WP 5 'Veiligheidsaspecten en risico's – HAZID-studie, rapportage case 3 Lokale productie van waterstof bij een tankstation

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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 voeren

WVIP WP 5 werkt aan veiligheidsanalyse en draagt bij aan de 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 waterstofproductie, waterstofinfrastructuur en specifiek voor partijen die zich bezighouden met waterstofproductie en –infrastructuur, inclusief transportmethoden waterstof over de weg.

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

- Case 1 Waterstoftankstation
- Case 2 Waterstoftransport over de weg (tubetrailer)
- Case 3 Lokale productie
- Case 4 Waterstofaggregaten
- Case 5 Service & onderhoud
- Case 6 (mobiele) Bunkering van waterstof

Deze rapportage betreft case 3, lokale productie van waterstof bij een waterstoftankstation.

Dit document brengt de risico's in kaart voor de specifieke situatie van lokale productie van waterstof bij een waterstoftankstation en geeft tevens aanbevelingen om de geïdentificeerde risico's te mitigeren.

Summary

This report summarizes the results and recommendations of the Hazard identification study (HAZID) for production of hydrogen, through PEM electrolysis, in close vicinity of a fuelling station that includes hydrogen fuelling for cars.

The HAZID study was executed under the umbrella of the Dutch Hydrogen Safety Programme (Dutch acronym: WVIP). Uptake of the findings and recommendations of this HAZID case takes place within WVIP.

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1. 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 program. https://opwegmetwaterstof.nl/veiligheid/

The scope includes:

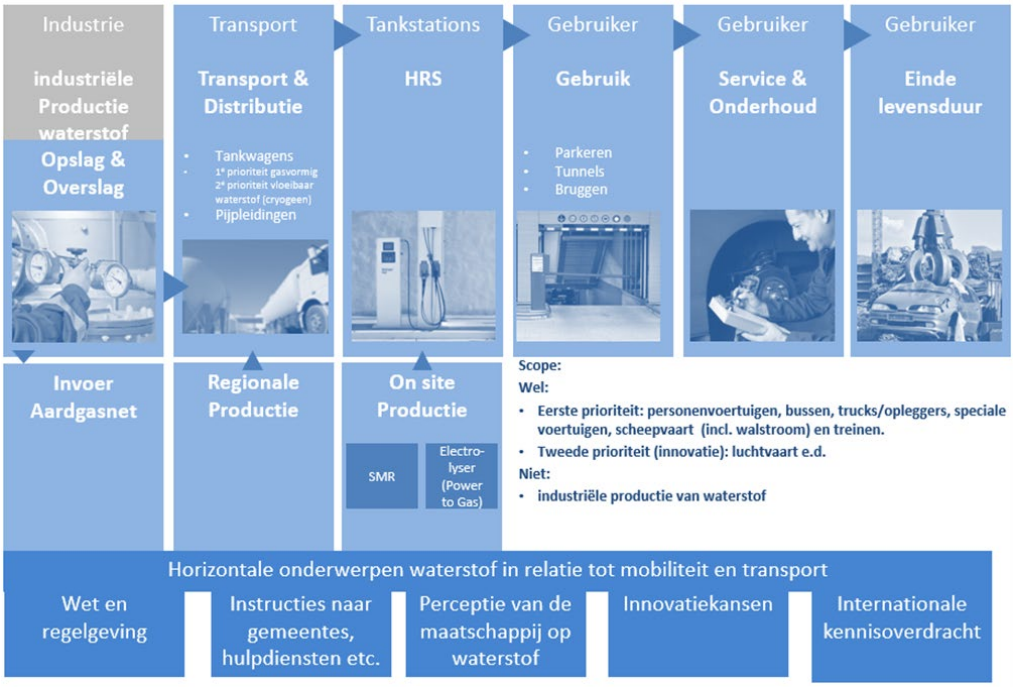

Figure 1: Scope WVIP This report contains the results and recommendations of the HAZID regarding the production of hydrogen, next to a hydrogen fuelling station

2. Narrative

In the near future it is likely that hydrogen will be generated near a car fuelling station using green electricity to produce green hydrogen. In addition to conventional fuels, this filling station then also offers the option of refueling with hydrogen.

In this context, a local generation of hydrogen near a filling station is envisaged which matches the following base data:

- PEMFC system, 1 MW (approx. 450 kg H_2/day)
- Connected to mains electricity
- Produced hydrogen is stored in a hydrogen storage/buffer vessel (400 barg)
- From hydrogen storage, at desired times, hydrogen is moved from buffer tank to hydrogen storage at filling station.
- Operating conditions PEM electrolysis:
  - Temperature: 80 °C
  - Cathode pressure: 30 bara
  - Anode pressure: 3 bara
  - Current density: 2A/cm^2
  - Cell voltage: 2V
  - Cathode catalyst: Pt/C
  - Anode catalyst: IrO_2

3. Activities and meetings

3.1. HAZID team

The HAZID team consisted of the following persons, with their respective roles:

TNO – Chairman HAZID; Expert and TL WG 5
NEN – Scribe, co-PM WP 5
TNO – Expert design
TNO - expert Electrolysis
Fire brigade Netherlands – Hazard specialist

3.2. Meetings

The HAZID was conducted in 1 session (live) on June 17, 2022 in TNO, location Petten.

