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Land-Use Planning in Germany for Hydrogen Plant

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Land-Use Planning

- Land-Use Planning is a specific requirement from the EU Seveso III Directive.
- The siting of establishments and potential impacts on vulnerable objects as well as developments in the vicinity of establishments should be considered.
- One of the key elements of a land-use planning decision is the consequence modelling.
- For hydrogen the following scenarios are relevant:
  - release of gaseous hydrogen with ignition (jet flame)
  - release of gaseous hydrogen, dispersion and unconfined ignition (unconfined vapour cloud explosion)
  - release of gaseous hydrogen, dispersion and confined ignition
  - release of liquid hydrogen (consequence modelling poses some difficulties) – not considered in this presentation

Guidance KAS-63 of the German Commission for Plant Safety

- „Determination of the appropriate safety distance for installations with gaseous hydrogen"
  Ermittlung des angemessenen Sicherheitsabstands für Anlagen mit gasförmigem Wasserstoff (November 2023)
  https://www.kas-bmu.de/app.php/nachricht/kas-63.html?file=files/publikationen/KAS-Publikationen/chronologische%20Reihenfolge/KAS_63.pdf&cid=32031
- Aim to provide a simplified, approach based on standardised criteria.
- Two types of plant defined:
  - with pipework ≤ 15 mm bore diameter (this is a common size used in electrolyser plant, and associated storage units, filling equipment, etc.);
  - with pipework > 15 mm bore diameter.
- Standard release cross-sectional area 180 mm^2 (equivalent 15mm dia.) or 490 mm^2 (equivalent 25mm dia.)

Parameters for the modelling

- The following standardised paramaters are applied:
  - operating temperature: 20 °C
  - ambient temperature: 20 °C
  - Wind: calm
  - discharge coefficient: 0.62
  - receptor point height: 2 m
  - angle of release 45° above horizontal

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Models

- Hydrogen jet release:
  - modified Schatzmann
  - the original single-substance system is modified to use an extended energy balance and the gas equations for the gas mixture (substance in air) are calculated.
- Explosion:
  - Baker-Strehlow-Tang (1999) DOI: 10.1002/prs.680180412
  - reactive gas
  - congestion and confinement using the matrix from Pierarazio et al (2005) DOI: 10.1002/prs.10048
- Jet Flame:
  - calculation of the length, Molkov / Saffers (2013) DOI: 10.1016/j.ijhydene.2012.08.106
  - radiation of the jet fire, Houf / Schefer (2007) DOI: 10.1016/j.ijhydene.2006.04.009, and Ekoto et al (2014) DOI: 10.1016/j.ijhydene.2014.03.235

End-point evaluation

- explosion overpressure: 50 mbar
- thermal radiation: 1,6 kW/m^2

Vulnerable objects should not be closer to the source than the distances of these contours.

Calculation

- Calculations were carried out for both cases of the release cross-sections (180 mm² and 490 mm²)
- For release (operating) pressures of 100 bar – 1000 bar in 100 bar increments distances were calculated for the two explosion cases (a) without turbulence creating barriers, and (b) with turbulence creating barriers, leading to a detonation. In addition the distance for the thermal radiation was determined.
- In the guidance the tables of results are reproduced.

Results: Release cross-sectional area 180 mm²

Leckfläche 180 mm²

Betriebsüberdruck	Massenstrom	Explosionsfähige Masse	Fall 1	Fall 2	Wärmestrah-lung
100 bar	0,684 kg/s	0,47 kg	20 m	51 m	34 m
200 bar	1,345 kg/s	1,1 kg	25 m	67 m	47 m
300 bar	1,966 kg/s	1,6 kg	28 m	77 m	56 m
400 bar	2,554 kg/s	2,2 kg	31 m	84 m	64 m
500 bar	3,112 kg/s	2,7 kg	33 m	90 m	70 m
600 bar	3,642 kg/s	3,2 kg	35 m	95 m	76 m
700 bar	4,146 kg/s	3,6 kg	36 m	99 m	81 m
800 bar	4,629 kg/s	4,0 kg	37 m	102 m	85 m
900 bar	5,091 kg/s	4,4 kg	38 m	105 m	88 m
1.000 bar	5,535 kg/s	4,7 kg	39 m	108 m	92 m

Results: Release cross-sectional area 490 mm²

Leckfläche 490 mm²

Betriebsüberdruck	Massenstrom	Explosionsfähige Masse	Fall 1	Fall 2	Wärmestrahlung
100 bar	1,863 kg/s	1,9 kg	31 m	82 m	56 m
200 bar	3,663 kg/s	4,4 kg	40 m	107 m	78 m
300 bar	5,352 kg/s	6,9 kg	46 m	123 m	94 m
400 bar	6,953 kg/s	9,2 kg	50 m	136 m	106 m
500 bar	8,471 kg/s	11,4 kg	53 m	145 m	117 m
600 bar	9,913 kg/s	13,5 kg	56 m	153 m	126 m
700 bar	11,288 kg/s	15,4 kg	58 m	160 m	133 m
800 bar	12,601 kg/s	17,2 kg	60 m	166 m	140 m
900 bar	13,859 kg/s	18,8 kg	62 m	170 m	146 m
1.000 bar	15,068 kg/s	20,3 kg	63 m	175 m	152 m

Recommendation for appropriate safety distances

	Angemessener Sicherheitsabstand für die Leckflächen	
Betriebsüberdruck P	**180 mm²**	**490 mm²**
P < 100 bar	50 m	80 m
100 ≤ P < 200 bar	70 m	110 m
200 ≤ P < 400 bar	80 m	140 m
400 ≤ P < 600 bar	95 m	150 m
600 ≤ P < 800 bar	100 m	170 m
800 ≤ P ≤ 1.000 bar	110 m	180 m

Closing comments

- The method was designed to be a simplified generic approach to deal with the large number of potential hydrogen projects which had been announced.
- The guidance is limited in its application because of the very high mass-flow rates required in comparison with what is realistically possible.
- Within electrolysis units, storage units constructed from smaller pressure vessels, and trailer filling stations (in our experience) the mass flow is restricted / limited.
- The guidance may be useful for larger scale operations (particularly large storage facilities)
- Liquid hydrogen (LH2) was not addressed, because of uncertainties in which models are suitable – this is currently the topic of international research efforts.
- Land-use planning should be thought about for smaller sites which are likely to expand in the future.

Vielen Dank für Ihre Aufmerksamkeit !