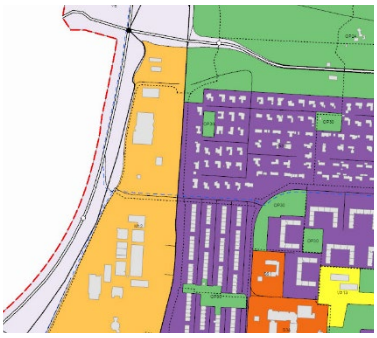
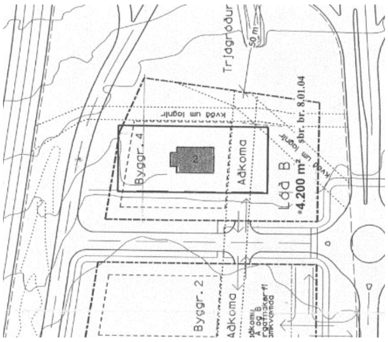
Reykjavík, 10. október 2024
USK24080163

Stekkjarbakki 2– Fyrirspurn til skipulagsfulltrúa

Á embættisafgreiðslufundi skipulagsfulltrúa 19. september 2024 var lögð fram fyrirspurn Jóns Hrafns Hlöðverssonar, dags. 15. ágúst 2024, ásamt greinargerð, dags. 14. ágúst 2024, um uppbyggingu vetnisstöðvar á lóð nr. 2 við Stekkjarbakka.



Aðalskipulag Reykjavíkur 2040



Deiliskipulag

Loftmynd

Skipulag í gildi

Aðalskipulag: Í gildi er Aðalskipulag Reykjavíkur 2040, samþykkt í borgarstjórn Reykjavíkur þann 19. október 2021 og birt í B-deild stjórnartíðinda þann 18. janúar 2022. Skv. aðalskipulaginu tilheyrir lóðin M12 Mjódd – Miðsvæði. þar segir

„Fjölbreytt verslun, m.a. sérvöruverslun og þjónusta og starfsemi sem þjónar heilum borgarhluta. Verslun og þjónusta, skrifstofur, stofnanir, afþreying og íbúðir, einkum á efri hæðum bygginga. Matvöruverslanir heimilar. Veitingastaðir í flokki I og II eru heimilir og veitingastaðir í flokki III geta verið heimilir, þó með takmörkuðum opnunartíma til kl. 1 um helgar og 23 á virkum dögum.“

Deiliskipulag/ Hverfisskipulag: Svæðið er hluti af þróunarsvæði 6.1.4 í Hverfisskipulagi Neðra Breiðholt. Í gildi er deiliskipulag fyrir Norður Mjódd samþykkt 13.apríl 1999 með síðari breytingum.

Fyrirspurn

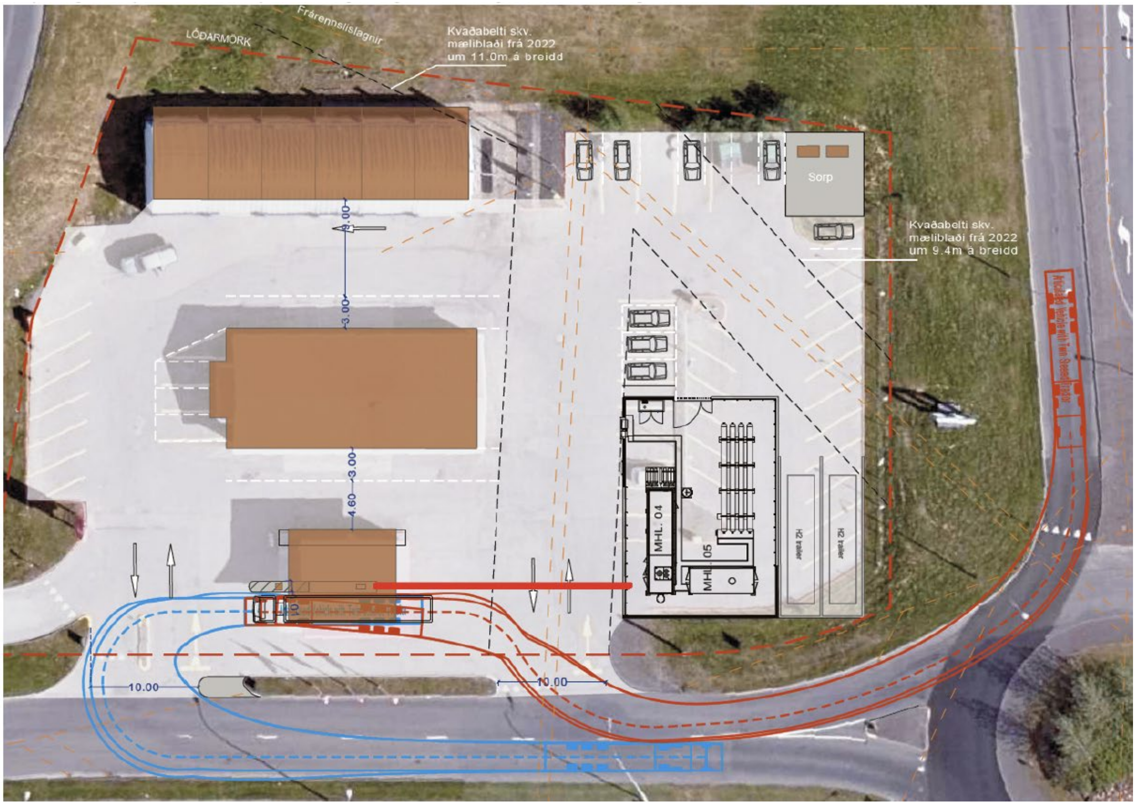
Lóðin Stekkjarbakki 2 er iðnaðar og þjónustulóð. Um árbil hefur verið starfrækt á lóðinni lúgusjoppa, bensínafgreiðsla og handvirk bílaþvottstöð. Vilji er til þess hjá lóðarhöfum að breyta starfseminni á lóðinni þannig að einnig megi koma fyrir vetnis áfyllingarstöð á lóðinni. En slík starfsemi krefst rýmis innan lóðar. Og það sem háir slíkum áformum er takmarkaður byggingarreitur lóðarinnar. Takmörkunin kemur til af því að tvær stórar frárennslisæðar liggja þvert yfir eystri hluta lóðarinnar.

Það er skemmst frá því að segja að Veitur hafa tekið jákvætt í þessar hugmyndir. Í viðbrögðum þeirra á fundi 8. júlí s.l. kom það m.a. fram að hægt væri að koma mannvirkjum fyrir, utan lagnakvaðar. Í því sambandi er vilji hjá framkvæmdaraðila að opna á aðra staðsetningu í ljósi þess hve létt mannvirki er um að ræða.

Mat á væntanlegum þörfum fráveitukerfisins var gert af Veitum til að áætla hvenær Veitur gætu þurft að komast að lögnum sem liggja í gegnum lóðina. Matið sýndi að skólplögnin er nógu stór fyrir núverandi rennsli og væntanleg framtíðarrennsli en að regnvatnslögnin er of lítil.

Veitur ætla að forðast að grafa upp lagnir og auka þess í stað afkastagetu regnvatnskerfisins með því að innleiða blágrænar ofanvatnslausnir með komandi uppbyggingu Norður Mjóddar og Borgarlínu. Þessar væntanlegu uppbyggingarverkefni eru enn mjög snemma á skipulagsstigi og mikil óvissa ríkir um framtíðarskipulag svæðisins þannig að Veitur hafa ekki áhuga á að færa lagnir af lóðinni að svo stöddu.

