WP5 Veiligheidsaspecten en risico's – HAZID studie, rapportage case 2: waterstof opname, transport en aflevering met tube trailers

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Aanleiding

WVIP WP5 heeft als doel om voor een aantal concrete toepassingen van waterstof in het publieke domein een Hazard identificatie (HAZID) uit te voren

WVIP WP 5 werkt aan veiligheidsanalyse en het bijdragen aan borging van waterstofveiligheid in het publieke domein en heeft als doelstelling:

1. Het systematisch inventariseren van alle mogelijke veiligheidsrisico's van een aantal concrete cases die gepaard gaan met de productie, opslag, transport en gebruik van waterstof.
2. Welke mitigerende maatregelen zijn noodzakelijk voor de gedefinieerde cases om waterstof als veilige en betrouwbare energiedrager grootschalig te kunnen introduceren en daarmee de publieke acceptatie te vergroten.

Dit document is bedoeld voor alle partijen die bezig waren, momenteel bezig zijn, dan wel in de nabije toekomst betrokken zullen zijn bij de ontwikkeling van de waterstof productie, waterstofinfrastructuur en specifiek voor partijen die zich bezig houden met waterstof productie en –infrastructuur, inclusief transportmethoden waterstof over de weg.

De HAZID cases zijn geselecteerd binnen de TEC van WVIP en betreffen :

- Case 1 Waterstof tankstation
- Case 2 Waterstof transport over de weg (tube trailer)
- Case 3 regionale productie
- Case 4 Huishoudelijk gebruik waterstof
- Case 5 Service & onderhoud
- Case 6 eind levensduur

Deze rapportage betreft case 2, waterstof transport over de weg (tube trailer)

Dit document geeft, voor de specifieke situatie van een waterstof tankstation, handvatten om de vragen en antwoorden over de veiligheidssituatie rondom het transport en levering van waterstof met tube trailers centraal te ontsluiten met het doel de waterstofveiligheid voor deze situatie te borgen.

Introduction

This Hazard identification session for this case was organised in the context of the WVIP (Dutch acronym of Waterstof Veiligheid Innovatie Programma (WVIP, Dutch for Hydrogen Safety and Innovation Program), where, in working group 5, safety aspects are being investigated, using the methodology and approach of systematic hazard identification (HAZID). Further information can be found on the website of the WVIP, which also describes the complete WVIP scope.

This scope includes:

