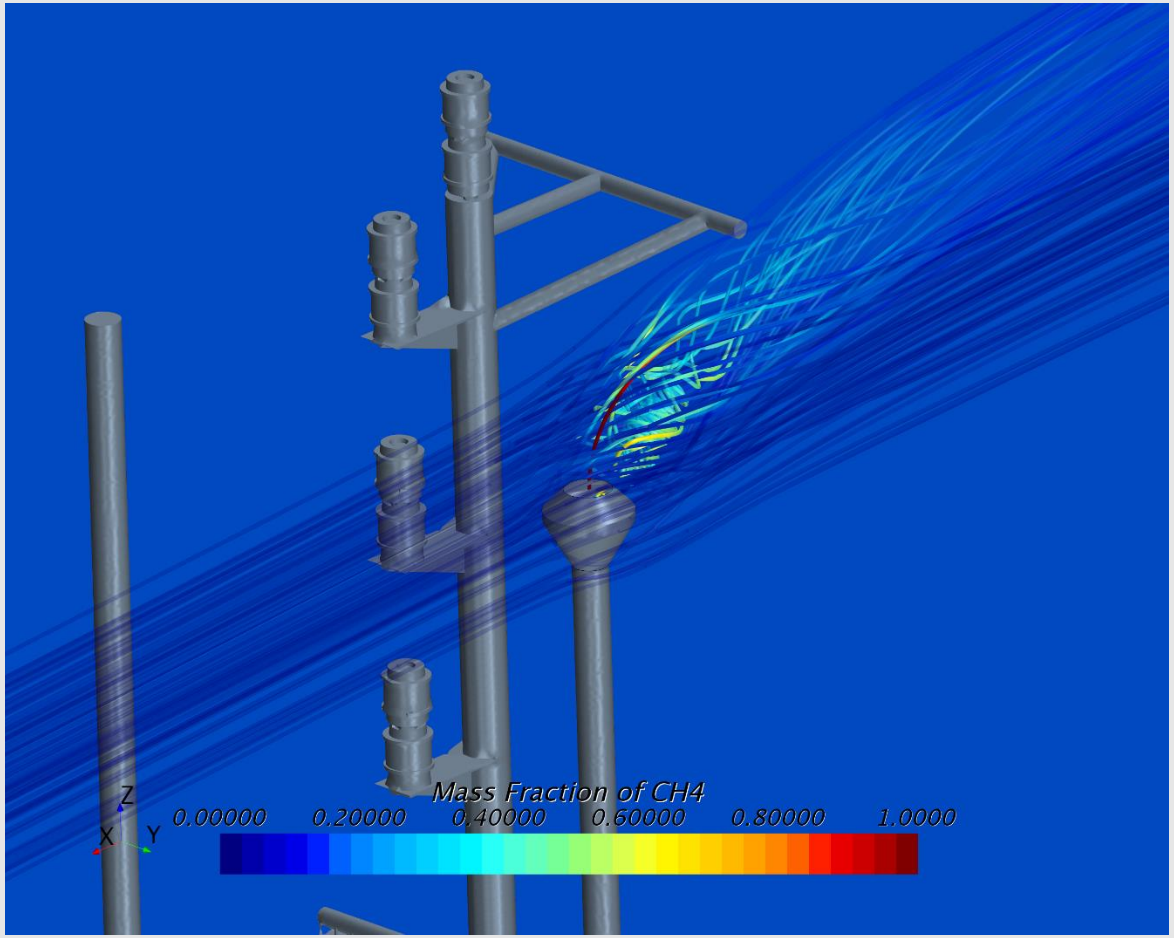


In severe, emergency, cases where the automation system operation is insufficient and the pressure inside the tank rises above 9barg safety valves will open releasing the natural gas through the vent mast to the atmosphere and this way reduce the pressure in tank.