Fyrirhuguð áform munu ekki hafa áhrif á bílastæðabókhald þeirra mannvirkja sem fyrir eru á lóðinni.



Umsögn

Óskað er eftir áliti skipulagsfulltrúa á að koma fyrir vetnisáfyllingarstöð á núverandi bílastæði við Stekkjarbakka 2.
Eins og tekið er fram í fyrirspurn er svæðið í miklum skipulagbreytingu það er verið að þróa blandaða byggð og koma fyrir borgarlínu. Framtíðar íbúðarbyggð mun vera staðsett í nálægð við fyrirhugaða Vetnisstöð eða um það bil 25 metrum.

Niðurstaða

f.h. skipulagsfulltrúa Reykjavíkur

Hrönn Valdimarsdóttir

verkefnastjóri

Svava Svanborg Steinarsdóttir

Frá: Hrönn Valdimarsdóttir
Sent: miðvikudagur, 23. október 2024 13:19
Til: Heilbrigðiseftirlit
Afrit: Svava Svanborg Steinarsdóttir; Helgi Guðjónsson
Efni: RE: Vetnisáfyllingarstöð í íbúðabyggð
Viðhengi: Stekkjarbakki 2 - (fsp) Vetnisstöð Umsögn skipulagsfulltrúa.docx

Sent to GoPro Case: -1

Góðan dag
Ég ætla að óska eftir formlegri umsögn frá HER varðandi þetta mál.
í viðhengi er drög að umsögn frá okkur.

Kv. Hrönn

Frá: Hrönn Valdimarsdóttir
Sent: þriðjudagur, 8. október 2024 11:08
Til: Svava Svanborg Steinarsdóttir [redacted] Helgi Guðjónsson [redacted]
Efni: Vetnisáfyllingarstöð í íbúðabyggð

Góðan dag
Vitið þið hvort það séu einhverjar fjarlægðartakmarkanir eða slíkt varðandi Vetnisáfyllingarstöð í íbúðabyggð. Við erum með fyrirspurn um slíka stöð á bensínstöðvarlóð sem er staðsett c.a 25 metra frá fyrirhugaðri íbúðarbyggð í Norður Mjódd.

Langar að heyra hvort þið þekkið þessa starfsemi og hvort það sé eitthvað sem ég þarf að taka með í umsögnina. T.d varðandi mengun, hljóðvist, eldhættu eða því um líkt.

Kveðja,

Hrönn Valdimarsdóttir
Landslagsarkitekt

Sími: +354 411 11 11
Skrifstofa skipulagsfulltrúa
Umhverfis- og skipulagssvið Reykjavíkurborgar
Borgartúni 12–14
105 Reykjavík

Reykjavík 5. nóvember 2024
2024100290

Umhverfis- og skipulagssvið
Skrifstofa skipulagsfulltrúa
b.t. Hrannar Valdimarsdóttur
Borgartúni 12-14
105 Reykjavík

Umsögn Heilbrigðiseftirlits Reykjavíkur um fyrirhugaða vetnisáfyllingarstöð við Stekkjarbakka 2, í nágrenni við íbúðarbyggð

Vísað er til tölvubréfs skrifstofu skipulagsfulltrúa dags. 23. Október 2024 þar sem óskað er umsagnar Heilbrigðiseftirlits Reykjavíkur (HER) um fyrirhugaða vetnisáfyllingarstöð við Stekkjarbakka 2, í nágrenni við fyrirhugaða blandaða íbúðarbyggð. HER hefur farið yfir málið og gögn þess og gefur eftirfarandi umsögn.

HER hefur kynnt sér erlendar rannsóknir og gögn varðandi vetnisáfyllingarstöðvar og samkvæmt þeim gögnum þarf að gera heildstætt áhættumat áður en staðsetning vetnisáfyllingarstöðvar er ákveðin. Slíkt mat þarf að liggja fyrir áður en staðsetning er fastsett í skipulagi. Vetni er mjög eldfimt gas og getur verið hættulegt heilsu manna í háum styrk. Þar sem gasið er mjög hvarfgjarnt er þó ekki líklegt að það valdi heilsufarsáhrifum við leka í áfyllingarbúnaði undir beru lofti. Helstu áhættuþættir eru sprengihætta og eldhætta, aðallega tengd lekum, tæringu og þrýstingsvandamálum í tönkum.

Þegar ákvarða á hæfilega öryggisfjarlægð vetnisáfyllingarstöðva frá íbúðarbyggð þarf að horfa til niðurstöðu áhættumatsins en í þeim gögnum sem HER hefur kynnt sér er lágmarksfjarlægð fyrir íbúðarbyggð af þeirri hæð og þéttleika sem fyrirhuguð eru í Norður-Mjódd á bilinu 35-50 m. Hafa ber í huga að ef stærri atburðir verða, s.s. sprenging í tankbíl, getur áhrifasvæði verið mun stærra þó tíðni slíkra atburða sé lág. Gerð þeirrar byggðar sem er í nágrenni stöðvanna skiptir miklu máli, s.s. hver þéttleiki hennar er og hversu há húsin eru. Meðfylgjandi þessu bréfi eru erlendar greinar og leiðbeiningar varðandi áhættumat og öryggisfjarlægðir fyrir vetnisstöðvar.

Niðurstaða HER er í ljósi ofangreinds að ótímabært sé að ákvarða staðsetningu fyrir vetnisáfyllingarstöð í skipulagi þar sem gera þarf heildstætt áhættumat sem byggir á stærð og gerð fyrirhugaðrar stöðvar, gerð byggðar í nágrenni og nálægð við aðra innviði. Miðað við þau gögn sem HER hefur rýnt er æskilegt að staðsetja slíka stöð fjær íbúðarbyggð og í það minnsta í meiri fjarlægð en 25 m.

Heilbrigðiseftirlit Reykjavíkur
heilbrigðiseftirlit@reykjavik.is
www.reykjavik.is/heilbrigðiseftirlit
Borgartúni 12-14
105 Reykjavík