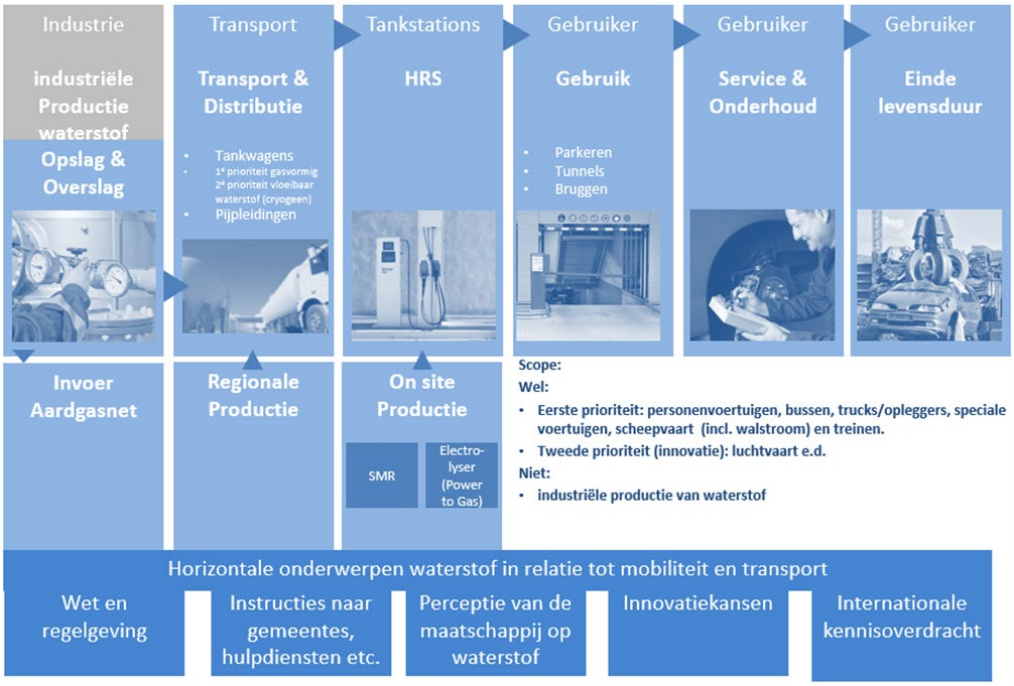

Figure 1. Scope WVIP This report contains the results and recommendations of the HAZID regarding a hydrogen fueling station in the public domain.

Activities and meetings

HAZID team

The HAZID team consisted of the following persons, with their respective roles:
TNO – Chairman HAZID
TNO – Expert and PM WG 5
NEN – Co-PM WP 5
Experts:

- Air Products (2 experts)
- Gerwen Advies
- Ministerie IenW (DGMI)
- NIPV
- Shell
- TNO (2 experts)
- RWS
- Veiligheidsregio Groningen
- Veiligheidsregio Rotterdam-Rijnmond

Meetings

The HAZID for this case 2 was conducted in 3 sessions in February- march 2021. Each session was about 3 hrs.

HAZID study approach and scope of work

The main objective of this HAZID study was twofold. First, to identify and evaluate potential safety risks (e.g. knowledge gaps in hydrogen safety) related to the transport of hydrogen by road in the public domain. Second, to identify barriers and formulate recommendations to mitigate the identified risks. Those two objectives for further uptake within or outside WVIP if relevant.

The HAZID includes an assessment for both transport of gaseous hydrogen in tube trailers (200-500 bar) and liquified hydrogen in cryogenic and well isolated tanker trucks (1.7 bar, -252 °C), including:

- filling of the truck, typical at a production location in an industrial area (non-public);
- transport by road, typical by public infrastructure, such as highways and tunnels, in the public domain (see Figure 2);
- delivery of hydrogen to an (end) user, typically a hydrogen (or multi) fuel station in the public area;
- maintenance of transport vehicles.

Typical transport vehicles are depicted in Figure 3 and Figure 4.

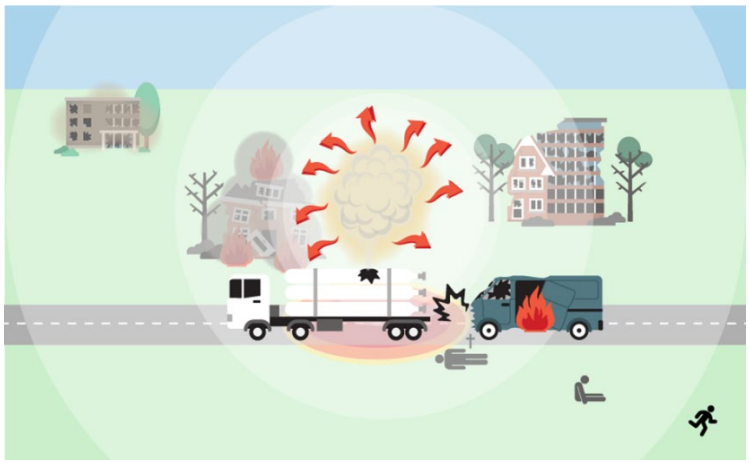

Figure 2. Hydrogen transport and collision

Figure 3 Typical gaseous tube trailer [Air Liquide]

Figure 4 Typical cryogenic liquid tanker truck [Air Liquide]

This HAZID is executed according the Terms of Reference for this project (see document number N009 on NEN project website I-Solutions) , including a description of the risk assessment methodology according the "*Handreiking Generieke Risicobenadering versie 1.1 03-2017*" (as developed for safe production, transport storage and handling of hazardous substances in the Netherlands) and NEN-EN-ISO 17776:2016 developed for and applied in the international oil & gas industry).