3.3. 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 production of hydrogen, through a PEM electrolysis system that is situated close to a fuelling station that includes hydrogen fuelling of cars. Secondly, to analyse possible hazardous situations that may result from the adjacent fuelling station.

This HAZID was 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 the international oil & gas industry https://www.nen.nl/nen-en-iso-17776-2016-en-229028).

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 were 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 colour scheme (figure 2).

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 2: Risk matrix used during HAZID.

3.4. Main findings

For the complete HAZID reporting in Excel format, reference is made to the attachment of this report. 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 risks in the orange (10-15) or red (15-34) risk regime.
- There are several hazards found in the yellow risk regime (4-10), including :
  - Nr. 1.2.1: a Hydrogen fire and/or explosion can bring damage to people and property, in particular when there is proximity to population. A gas cloud scenario is currently not included in guideline PGS-35 & the QRA. Internal safety distances from installation/buffer tank/pump are to be verified. Also, a communication plan to local residents should be drawn-up.
  - Nr. 1.2.2: in line with 1.2.1, a domino effect can take place in case of a multi fuel station, located in close proximity of the hydrogen production unit.
  - Nr. 1.2.3: risk associated with adjacent land-use, such as crop fields, airfield, wind turbines area, etc.

- Nr. 1.2.4: risk associated with proximity to transport corridors.
- Nr. 1.2.6: risk associated with social acceptance and local attitude, social climate.
- Nr. 2.1.4: risk associated with control philosophy and recognition of process deviations.
- Nr. 2.1.5: risk associated with emergency response.
- Nr. 2.2.2: risks of electrolyser membrane defects, leading to explosive mixture.
- Nr. 2.2.3 and 2.2.4: embrittlement or corrosion of installation.
- Nr. 2.2.6: third party intrusion and or vandalism.
- Nr. 2.2.9: equipment failure that leads to blow-off of installation.
- Nr. 2.4.1: falling-off of installation.
- Nr. 2.4.4: injuries as result of heavy lifting and broken line or chain.
- Nr. 3.1.1: disease hazards.
- Nr. 3.1.5: physical hazards (e.g. noise).
- Nr. 3.1.6: mental hazards.

4. Conclusions and recommendations

4.1. Conclusions

With the proper safety barriers implemented, no unacceptable risks are expected in the use of a PEM electrolysis (hydrogen production) facility near by a 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.

4.2. Recommendations

The main recommendations of the HAZID analysis include :

- Draw up an emergency plan 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 hrs.
- Organise proper training regarding maintenance for personnel.
- Prepare maintenance philosophy (permit to work, workplans, shutdown procedures, etc.), also considering subcontractors.
- Special attention should be given to the activation of the emergency button ("noodstopsysteem") and alarm by the public. In particular, typical deviations from existing systems at gas stations are of importance. Special attention should be given to (automatic) flaring as part of the emergency procedure. This may / may not be a desirable measure depending on the hazard (quantity of potential ignition etc.).
- 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).
- Special attention to flaring (quantity and source of potential ignition etc.).
- Consider wind directions and number of set-up locations for emergency services.
- Containerized facilities are recommended to avoid freezing.
- Hazard resulting from vandalism and misuse by unauthorized personnel should be taken into account in the facility design and operations.

- External ignition sources and infrastructure should be considered when choosing the facility location (e.g. overhead high voltage cables)
- Assess regulations and protocols for aviation, drones helicopters etc. above and /or near the facility
- Fluor (PFAS) concentration in the water circuit as a result of electrolysis should be further investigated.
- A dedicated emergency information number exist for Broom & LPG. It should be verified if there is a need for dedicated hydrogen emergency number
- Besides contractor, the operator should be able to manage operations and have knowledge of the facility and associated risks. Requirements to operators of production units in the permitting procedure should be verified. See e.g. https://opwegmetwaterstof.nl/wp-content/uploads/2020/03/WVIP_uniforme_vergunnningverlening_rapport_23_03_2020_F-1.pdf
- Include the above items in the HAZOP analysis

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.

Annex 1: HAZID worksheet

The HAZID worksheet is a separate Excel file with all notes and conclusions. For more information about the worksheet, please contact Lennart de Waart: mail to : energy@nen.nl