Virðingarfyllst

f.h. Heilbrigðiseftirlits Reykjavíkur

Svava S. Steinarsdóttir
Verkefnastjóri

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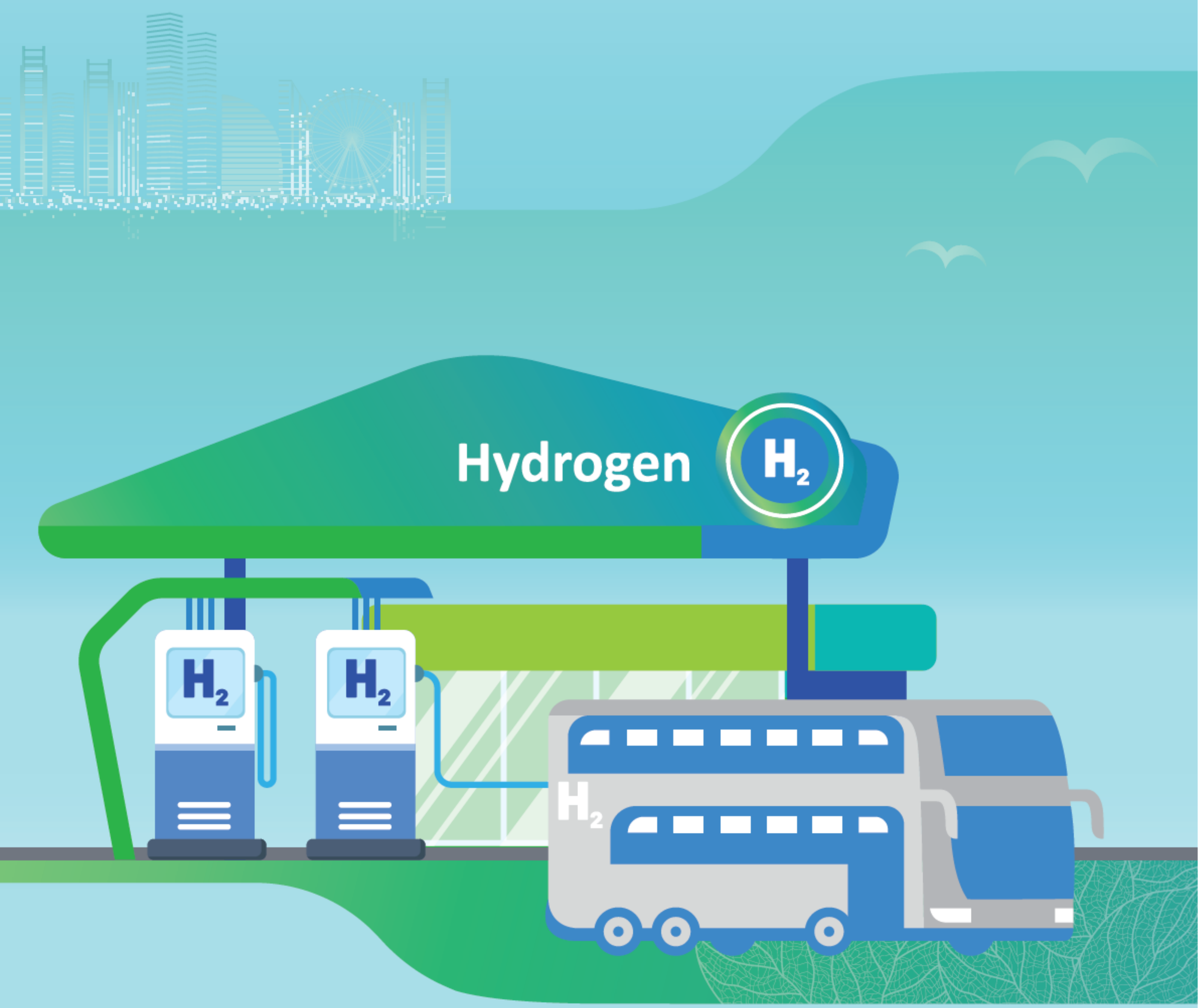
Code of Practice for

Hydrogen Filling Stations



Issue 0

February 2024

機電工程署
EMSD

Code of Practice

for

Hydrogen Filling Stations

Issue 0

February 2024

Electrical and Mechanical Services Department

Preface

This Code of Practice covers the design, installation, testing and commissioning, operation and maintenance of the hydrogen equipment inside the hydrogen filling stations.

The basis of this Code of Practice includes:

- ISO standards in relations to hydrogen filling station, e.g., 19880 Gaseous hydrogen — Fuelling stations;
- GB standards in relations to hydrogen filling station, e.g., GB 50156 Technical standard of fuelling station and GB 50516 Technical code for hydrogen fuelling station;
- BCGA Code of Practice 41 The design, construction, maintenance and operation of filling stations dispensing gaseous fuels; and
- NFPA 2 Hydrogen Technologies Code.

Where there exists a conflict between requirements prescribed in Section 4 of this Code of Practice, and owner's selected standards according to the relevant clauses in this Code of Practice, the more stringent one shall govern.

Notwithstanding the standards specified in this Code of Practice, equivalent standards, codes or guidance notes that are prevailing and well adopted will be accepted if deemed appropriate by EMSD.

EMSD reserves the final determination on the interpretation of this Code of Practice.

Content

1. Interpretation of Terms

Buffer cylinders – pressure vessels designed for the purpose of temporarily storing compressed hydrogen, typically located before or after compressors systems to help the dampening or adjustment of the flow pressures.

Compressed hydrogen storage system – in relation to hydrogen fuelled vehicle, refers to hydrogen storage on-board vehicle as defined in the Global Technical Regulation No. 13

EMSD – Electrical and Mechanical Services Department of the Government of the Hong Kong Special Administrative Region of the People's Republic of China.

Hydrogen cylinders – in relation to hydrogen fuelled vehicle, means container vessel storing hydrogen as propellant for the vehicle.

Hydrogen fuelled vehicle (HFV) – the vehicle using hydrogen as propellant.

Hydrogen fuel cell vehicle (HFCV) – the vehicle using hydrogen as propellant with fuel cell technology.

Hydrogen storage – refers to the storage of hydrogen gas, comprising of fixed pressure tanks/containers/vessels manifolded together to supply gas to the filling station, or tubes mounted on a transportable trailer.

Nominal working pressure (NWP) – in relation to hydrogen cylinders in hydrogen fuelled vehicle, means the settled pressure of compressed gas in fully fuelled container or storage system at a uniform temperature of 15 °C.

Pressure – The pressure terminology used in this Code of Practice is based on ISO 19880, and is described in Appendix A.

Skid mounted filling stations – a modular design filling stations for hydrogen fuelled vehicle to refuel. It integrates all key components, from storage, to compression and dispensing, and mounted onto one transportable skid.

Stationary filling stations – a filling station where key components are installed on-location.

2. Objectives & Scopes

2.1. Objectives

2.1.1. This Code of Practice provides a general outline of the minimum safety requirement to be followed by the owner of Hydrogen Filling Stations (HFS), to ensure the health and safety at work of their employees and to conduct their operations in a safe manner so that members of the public are not exposed to undue risks from hydrogen.

2.2. Scope

2.2.1. This Code of Practice covers the design, installation, testing and commissioning, operation and maintenance of the hydrogen equipment inside the HFS as illustrated in **Appendix B**.

2.2.2. The Code of Practice covers both stationery filling stations and skid mounted filling stations. Unless specified otherwise, the requirements in this Code of Practice apply to both types.

2.2.3. This Code of Practice does not cover liquid hydrogen, and hydrogen in the form of hydrogen carriers such as metal hydrides or liquid organic hydrogen carriers (LOHC).