Such a situation was selected for the analysis since it is tied to the largest possible natural gas emission to the atmosphere. Such a situation will be promoted in case of relatively full tank in conjunction with:

1. Fire in the immediate vicinity of the tank or
2. Large scale damage to tank’s insulation

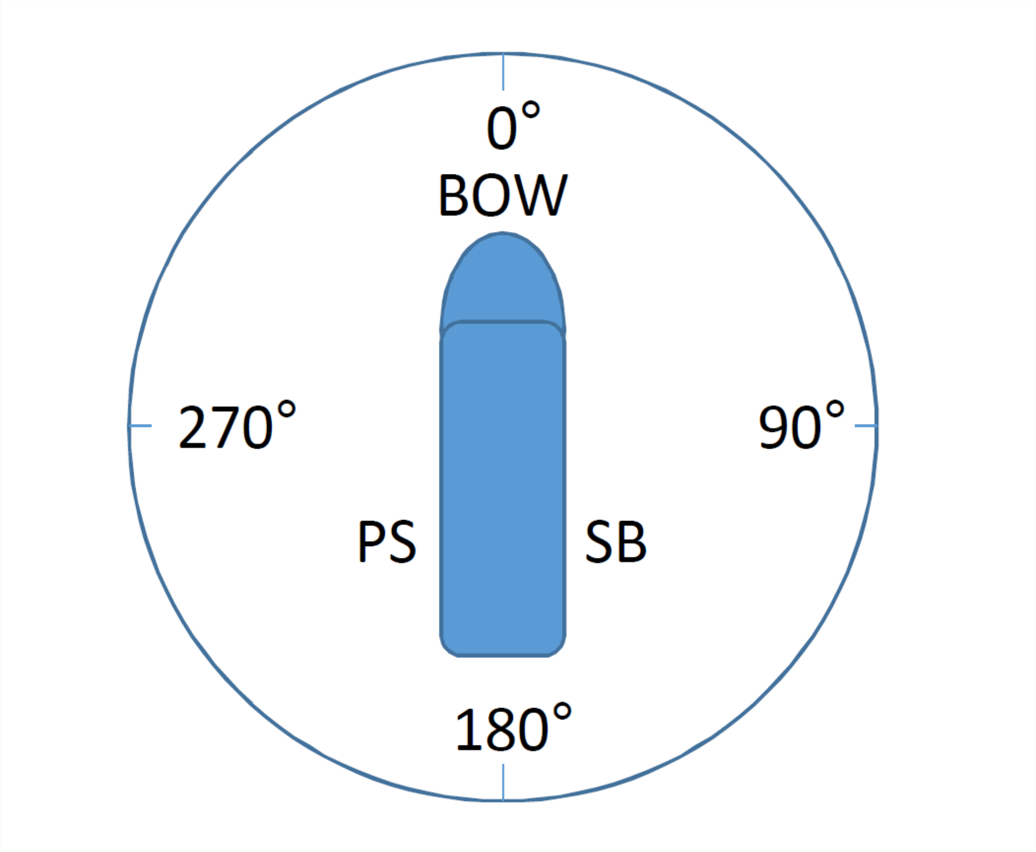
Problem: check, situation: check…. wait! What are we looking for?



Natural gas (primarily consisting of methane) is ignitable in a range from 5% to 15% concentration in air. The lower bound being termed Lower Explosion Level (LEL) and the higher bound being termed Upper Explosion Level (UEL). The mixture reaches a critical flammability at 9% natural gas concentration.

Hence, clearly, the main interest value in case of this study is the concentration of the natural gas in air.

