Risk Analysis for Hydrogen Distribution Systems (DNV GL, report OGNL.172353)

A study was carried out for Liander on the heat radiation - and thus the lethality - of a flare fire that could occur in the event of a rupture in an underground distribution pipeline. The calculations are based on the assumption that the pipeline is exposed, as is the case when the soil is blown away. The heat radiation and the site-specific risk (SSR) for both hydrogen and natural gas have been calculated for each pipeline configuration. It was decided in consultation with the client not to look into more complex scenarios that could occur with distribution pipelines. For example, there was no investigation into the danger of hydrogen accumulating in buildings and exploding, or what could happen if the pipeline ruptures, but the ground is not blown away.

The Decree on the External Safety of Pipelines (*Besluit externe veiligheid buisleidingen*, Bevb) applies to high-pressure pipelines (16 bar and higher). The SSR of these high-pressure pipelines must be less than 10^{-6} per year in the vicinity of vulnerable properties. In the case of properties with limited vulnerability, this 10^{-6} per year is a target value. The rules for how the SSR should be calculated are laid down in the Risk Calculation Manual Bevb (*Handleiding risicoberekeningen Bevb*, HRB). The analysis is as closely as possible in keeping with the modelling prescribed in module D of this HRB. Module D of the HRB relates to chemical pipelines, including hydrogen.
However, the pipeline configurations examined in this study fall outside the scope of the HRB because the pressure is lower than 16 bar. There is no prescribed calculation method for these pipelines at lower pressure and the HRB method has therefore been adopted as far as possible.
Part of the analysis entails a rudimentary site-specific risk calculation for various pipelines. An important input parameter for this is the pipeline's failure rate. When making quantitative risk analyses (QRAs) for high pressure natural gas pipelines, the failure rate shall be calculated using a method prescribed in Module D of the HRB (sections 2.2 and 4).
Neither method is prescribed for the current risk analysis since the pipelines have a pressure lower than 16 bar. However, to give an opinion on how the risk of hydrogen pipelines relates to the risk of natural gas pipelines, it has been decided to calculate an identical failure rate for all pipelines, which follows from the requirements for state-of-the-art hydrogen pipelines. For this purpose, it is also necessary to assume a depth for the pipeline. This depth is estimated at 80 cm.

The failure rate is calculated at $3.74 \cdot 10^{-5}$ per km per year. The pipeline is modelled as a 100-metre section. All scenarios are linked to this fictitious pipeline. The scenarios that have been calculated are pipeline fractures with the following characteristics:
- 100 mbar, diameter 63 mm
- 100 mbar, diameter 110 mm
- 8 bar, diameter 110 mm
- 8 bar, diameter 114.3 mm

The calculations are based on the assumption that the diameters given above are the inner diameters. In reality, these are the outer diameters. This choice results in higher calculated heat radiation and is therefore conservative.

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The calculations have shown that the heat radiation - and therefore the lethality and risk resulting from this heat radiation - of hydrogen is less than that of natural gas under identical conditions. The results of the calculations are summarized in the table below.

	Hydrogen		**Natural gas**	
	Peak heat [kW/m²]	**Distance SSR [m]**	**Peak heat [kW/m²]**	**Distance SSR [m]**
100 mbar - 63 mm	83	10^{-6}: n.a. 10^{-7}: n.a. 10^{-8}: 3.3	60	10^{-6}: n.a. 10^{-7}: n.a. 10^{-8}: 4.5
100 mbar - 110 mm	101	10^{-6}: n.a. 10^{-7}: 0.1	105	10^{-6}: n.a. 10^{-7}: 2.4
8 bar – 110 mm	38	10^{-6}: n.a. 10^{-7}: n.a. 10^{-8}: 6	57	10^{-6}: n.a. 10^{-7}: 10 10^{-8}: 17
8 bar – 114 mm	37	10^{-6}: n.a. 10^{-7}: 3.6	56	10^{-6}: n.a. 10^{-7}: 10.6

n.a.: not applicable

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