2.3. Regulations and References

2.3.1. The owners of HFS shall make particular reference to the following ordinance where applicable:

- Gas Safety Ordinance (Cap. 51)
- Fire Services Ordinance (Cap. 95)
- Buildings Ordinance (Cap. 123)
- Dangerous Goods Ordinance (Cap. 295)
- Occupational Safety and Health Ordinance (Cap. 509)

2.3.2. This Code of Practice makes reference to the following publications (latest editions of these publications shall be used in each case):

IEC 60079	Explosive atmospheres
ASME B31.12	Hydrogen Piping and Pipelines
BCGA CoP 33	The Bulk Storage of Gaseous Hydrogen at Users' Premises
BCGA CoP 4	Gas Supply and Distribution Systems (Excluding Acetylene)
BCGA CoP 41	The Design, Construction, Maintenance and Operation of Filling Stations Dispensing Gaseous Fuels
EIGA 211/17	Hydrogen vent systems for customer applications
GB 50156	Technical standard of fuelling station
GB 50516	Technical Code for Hydrogen Fuelling Station
GB 50177	Design code for hydrogen station
GB/T 19773	Specification of hydrogen purification system on pressure swing adsorption
GB/T 19774	Specification of water electrolyte system for producing hydrogen
GB/T 31139	Safety technical regulations for mobile hydrogen refueling facility
GB/T 34425	Fuel cell electric vehicles—Hydrogen refuelling nozzle
GB/T 34583	Safety technical requirements for hydrogen storage devices used in

	hydrogen fuelling station
GB/T 34584	Safety technical regulations for hydrogen refueling station
GB/T 42855	Technical requirements of fuelling protocols for hydrogen fuel cell vehicles
GB/Z 34541	Safety operation management regulation for hydrogen fueling facilities of hydrogen vehicles
ISO 14687	Hydrogen fuel quality — Product specification
ISO 15649	Petroleum and natural gas industries — Piping
ISO 16110-1	Hydrogen generators using fuel processing technologies — Part 1: Safety
ISO 19880	Gaseous hydrogen — Fuelling stations
ISO 22734	Hydrogen generators using water electrolysis — Industrial, commercial, and residential applications
ISO 26142	Hydrogen detection apparatus — Stationary applications
ISO/TS 19883	Safety of pressure swing adsorption systems for hydrogen separation and purification
NFPA 2	Hydrogen Technologies Code
SAE J2600	Compressed Hydrogen Surface Vehicle Fueling Connection Devices
SAE J2601	Fueling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles

SAE J2601-2	Fueling Protocol for Gaseous Hydrogen Powered Heavy Duty Vehicles
SAE J2601-3	Fueling Protocol for Gaseous Hydrogen Powered Industrial Trucks
SAE J2719	Hydrogen Fuel Quality for Fuel Cell Vehicles
SAE J2799	Hydrogen Surface Vehicle to Station Communications Hardware and Software

3. Agreement Requirements

3.1. General

3.1.1. Upon request, the owner shall facilitate and allow representatives of the EMSD to visit the owner's premises and manufacturer's facilities, as well as access relevant documents, for conducting inspections and verifying compliance.

3.1.2. The application for agreement shall be made in consultation with EMSD.

3.2. Agreement for Construction and Agreement for Use

3.2.1. The owner of HFS shall obtain the agreement from the EMSD before construction of HFS, and before use of HFS, and upon any change or modification to the original design, installation, operation, and maintenance arrangement.

3.2.2. Prior to the construction of a HFS, the owner shall submit the following information to EMSD for consideration:

- Quantitative Risk Assessment report for the hydrogen filling station (Refer to Section 3.3).
- A compliance check report to confirm that the requirement in Section 5 have been met. The report should be completed by an independent third party.
- Technical information, such as drawings, design, calculation, specification, which are relevant to the requirement in Section 5, including but not limited to:
  - Overall site layout plan with detailed dimensions;
  - Elevation and sectional views of the hydrogen filling station with all key dimensions clearly specified;
  - Detail P&ID of the hydrogen filling station;
  - Determination and zoning of hazardous areas;
  - Piping layout, including type of protection;

- A list of all hydrogen system and equipment in the filling station. For electrical apparatus, the type of protection appropriate for the respective hazardous zones should be indicated;
- Schematic diagram of safety control systems;
- Layout plan showing positions of hydrogen detectors and emergency devices/switches;
- Installation details of the hydrogen storage;
- Plans showing fire service installations;
- Plans showing the ventilation arrangements for the hydrogen filling station;
- Electrostatic discharge prevention measures;
- Alarm settings from fire and gas detection system arrangements;
- Explosive Atmosphere (Ex) certificates for the relevant electrical apparatus;
- Site security arrangement;
- Specifications of the hydrogen containers, compressors, dispensers, hydrogen detectors and breakaway couplings;
- Flow rate calculations for compressor performance, pipeline capacity, and pressure relief device vent pipe capacity;
- Design and calculation of the lightning protection system; and
- Other relevant information as requested.

3.2.3. Upon completion of all construction work and before the HFS is put into operation, the owner shall submit the following information to EMSD for consideration:

- A compliance check report to confirm that the requirements in Section 6 have been met. The report should be completed by an independent third party.
- Testing and commissioning procedures and programme of the

hydrogen filling station installation.

- Test report and certificate relevant to Section 6, including but not limited to:
  - Pipework pressure test certificates;
  - Pressure relief device pressure test certificates (when applicable);
  - Earthing impedance report;
  - Electrical continuity test certificate for hydrogen pipework;
  - Electrical testing certificate for bonding and grounding of dispenser system;
  - Test report for emergency shutdown system;
  - Test report/certificate for lightning protection system;
  - Work completion certificate for fixed electrical installations (WR1);
  - Calibration certificates for pressure gauges and thermometers (if fitted);
  - Certificates of corresponding Explosive Atmosphere (Ex) classification for electrical components and equipment used in hazardous areas (including hydrogen compressors and dispensers;
  - Certificate of explosion-proof electrical components and equipment used in hazardous areas (including hydrogen compressors and dispensers);
  - Calibration and test certificate for hydrogen detector; and
  - Other relevant information as requested.
- The plan and arrangement relevant to the requirements in Section 7, including but not limited to:
  - Operation and Maintenance Manual;
  - Isolation procedure;

- Site security arrangement;
- Signage of the HFS;
- Emergency response plan of the HFS; and
- Other relevant information as requested.

3.3. Quantitative Risk Assessment

3.3.1. A Quantitative Risk Assessment (QRA) report shall be required for the hydrogen filling station as a part of the Agreement for Construction process. The owner of the station shall employ an independent quantitative risk assessment consultant to prepare a QRA report demonstrating that the risk levels associated with the station are in compliance with relevant Hong Kong Risk Guidelines referred to in Section 4.4 of the Hong Kong Planning Standards and Guidelines.

3.3.2. The QRA should demonstrate that the mitigation measures employed are appropriate to achieve the desired level of risk of the station. Reference shall be made to the Guidance Note on General QRA Studies for Hydrogen Installations in Hong Kong issued by EMSD for the standard approach to QRA of hydrogen installations in Hong Kong.

3.3.3. The QRA report shall take into account the hydrogen storage, site topography, meteorological conditions, ignition sources, interaction with other flammable fuels and existing planned population in the vicinity of the filling station.

3.3.4. The QRA report shall consider the appropriate design of forced and/or natural ventilation and the means/placement of hydrogen detection and appropriate station response.

3.3.5. For major alterations of HFS, a fresh QRA may be required if the proposed alterations change the basis of the original QRA.

3.4. Independent third party

3.4.1. Where the application requires the engagement of an independent third party, the following requirements shall be satisfied:

- The third party should possess the necessary expertise, qualifications, and experience in the relevant field.

- The third party should have a comprehensive understanding of the applicable regulations, industry standards, and best practices.

3.4.2. The qualification and job reference of the third party, which demonstrate its capability, shall be submitted to EMSD for agreement.

3.5. Competent person

3.5.1. A competent person refers to a person who is by virtue of his training, qualification and substantial practical experience

3.5.2. The training shall include, but not limited to, training in the properties of hydrogen, the use of safety devices and emergency handling.

3.5.3. The training records, qualification and experience of the competent person, shall be submitted to EMSD for agreement.

4. Siting Requirements

4.1. General

4.1.1. This section defines the siting and minimum separation distance requirements from adjacent buildings for hydrogen filling stations from a risk point of view. It also outlines the minimum separation distance requirements between hydrogen filling facilities and other critical features for compliance.