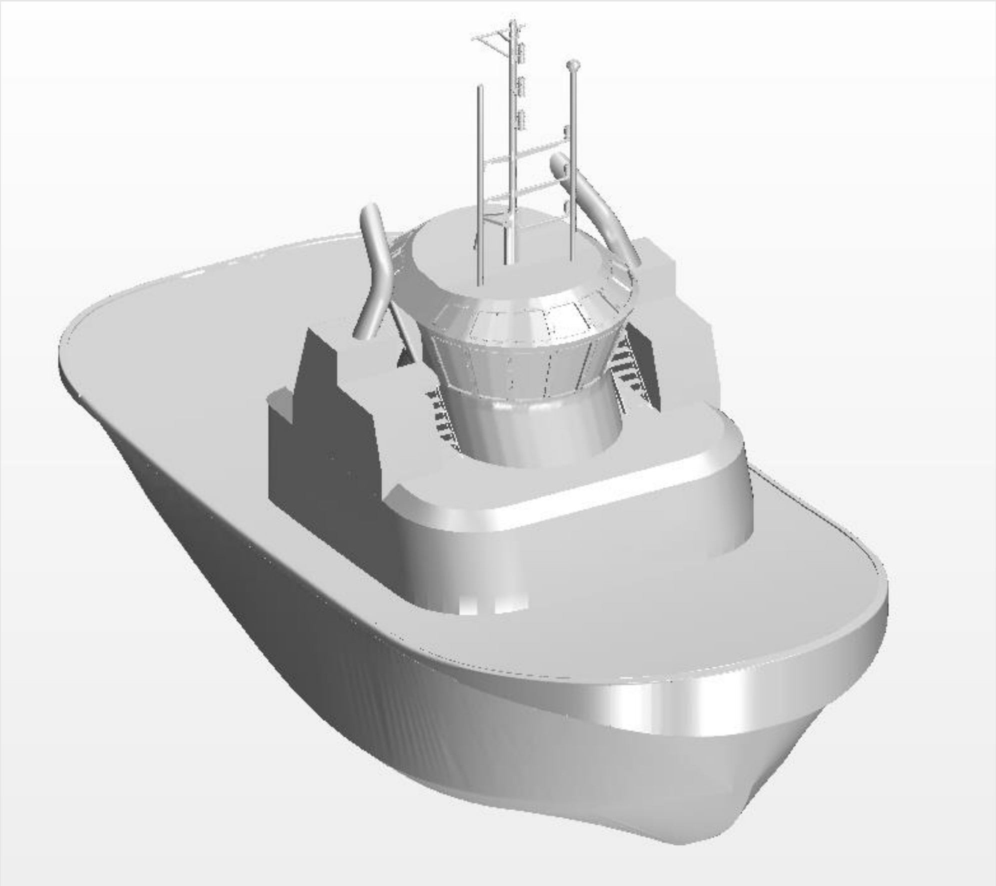
Variables



We have decided that the wind velocity and direction would be two most important variables, hence four win directions at varying speeds were analyzed.

Initially more wind headings were selected (i.e. every 30^0) however it was fast found that extra headings do not significantly contribute to the picture.

Modelling – details & strategy



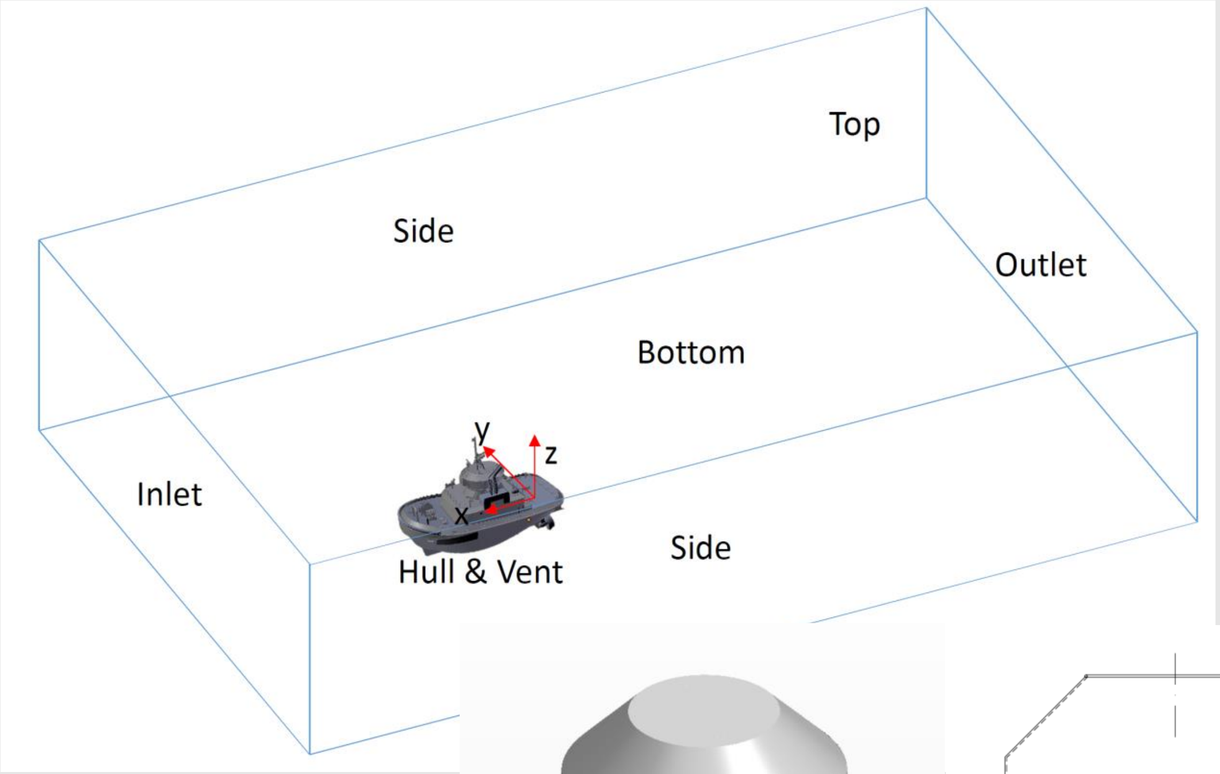
Details of setup:

- Non-reacting multi-component mixture
- Ideal gas
- Methane used to represent NG
- Standard k-ε with high y+ wall treatment (y+ above 30 in case of the study) with realizability option turned on

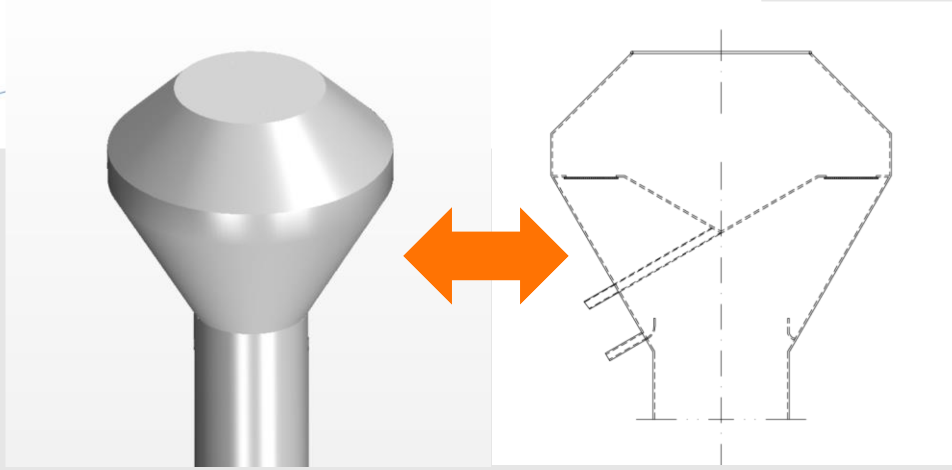
Strategy:

1. Java macro used to define series of runs
2. Geometry rotated and re-meshed for each change in direction
3. Results extracted in form of field plots with LEL iso-surfaces marked