The hazards as considered in the HAZID included the following categories:

1. External and environmental hazards
2. Facility hazards
3. Health Hazards
4. Project implementation issues

In each category, the HAZID assessment was carried out in 4 Steps: in step 1, with the use of guidewords a typical associated scenario that could take place was defined, in step 2 the consequences of the occurrence of these scenarios was evaluated. In step 3 the possible barriers towards the consequences were defined. Finally, in step 4 the risk assessment took place, in terms of probability (A-E) ,consequences for people and environment (1-6). With this analysis the risk factor was calculated (1-34) and also presented in a color scheme (figure 5).
These risk factors should not be regarded as absolute factors, since this should be evaluated in the context of the public domain area in which the events are envisaged to take place. The factors should therefore be used as relative to each other.

Risk matrix

Consequence (Effect class)				Probablity (Frequency of occurence)				
				Scarcely	Seldom / rarely	Now and than	Regular	Often
	People	Environment		Never heard of in industry	Has occurred in this type of industry/sector	Has occurred in similar type of company	Has occurred several times in similar type of company	Has occurred several times in a year on one location
				A	B	C	D	E
Zero	No injury Medical treatment (First Aid)	No / limited effect (pinhole leaks)	1	1,5	2,0	2,5	3,5	4,5
Minor	Medical Treatment case, substited work Slight health damage, no irreverse effects	Minor effect (small leak)	2	1,9	2,5	3,1	4,4	5,6
Major	Major injury, Lost Time injury Irreverse health seffects	Local effect (major leak)	3	3,8	5,0	6,3	8,8	11,3
Severe	Disability One fatality	Severe / regional effect (small equipment rupture, large leak)	4	5,6	7,5	9,4	13,1	16,9
Very severe	More than one fatality (<50)	Very severe / national effect (large equipment rupture, very large leak)	5	7,5	10,0	12,5	17,5	22,5
Catastropic	Many fatalities (>50)	Massive / international effect (loss of containment complete asset)	6	11,3	15,0	18,8	26,3	33,8

1 t/m 4	Low risk level
4,1 t/m 10	Medium risk level
10,1 t/m 15	High risk level
15,1 t/m 34	Very high risk level

Figure 5. Risk matrix.

Main findings

The complete HAZID reporting is in Excel format and available on request, see the reference in the Annex of this document.

Main findings include :

- No 'very high' (red) risks;
- One 'high risk' (orange) risk, including:
  - Nr. 1.2.5: incident with truck/trailer in category A or B tunnel
- Several 'medium risks' (yellow), including :
  - Nr. 1.1.1 : Leak on gas pressurized hydrogen tank at fueling station
  - Nr. 1.1.2 : Slippery roads, overturning of trailer on road/highway (in rural area)
  - Nr. 1.2.1 : (One-sided) Accident with trailer near densely populated area
  - Nr. 1.2.1 : Unexpected release of hydrogen during salvage
  - Nr. 2.1.5 : Third party intrusion or vandalism
  - Nr. 2.1.10 : Leaks, e.g. from flanges, connections (e.g. fittings)
  - Nr. 2.1.14 : Heat radiation due to external fire
  - Nr. 2.3 : Pipeline damaged during excavation work (unnoticed), leading to loss of containment at start of unloading to delivery station.
  - Nr. 2.4.1: Discharge hose not properly connected: torch fire, cloud fire or explosion (incl potential backflow)
  - Nr. 3.2.1 : Enclosed area's (lack of air)
  - Nr. 4.1.1 : Stability and contractual conditions, transport company selection constraints/ non-qualified personnel on truck trailer
  - Nr. 4.1.2 : Governmental contracting requirements, legislation appears clear but may be challenging to interpret / fully comprehend
  - Nr. 4.1.3 : Additional engineering and company guidelines & standards
  - Nr. 4.2.1 : HAZOP, QRA (Quantitative Risk Analysis), root cause analysis, MOC have not (properly) been executed
  - Nr. 4.2.2 : Preparation and update of Hazards and Effects Register absent
  - Nr. 4.2.3 : Absence of Quality Assurance measures
  - Nr. 4.3.2 : Absence of medical support service, firefighting support, evacuation
  - Nr. 4.3.3 : Controlling of hydrogen fire / controlled burn out of fire

Conclusions and recommendations

Main conclusions

With the proper safety barriers implemented, limited risks are expected in the use of a hydrogen fuelling station in the public domain. Risks for which additional measures should be implemented have been identified (see 2.4).