4.1.2. Where multiple fuel types are stored or dispensed on the site, consideration shall be given to the detailed design of these areas separately. The influence of each area on other aspects of the hydrogen filling station shall also be reviewed holistically within the quantitative risk assessment in accordance with the Guidance Note on General QRA Studies for Hydrogen Installations in Hong Kong issued by EMSD.

4.1.3. The hydrogen filling station shall be located along main roads which are considered safe for hydrogen tube trailer transport, or at a location which can be easily reached from the main roads without passing through highly populated areas.

4.1.4. The hydrogen filling station shall not be located near overhead electrical power lines. Overhead electrical lines shall not span across and are at a distance not less than 1.5 times the height of the pole. It shall be sited so that damage to any equipment or vehicles by electric arcing from overhead or other cables cannot occur.

4.1.5. A minimum size of 750 m2 will normally be required for a new stationary hydrogen filling station.

4.2. Separation Distances from Surrounding Land Uses

4.2.1. Hydrogen filling stations should meet the separation distance requirements from surrounding land uses as specified in the following table. However, the final accepted separation requirements shall be subject to the Quantitative Risk Assessment report as in Section 3.3.

	Distance from Hydrogen Storage/ compressor/ vent pipe/ dispenser
Low density residential/ Incidental Dwelling/ Commercial/ Industrial/ Recreational	25 m
High-rise residential/ Educational/ hospital	50 m

Table 1: Minimum recommended separation distances from surrounding land uses

4.2.2. If the separation requirements as specified under Clause 4.2.1 cannot be met, a fire wall complying with Section 5.18 with 2-hour fire resistance rating shall be erected in order to suitably reduce the separation distance subject to the Quantitative Risk Assessment report as in Section 3.3. The height of the fire wall shall be at least 2.5m.

4.3. Equipment Layout Distances within Hydrogen Filling Station Boundary

4.3.1. The minimum separation distance requirements between hydrogen equipment inside the filling station are shown in the following table.

	Hydrogen storage	Hydrogen vent pipe	Hydrogen compressor	Hydrogen dispenser	Hydrogen unloading facility
Hydrogen storage	-	Nil	Nil	Nil	Nil
Hydrogen vent pipe	Nil	-	Nil	Nil	6 m
Hydrogen compressor	Nil	Nil	-	Nil	Nil
Hydrogen dispenser	Nil	Nil	Nil	-	Nil
Hydrogen unloading facility	Nil	6 m	Nil	Nil	-
LPG/ petrol/ diesel dispenser	Nil	Nil	Nil	4 m	Nil
EV charging facilities/ ignition source / site boundary	5 m	5 m	5 m	5 m	5 m

Table 2: Minimum equipment layout distances within filling station boundary

Notes:

i. Clause 4.3.1 is not applicable to skid mounted filling station. The separation distances between hydrogen equipment inside the filling station shall be determined in accordance with relevant international standards subject to the Quantitative Risk Assessment report as in Section 3.3.

ii. If the separation requirements as specified under Clause 4.3.1 cannot be met due to site constraint, a fire wall complying with Section 5.18 with at least 2-hour fire resistance rating shall be erected in order to suitably reduce the separation distance subject to the Quantitative Risk Assessment report as in Section 3.3. The height of the fire wall shall be at least 2.5m.

iii. The equipment layout distances between LPG and petrol/ diesel filling facilities and other critical features shall be made reference to the Code of Practice for LPG Filling Stations in Hong Kong issued by the Gas Authority.

iv. The equipment layout distances between hydrogen equipment and non-specified LPG/ petrol/ diesel filling facilities shall be determined in accordance with relevant international standards subject to the Quantitative Risk Assessment report as in Section 3.3.

5. Design and Installation

5.1. General

5.1.1. Unless the requirements are otherwise stated in Section 4 of this Code of Practice, the overall design and installation of hydrogen filling station shall at least comply with one of the following standards:

- ISO 19880 Gaseous hydrogen — Fuelling stations.
- GB 50156 Technical standard of fuelling station.
- GB 50516 Technical code for hydrogen fuelling station.
- BCGA 41 The design, construction, maintenance and operation of filling stations dispensing gaseous fuels.
- NFPA 2 Hydrogen Technologies Code.

5.1.2. The overall hydrogen filling station and all of its equipment shall be suitable for the environment and conditions of use, taking all factors into account, including temperature, pressure, material compatibility, hazardous area classification, maintainability and fire safety.

5.1.3. The hydrogen quality supplied by the filling station shall comply with one of the following standards:

- ISO 14687 Hydrogen fuel quality.
- GB/T 37244 Fuel specification for proton exchange membrane fuel cell vehicles—Hydrogen.
- SAE J2719 Hydrogen Fuel Quality for Fuel Cell Vehicles.

5.1.4. Provisions shall be made for the collection of hydrogen samples for the quality testing.

5.1.5. All hydrogen equipment shall be securely mounted on a proper supporting structure or foundation, with due consideration for the added weight from other static and dynamic loadings, such as wind and explosion loads.

5.2. Hydrogen delivery by tube trailers

5.2.1. The tube trailer shall have a valid Dangerous Goods Vehicle license.

5.2.2. A designated parking space for tube trailer shall be provided inside the filling station.

5.2.3. A fire wall complying with Section 5.18 with minimum 4-hour fire resistance rating shall be erected facing the discharge end of the tube trailer. The height and the width of the fire wall shall meet the requirements specified under Clause 5.0.7-3 of GB 50516.

5.2.4. A bump stop with ground markings shall be installed in the parking space to indicate normal parking position.

5.2.5. The tube trailer shall be equipped with a shut-off valve at the downstream of the discharge manifold. The shut-off valve shall be initiated by an emergency shutdown system.

5.2.6. The flexible hose of the tube trailer used for unloading shall be equipped with a safety shut-off system with excess flow device that protects the hazardous effect of the hose rupture, pull-apart and failure.

5.2.7. The tube trailers within the designated tube trailer parking space are deemed as hydrogen storage facilities, so their parking spaces shall meet the requirements in Section 5.4

5.2.8. Whenever the tube trailer parks as specified under Clause 5.2.7, a fire wall complying with Section 5.18 with minimum 2-hour fire resistance rating shall be erected between the vessels of tube trailer and the hydrogen/ LPG/ petrol/ diesel dispensers. The height and the width of the fire wall shall meet the requirements specified under Clause 10.7.15 of GB 50156 Technical standard of fuelling station. This Clause is not applicable to skid mounted filling station.

5.3. On-site production of hydrogen

5.3.1. For hydrogen production using water electrolysis, the system shall be designed and installed with reference to an applicable standard, for example:

- ISO 22734 Hydrogen generators using water electrolysis — Industrial, commercial, and residential applications.

- GB 50177 Design code for hydrogen station.

5.3.2. For hydrogen production using pressure swing adsorption (PSA), the system shall be designed and installed with reference to an applicable standard, for example:

- ISO 16110 Hydrogen generators using fuel processing technologies.
- ISO/TS 19883 Safety of pressure swing adsorption systems for hydrogen separation and purification.

5.3.3. For hydrogen production using Steam Methane Reforming (SMR), the system shall be designed and installed with reference to an applicable standard, for example:

- ISO 16110 Hydrogen generators using fuel processing technologies.
- GB 50177 Design code for hydrogen station.