Boundary conditions

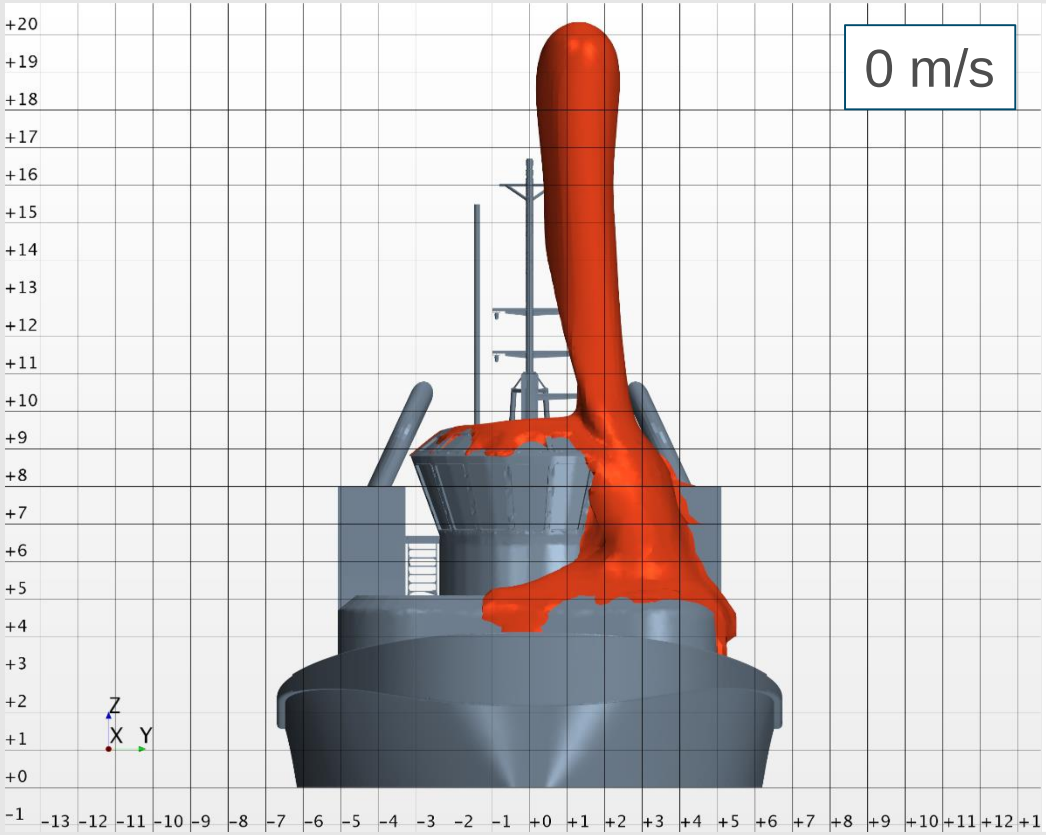


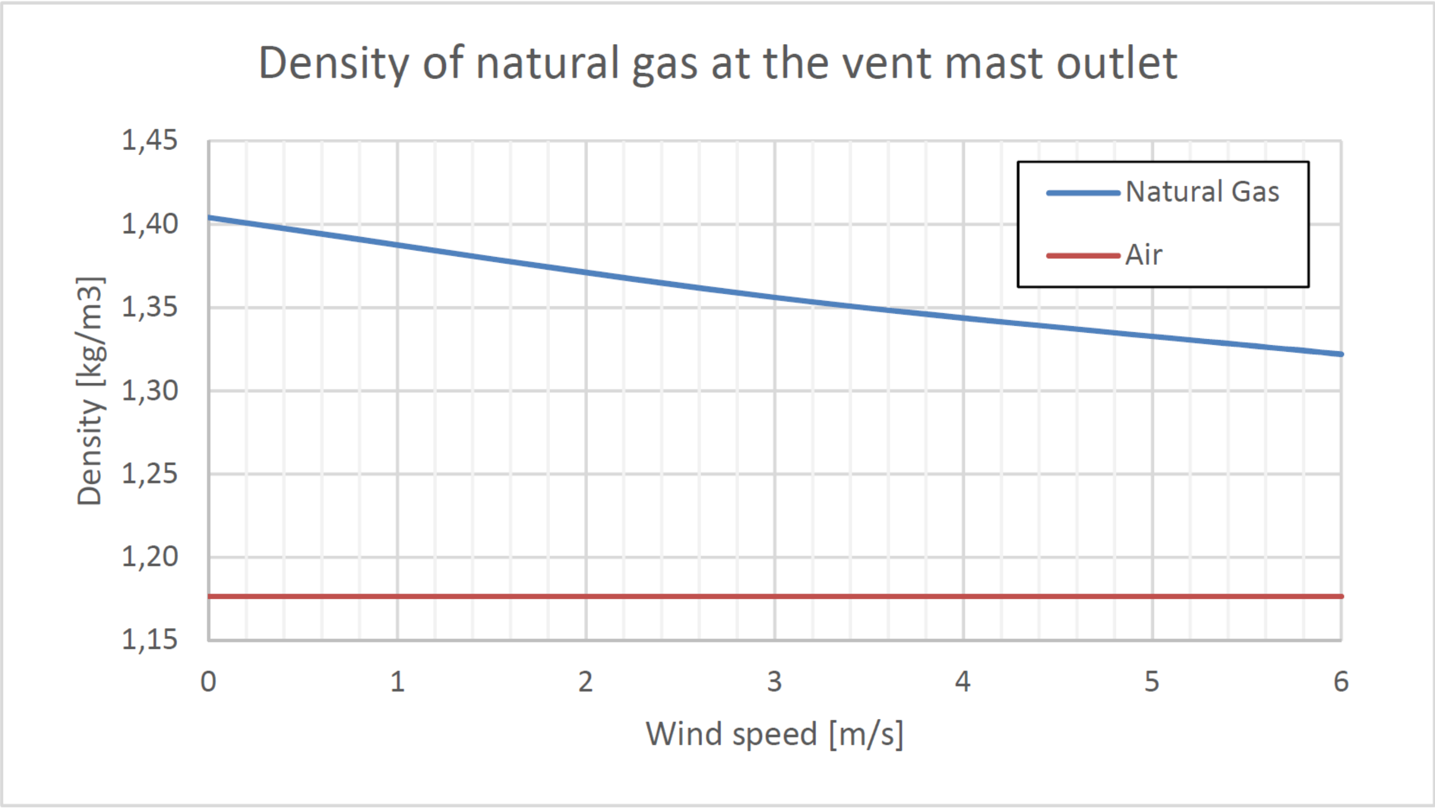
Boundary	Type
Vent	Mass flow inlet
Inlet	Velocity inlet
Side	Velocity inlet
Top	Velocity inlet
Bottom	No-slip wall
Hull	No-slip wall
Outlet	Pressure outlet