The HAZID methodology is a useful instrument to bring possible hazards to the surface. Upon project implementation, the HAZID results should be used as input for more detailed analysis, such as HAZOP.

Recommendations

The main recommendations of the HAZID analysis include :

- Draw up an emergency plan for hydrogen trucks for delivery points, such as hydrogen fuelling stations per location. Not only emergency instructions on the emergency column, but also in the mind of the parties involved.
- Companies, locations to prepare for after-care of fires exceeding 2 hours.
- Organise proper training regarding maintenance for personnel.
- Prepare maintenance philosophy (permit to work, workplans, shutdown procedures, etc.), also considering subcontractors.
- Include the above items in the HAZOP analysis.
- Detection, alerting, flight behaviour is a point of attention because hydrogen is odourless and colourless. The flame is invisible during the day and ignites easily. It is important to recognize the danger timely (line 1.1.1 of HAZID).
- Verify standards for set-up locations of tube trailers, containers, etc. in the public area.
- Special attention to activation of emergency button or emergency stop by public, focusing on typical deviations from existing systems at gas stations. Special attention to flaring (quantity and source of potential ignition etc.).
- Consider wind directions and number of set-up locations for emergency services.
- Legislation may be challenging to interpret, comprehend and apply. Point of attention as this is a topic which may only appear to be covered by legislation/regulation. A typical scenario could be that it concerns a relatively new technology, for which regulations are not yet adequately in place and that the safety net with regulations is not sufficient.
- Check on engineering standards tube trailers on extreme (NL applicable) weather conditions and cold, such as intrusion of water leading to freezing.
- Verify procedures and criteria for connecting and disconnecting trailers during lightning or bad weather conditions.
- Flooding: check if
    - flood risk is addressed in permitting procedures, e.g. flood plains (uiterwaarden) low lying areas,
    - drive-away protection (wegrijdbeveiliging) as result of floating (general / ADR),
    - specific (customized) measures safeguarding location (e.g. “poortbeleid”).
- To further investigate ignition probabilities, scenario's, probabilities etc. and lay-out of trailer and tube (sizing and volumes). See also knowledge gaps WVIP WP 4. Possibility of gas cloud scenario at lower pressures (e.g. 300 bar) Incl. benchmark study on other gas transport scenario's.
- Tunnels:
    - Review legislation with regard to hydrogen transport in tunnels (and incident scenario's).

    - To further investigate ignition probabilities, scenario's, probabilities etc. See also knowledge gaps WVIP WP 4. Incl. benchmark study on other gas transport scenario's
    - Probability of accumulation of hydrogen in an enclosed space in tunnel, potential explosion hazards.
    - Monofuel / multifuel suggested to revise and/or develop national guidelines (including ATEX). Especially for fitting into existing situations (see case Stedin and case 1000 ampere (NEN website). Suggested to consider applying ATEX rules to hydrogen stations (unmanned / non-arbo situation).
- Prepare protocols / instructions on salvage operations of (hydrogen) pressurized vessels containing flammable or explosive gasses. Collaboration and sharing of knowledge between first responders and transport companies is of importance. (e.g. related to protocols, handelingsperspectieven).
- Point of attention: ensure availability of experienced/trained driver in future when demand may be higher or in case of increased labour shortage.

ANNEX 1: HAZID worksheet

The HAZID worksheet is a separate Excel file with all notes and conclusions and available on request. Please contact the Co-Projectmanager Lennart de Waart: Lennart.dewaart@nen.nl