5.4. Hydrogen Storage

5.4.1. Hydrogen storage refers to any of the followings:

- tube trailers; or
- all type of on-site hydrogen containers, including small buffer cylinders.

5.4.2. The hydrogen storage shall be located above ground and fulfil one of the following requirements:

- in open space with good natural ventilation; or
- in an enclosure or compartment equipped with forced ventilation system, only for small buffer cylinders.

5.4.3. The containers shall be designed and constructed in accordance with an internationally recognised pressure vessel code.

5.4.4. The containers shall be equipped with all of the following:

- automatic shut-off valve;
- pressure relief device or pressure safety valve;

- pressure gauge; and
- nitrogen purging interface.

5.4.5. The supporting structure shall provide individual support to each container.

5.4.6. A fire wall complying with Section 5.18 with minimum 2-hour fire resistance rating shall be erected between the hydrogen storage and the hydrogen/ LPG/ petrol/ diesel dispensers. The height and the width of the fire wall shall meet the requirements specified under Clause 10.7.15 of GB 50156. This Clause is not applicable to skid mounted filling station.

5.5. <u>Compressors</u>

5.5.1. Compressors shall be rated with the correct type of protection for explosive gas atmospheres for explosive gas atmospheres.

5.5.2. The compressor shall be fixed onto independent supports, with vibration reduction measures taken for the suction and discharge pipes.

5.5.3. Safety controls shall be installed to ensure temperature and pressure levels do not exceed or fall below operating levels.

5.5.4. Each compressor should be equipped with means to fully depressurise all parts of the system for maintenance purposes.

5.5.5. In cases where compressors are located within an enclosure or compartment that is not normally open, safety measures such as natural ventilation, hydrogen detection systems, forced ventilation for emergency and the associated interlocks shall be implemented.

5.5.6. A fire wall complying with Section 5.18 with minimum 2-hour fire resistance rating shall be erected between the compressor and the hydrogen/ LPG/ petrol/ diesel dispensers. The height and the width of the fire wall shall meet the requirements specified under Clause 10.7.15 of GB 50156 Technical standard of fuelling station. This Clause is not applicable to skid mounted filling station.

5.6. <u>Dispenser</u>

5.6.1. Dispenser shall be rated with the correct type of protection for explosive gas atmospheres.

5.6.2. A designated dispensing area shall be clearly marked on the ground.

5.6.3. The hydrogen supply to the dispenser shall be capable of being isolated.

5.6.4. The dispenser shall be equipped with at least one automatic shut-off valve which is inaccessible to the public and protected from vehicle impacts.

5.6.5. The dispenser shall be equipped with hose breakaway device. The disconnection of the hose breakaway device shall shut-off hydrogen flow to the nozzle.

5.6.6. The dispenser shall be equipped with check valve to ensure that there is no backflow during hydrogen filling.

5.6.7. The filling hose shall comply with ISO 19880-5 Gaseous hydrogen — Fuelling stations — Part 5: Dispenser hoses and hose assemblies or an equivalent standard.

5.6.8. The nozzle shall be designed in a way that they cannot couple with receptacles of lower nominal working pressures.

5.6.9. The nozzle shall comply with one of the following standards, or an equivalent standard:

- ISO 17268 Gaseous hydrogen land vehicle refuelling connection devices.
- SAE J2600 Compressed Hydrogen Surface Vehicle Fueling Connection Devices.
- GB/T 34425 Fuel cell electric vehicles—Hydrogen refuelling nozzle.

5.7. <u>Filling process</u>

5.7.1. The system shall fulfil relevant requirement regarding filling process in the standards to be adopted as specified in Clause 5.1.1 of this Code of Practice, or an alternative standard deemed appropriate by EMSD. Where there is no applicable provision in the type approval granted for the hydrogen fuelled vehicle and the alternative standard, the requirements in Clause 5.7.2 to Clause 5.7.7 shall prevail.

5.7.2. Prior to filling, the system shall perform a pressure integrity check to verify the integrity of the filling hose, hose breakaway device, nozzle and connection to the vehicle. It may also determine the pressure of hydrogen within the vehicle prior to filling. The details of pressure integrity check are as follows:

- The pressure shall be monitored for any significant loss while the vehicle is connected.
- If the pressure integrity check is not successful, the filling operation shall be terminated and the emergency shutdown shall be executed.
- As a consequence of the pressure integrity check, a quantity of hydrogen may be transferred. The maximum hydrogen mass allowed to be transferred to the vehicle during this process should be 200 g.

5.7.3. One of the following filling protocols shall be used:

- SAE J2601 Fueling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles.
- SAE J2601-2 Fuelling Protocol for Gaseous Hydrogen Powered Heavy Duty Vehicles.
- SAE J2601-3 Fueling Protocol for Gaseous Hydrogen Powered Industrial Trucks.
- GB/T 42855 Technical requirements of fuelling protocols for hydrogen fuel cell vehicles.
- A filling protocol which is approved by the manufacturers of the hydrogen fuelled vehicle to be filled at the station.

5.7.4. The filling of a vehicle containers shall be conducted within the process limit in the filling protocol, or comply with all of the following limits:

- Ambient temperature between −40°C and +50°C;
- dispenser fuel pressure less than the maximum operating pressure (MOP), which is as high as 125% of the hydrogen service level (HSL), i.e. 35 MPa or 70 MPa;
- dispenser fuel temperature greater than −40°C;
- a maximum of 10 pauses during filling where the fuel flow rate drops

below 0.6 g/s; and

- where communications are used, a communicated compressed hydrogen storage system temperature less than 85°C.

5.7.5. The maximum filling flowrate shall be subjected to the requirements in the table below:

Max. flowrate	Requirements
120 g/s (7.2 kg/min)	· Both the vehicle and the station are designed for the higher flow rate. · The dispenser has a high flow nozzle as per ISO 17268, which prevents connection to a standard vehicle receptacle, i.e., non-high flow receptacle. · Countermeasures are included to prevent vehicles that are not suitable for the filling protocol from being filled.
60 g/s (3.6 kg/min)	· Uses a connection defined in SAE J2600 or ISO 17268.

5.7.6. If vehicle to station communication is used, the requirement shall follow SAE J2799 Hydrogen Surface Vehicle to Station Communications Hardware and Software.

5.7.7. The filling process shall be terminated automatically within 5 seconds If one of the following circumstances occurs:

- An abort or halt signal is received from the vehicle being filled.
- Deviation from the filling protocol arises.

5.8. Piping System

5.8.1. The piping system shall comply with an applicable piping code.

5.8.2. The pipe material is preferrable S31603.

5.8.3. If pipes are located below ground level, the pipes should be laid in trenches made of non-combustible material. The trench should be covered with protection plate with ventilation holes to prevent trapping hydrogen.

5.8.4. If the hydrogen pipe is laid in a pipe trench, the design and arrangement of the pipe and other facilities shall comply with the relevant GB standards.

5.9. Valves

5.9.1. The following valves shall comply with ISO 19880-3 Gaseous hydrogen — Fuelling stations — Part 3: Valves or an equivalent standard.

- Check / non-return valves;
- Excess flow valves;
- Flow control valves;
- Hose breakaway devices;
- Manual valves; and
- Shut-off valves.

5.9.2. Pressure safety valve shall comply with ISO 4126-1 Safety devices for protection against excessive pressure — Part 1: Safety valves or an equivalent standard.