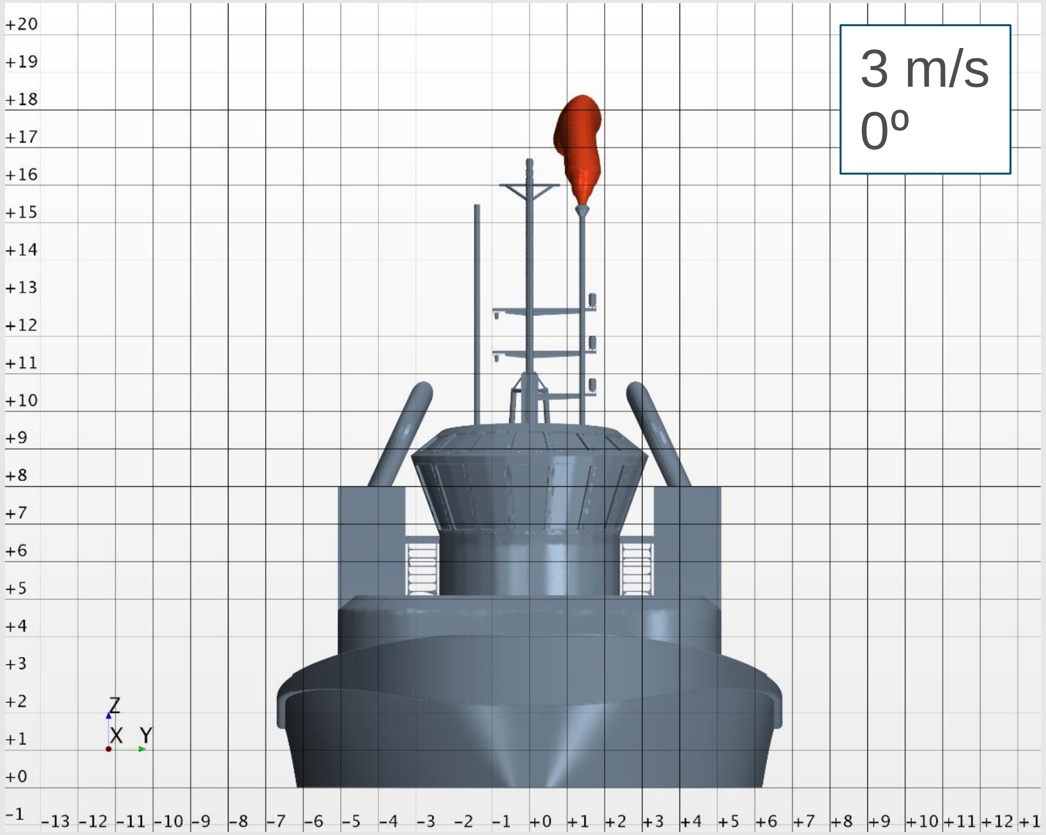
In case of 0 wind speed case all external boundaries are modeled as walls and the domain in enlarged in vertical direction in order to accommodate the buoyant flow and avoid any significant changes in ambient air density (that in turn could affect the buoyancy of natural gas vapour).