5.9.3. Pressure relief devices shall comply with ISO 4126-1 Safety devices for protection against excessive pressure — Part 2: Bursting disc safety devices or an equivalent standard.

5.10. Overpressure protection

5.10.1. The minimum component pressure ratings for the hydrogen dispensing system shall be 1.375 of HSL.

5.10.2. All pressurised parts shall be protected from overpressure by pressure relief devices (PRD) or pressure safety valves (PSV) other than rupture discs. The set point of the pressure protection shall be lower than 1.375 of HSL.

5.10.3. The flow capacity of pressure relief devices installed shall exceed the full flow capacity of the supply.

5.11. Vent system

5.11.1. All vent lines from pressure relief devices and pressure safety valves shall be connected to a vent stack.

5.11.2. The vent diameter shall not be smaller than the diameter of any connected PSV or PRD outlet, and large enough that it shall not prevent the PRD from functioning properly and does not restrict PRD flow.

5.11.3. The vent stack shall be adequately supported to cope with thrust loads created during discharge, as well as those created by the weather, such as wind loading.

5.11.4. The vent stack outlet shall terminate at 2m above the highest point of the station, or 5m above the ground level, whichever is the higher. The termination point should have adequate ventilation to prevent accumulation of gas, and thus forming a potentially explosive atmosphere.

5.11.5. The vent stack outlet shall be facing vertically upwards, or any direction in between horizontal and vertically upwards. Ingress of water and debris should be prevented. Caps shall not be used to cover the outlet.

5.12. Ventilation

5.12.1. When the hydrogen equipment is situated in a semi-enclosed area, such as beneath canopies or shaded structures, the design shall incorporate measures to prevent the accumulation of hydrogen. Specifically, the use of canopies with waffled slabs, which could potentially accumulate hydrogen within the void spaces, is prohibited.

5.12.2. Enclosures and compartments containing hydrogen equipment shall be equipped with forced ventilation systems with the correct type of protection for explosive gas atmospheres. The ventilation systems shall be initiated by:

- Maximum 1 % v/v hydrogen concentration detected by the hydrogen detection system.
- Emergency shutdown system.

5.12.3. Enclosures and compartments containing hydrogen equipment shall be equipped with adequate ventilation of minimum 5 air changes per hour (ACH).

5.13. Hydrogen Detection System

5.13.1. The hydrogen detectors shall comply with the accuracy requirements of ISO 26142 Hydrogen detection apparatus or an equivalent standard.

5.13.2. Hydrogen detectors shall be installed at the highest points in all of the following locations:

- Inside the enclosures or compartments containing hydrogen equipment;
- Near each hydrogen dispenser; and
- Fill-connection between the tube trailer and filling station.

5.13.3. Upon detection of maximum 1.0% v/v hydrogen concentration, all of the following response should be initiated:

- An audible alarm sounds inside and outside the enclosure.
- A red light flashes inside and outside the enclosure;
- A respective % v/v alarm sounds and indicator light illuminates at a monitoring station.
- All hydrogen supplies shut-off.
- All bay doors open (if any).
- Forced ventilation of enclosures and compartments set to minimum 15 air changes per hour (ACH).
- Shutdown of all hydrogen production systems.

5.13.4. Upon detection of maximum 2.0% v/v hydrogen concentration, further response should be initiated:

- A respective % v/v alarm sounds and indicator light illuminates at the monitoring station.
- All electrical power is disconnected, with the exception of the forced ventilation fan and other explosion proof equipment (such as

emergency equipment, lights and signs, if any).

- The fire alarm sounds for evacuation.

5.13.5. Hand-held, portable hydrogen leak detectors shall be accessible at the entrance of any enclosed or semi-enclosed area, and the tube trailer parking space.

5.14. Emergency shutdown system

5.14.1. The filling station shall be equipped with emergency shutdown system.

5.14.2. Without further manual intervention, the emergency shutdown system shall be initiated by any of the following:

- Manual emergency stop devices;
- Unsuccessful pressure integrity check of the dispenser system;
- Disconnection of the hose breakaway device;
- Detection of hydrogen concentration at maximum 2.0% v/v hydrogen concentration;
- Failure of the forced ventilation system; or
- Failure of hydrogen detection system.

5.14.3. In addition to Clause 5.14.2, the emergency shutdown may also be initiated by any of the following:

- Detection of a dispenser fuel pressure below the level targeted by the filling protocol;
- Detection of an unexplained reduction in dispenser fuel pressure; or
- Detection of a higher-than-expected dispensing flow and/or closure of an excess flow valve.

5.14.4. At least one manual emergency stop button shall be installed at each of the below locations:

- Next to hydrogen dispenser;

- Inside the hydrogen storage areas;
- Inside the filling station office; and
- Inside the skid or next to the compressor.

5.14.5. The response initiated by the emergency shutdown system shall include:

- Closing the automatic shut-off valve of the dispenser; and
- Activate the forced ventilation systems provided for enclosures and compartments containing hydrogen equipment to the specifications in Clause 5.13.3.

5.15. Hazardous areas classification

5.15.1. The owner shall develop the hazardous areas classification based on IEC 60079-10-1 Explosive atmospheres - Part 10-1: Classification of areas - Explosive gas atmospheres.

5.15.2. All electrical equipment in hazardous areas shall be protected in accordance with the IEC 60079 series, i.e., IEC 60079-0 and the appropriate other part of the IEC 60079 series for the type of protection used. For example, an intrinsically safe electrical system should comply with IEC 60079-0, IEC 60079-11, and IEC 60079-25.

5.16. Lightning protection

5.16.1. Lightning protection shall be provided for the station. Guidance can be found in BS EN/IEC 62305 Protection against lightning.

5.16.2. In the case where vent stacks are designed to carry lightning currents, this may be considered to achieve the requirement for lightning protection.

5.17. Earthing

5.17.1. Earthing shall be provided for the filling station, with electrical continuity covering the dispenser system, vent stack and all relevant piping.

5.17.2. A fixed electrostatic discharge pole shall be installed at the entrance of the filling station for incoming personnel to eliminate their own static electricity.

5.18. Fire wall

5.18.1. The fire wall shall be without openings or penetrations. Penetrations of the fire wall by conduit or piping shall be permitted provided that the penetration is protected with a firestop system in accordance with the Code of Practice for Fire Safety in Buildings issued by the Buildings Department.

5.18.2. The fire wall shall be constructed of non-combustible material with the fire resistance rating specified in accordance with the Code of Practice for Fire Safety in Buildings issued by Buildings Department or equivalent is provided.

5.18.3. The fire wall may be built on a boundary, but in such a case, it shall be wholly under the control of the owner of the station.

5.18.4. Whenever a fire wall is erected as specified under any clauses of this Code of Practice, a minimum separation distance of 1.5m should be maintained between the fire wall and any part of the tube trailer or hydrogen storage or compressor or dispenser.

5.19. Security fence and wall

5.19.1. A fence or wall shall be erected around the hydrogen storage and compressor area to ensure no unauthorised entry of the public into the operating site. Alternatively, any other means or measures that can effectively cordon off the operating area may be considered if approved by EMSD.

5.19.2. The fence or wall may be built on a boundary, but in such a case, it shall be wholly under the control of the owner of the station.

5.19.3. Whenever the fence or wall is erected as specified under Clause 5.19.1, a minimum separation distance of 1.5m should be maintained between the fence or wall and any part of the hydrogen storage or compressor.

5.20. Accessibility for works

5.20.1. Equipment installed at heights should have walkways and working platforms to be accessible for operation, inspection and maintenance.