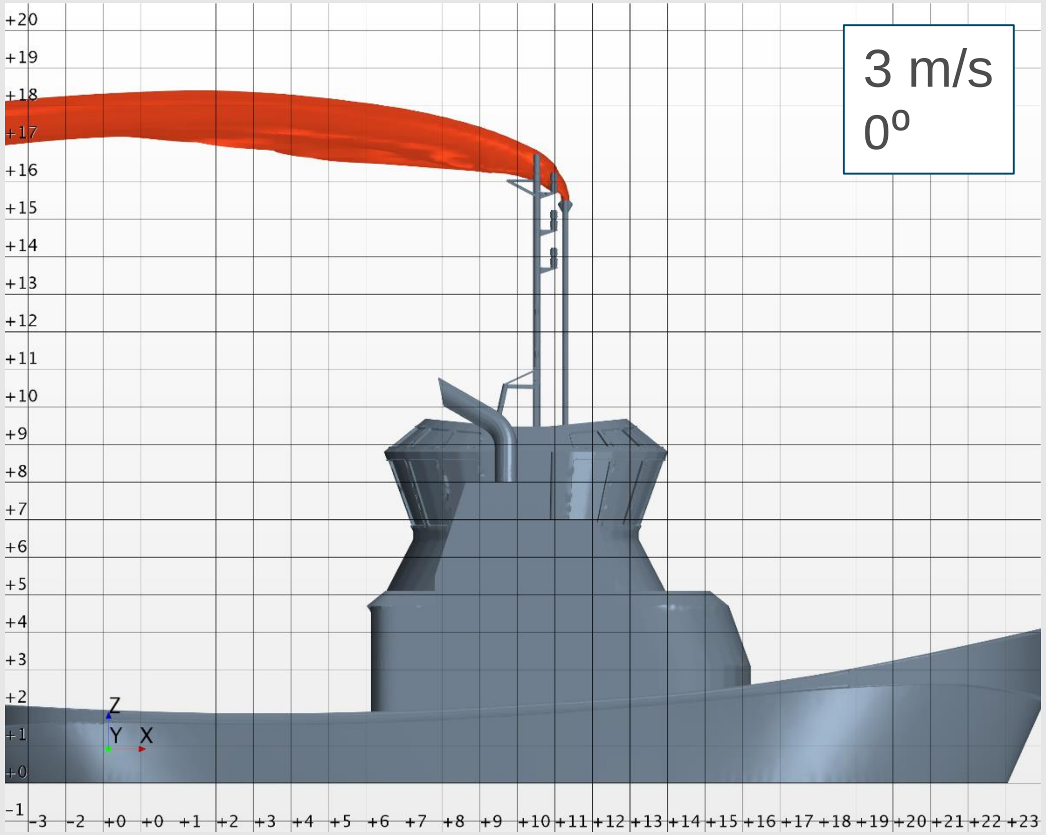
Results


0 m/s
+20
+19
+18
+17
+16
+15
+14
+13
+12
+11
+10
+9
+8
+7
+6
+5
+4
+3
+2
+1
+0
-1
-13 -12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 +0 +1 +2 +3 +4 +5 +6 +7 +8 +9 +10 +11 +12
Z
X Y

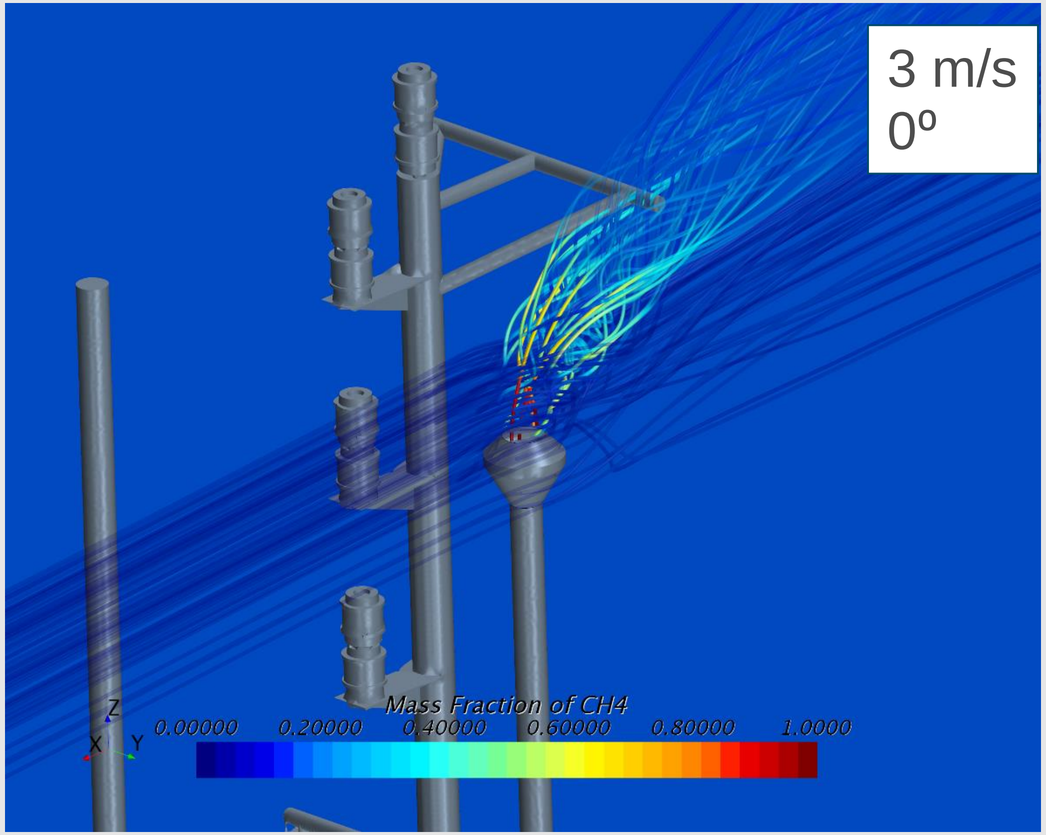

Density of natural gas at the vent mast outlet
Density [kg/m3]
1,45
1,40
1,35
1,30
1,25
1,20
1,15
0 1 2 3 4 5 6
Wind speed [m/s]
Natural Gas
Air

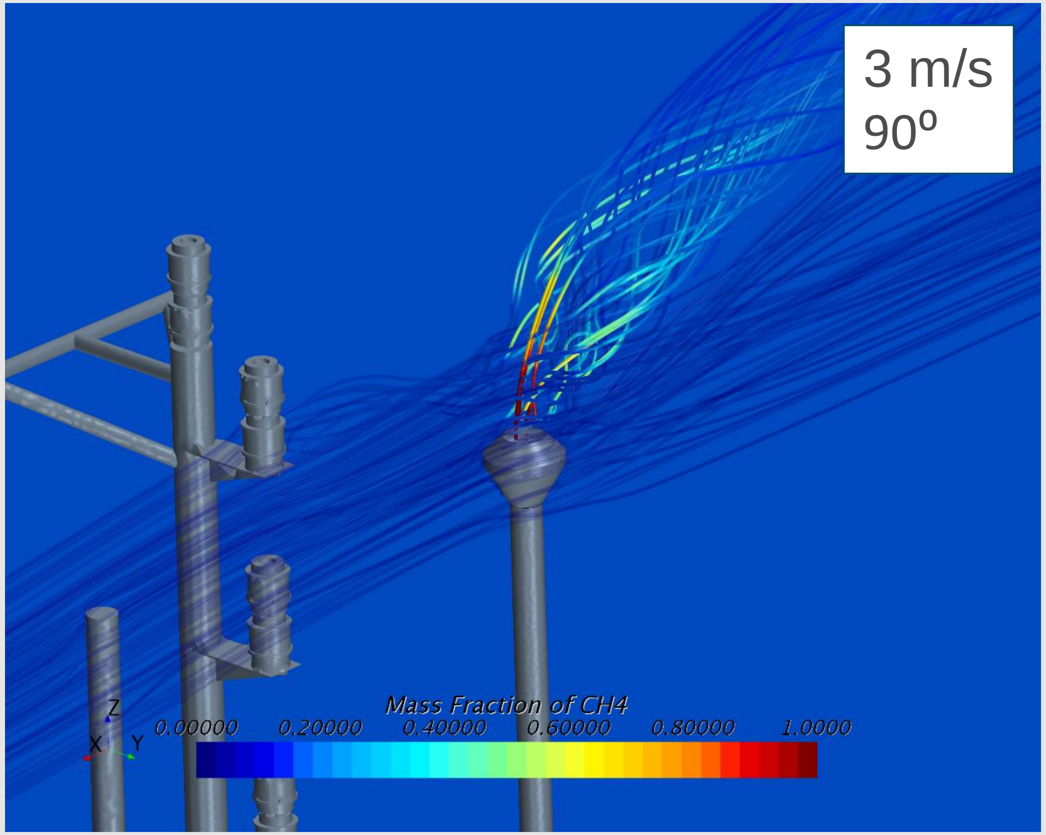
Results





Results


3 m/s
0º
Mass Fraction of CH4
0.00000
0.20000
0.40000
0.60000
0.80000
1.0000
Z
X
Y


3 m/s
90º
Mass Fraction of CH4
0.00000
0.20000
0.40000
0.60000
0.80000
1.0000
Z
X
Y

GAS DISPERSION STUDY

Summary and questions

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Summary and questions

1. Simcenter STAR-CCM+ is an efficient tool of addressing gas dispersion problems
2. Study confirmed that the most critical condition is the 0 wind speed
3. Gained insight allowed to place the engine room air inlets in the correct (safe) position
4. Study allowed to gain insight into the process of mixing of the air and NG at non-zero wind speed (range and intensity of mixing)
5. Work could be extended by use of system simulation for the tank-vent system modelling

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