5.20.2. The station shall be designed to allow the use of suitable manual handling equipment.

5.21. Vehicle collision protection

5.21.1. Vehicle collision protection shall be provided for tube trailer, hydrogen storage and dispensers as below:

- Continuous crash barriers where high speed (>50 km/h) and high vehicle impact is anticipated; and
- Bollard type for low-speed (<20 km/h) impact potential from on-site traffic.

5.21.2. Traffic calming measures, such as speed bumps and high containment kerbing, shall be provided.

6. Testing and Commissioning

6.1. General

6.1.1. The hydrogen filling station and all the equipment shall be tested and commissioned according to its design standards, manufacturers' instructions and the requirement of this Code of Practice.

6.2. Testing and commissioning plan

6.2.1. Prior to the actual testing and commissioning work, a plan shall be in place to clearly outline all relevant activities. Factory Acceptance Tests (FAT) and Site Acceptance Tests (SAT) shall be indicated in the plan.

6.2.2. Reference could be made to "Table I.1 — Minimum fuelling station acceptance inspection, testing and validation checklist" in ISO 19880 for the preparation of testing and commissioning plan.

6.3. Tests on components

6.3.1. All components, including compressor and dispenser, shall be tested according to the manufacturer's instructions.

6.3.2. All measuring instruments, including temperature sensor and pressure sensors, shall be calibrated.

6.3.3. Electrical continuity for bonding and grounding shall be tested.

6.3.4. Work completion certificate for fixed electrical installations (WR1) shall be obtained.

6.4. Pressure Test

6.4.1. Pressure tests shall be conducted for all pressure bearing parts for the hydrogen equipment, except tube trailers.

6.4.2. For pressure test on the vent pipe, the scope should include the piping between PSV or PRD, and the vent stack. The vent stack recommended design pressure shall be at least 40 bar.

6.4.3. The pressure test could be either hydraulic or pneumatic. If a pneumatic test is used, then either air, nitrogen, or helium is recommended as the medium.

6.4.4. The test pressure and procedure shall be based on the design standard of the filling station. The test pressure shall be no less than 1.1 of MAWP. No permanent deformation or mechanical failure shall be allowed.

6.4.5. Following the pressure and leak test, all isolation devices introduced to perform the test must be removed.

6.4.6. The test report shall include:

- name of contractor, and signature of the competent person who supervised the tests;
- test scope in the form of P&ID;
- materials, pressure rating and specification;
- test date;
- test pressure, test medium and duration; and
- test results.

6.5. <u>Leak Test</u>

6.5.1. Leak tests shall be conducted on the whole hydrogen system after assembled. The leak test should be conducted in conjunction with or following the pressure test.

6.5.2. The leak test should be pneumatic using non-flammable gas, such as nitrogen or helium as the medium.

6.5.3. The test pressure and procedure shall be based on the design standard of the filling station. The test pressure shall be no less than 0.85 of MAWP, which is equivalent to 1.1 of MOP. The system leakage shall be acceptable as per the design standard.

6.5.4. The test report shall include:

- name of contractor, and signature of the competent person who supervised the tests;
- test scope in the form of P&ID;
- materials, pressure rating and specification;

- test date;
- test pressure, test medium and duration; and
- test results.

6.6. Functional test for safety features

6.6.1. Functional test for hydrogen detection system shall be conducted at its design setting and the requirement in Section 5. The test procedures shall follow ISO 26142 Hydrogen detection apparatus or an equivalent standard.

6.6.2. Functional test for the emergency shutdown system shall be conducted as per its design settings and the requirement in Section 5.

6.6.3. Each device in the circuit or system should be checked individually for each input activation or simulation. Care should be taken to ensure that only the circuit under test caused the required action.

6.7. Purging

6.7.1. The filling station shall be purged with inert gas, such as nitrogen, prior to injecting hydrogen into the system.

6.7.2. When purging, any gas released should be vented through the vent system or through dedicated discharge points which vent into a safe area.

6.7.3. After the purging, the residual oxygen concentration shall be tested as less than 1 % v/v.

7. Operation and Maintenance

7.1. General

7.1.1. The owner of the HFS has the responsibility to ensure that the operation and maintenance of the station and the equipment therein, are conducted in a safe manner so that members of the public are not exposed to undue risks from hydrogen.

7.1.2. The owner shall ensure sufficient manpower and resource for the operations and maintenance of the HFS.

7.1.3. The owner shall implement a Permit to Work system for the operation and maintenance.

7.1.4. The owner shall assign a designated competent person for HFS to ensure its safe operation and maintenance.

7.2. Training

7.2.1. The owner shall ensure that no person shall carry out any operation or maintenance work in relation to the HFS, unless the person carrying out the work is competent by virtue of training and practical experience.

7.2.2. The owner shall provide training at least to the following persons:

- Station manager for on-site monitoring;
- Operator for dispensing; and
- Maintenance personnel.

7.2.3. The training content shall at least cover the following items:

- Properties of hydrogen and the relevant safety considerations;
- Normal operation of the station;
- The use of safety devices; and
- Emergency handling.

7.2.4. Induction training to newcomers and regular refresher trainings shall be conducted.

7.2.5. Testing or examination shall be arranged to ensure the training outcomes

7.3. Operation and maintenance manual

7.3.1. The owner shall establish proper operation and maintenance manual to at least cover:

- Procedure for station start-up and shutdown;
- Procedure for depressurisation, isolation, purging and inerting; and
- Procedure for resuming the station from hydrogen free condition.

7.3.2. All personnel shall eliminate their own static electricity before accessing the hydrogen equipment. This may be achieved by using a fixed electrostatic discharge pole placed at the entrance of the filling station, or other equivalent means.

7.3.3. The manual shall cover the provision of personal protective equipment for staffs working in the HFS.

7.3.4. No smoking policy shall be strictly enforced in the HFS.

7.4. Dispensing operation

7.4.1. Outside normal operating hours, the hydrogen supply to the dispenser shall be isolated.

7.4.2. The owner shall establish proper dispensing instructions displayed at the dispenser. These instructions shall include prohibitions against all of the following:

- The use of incompatible adapters, for example, 35 MPa vehicle filling from 70 MPa nozzle, or alternative fuel nozzles; and
- The filling into the hydrogen cylinders that are incompatible with the fuelling protocol employed at the station.

7.5. Emergency handling

7.5.1. The owner shall establish an emergency response plan (ERP) to handle accidents for HFS. The ERP shall cover all reasonably foreseeable incidents.

7.5.2. The owner shall develop the incident reporting mechanism with response contact parties, actions and response required.

7.5.3. Emergency instructions shall be displayed at all of the following:

- Next to hydrogen storage, including tube trailer parking area;
- Next to dispensers;
- At control desk; and
- In the station office.

7.5.4. The emergency instructions shall at least cover all of the following:

- measures taken when the emergency shutdown system activates;
- measures taken for any hose ruptures; and
- measures taken for the prevention of over-pressurisation of the hydrogen storage.

7.5.5. A drill for emergency scenario shall be carried out every half year.

7.6. <u>Hydrogen quality check</u>

7.6.1. The owner shall establish a hydrogen quality assurance plan following the recommendation from equipment manufacturer and an applicable standard, e.g., ISO 19880-8 Gaseous hydrogen — Fuelling stations — Part 8: Fuel quality control.

7.7. <u>Inspection and maintenance</u>

7.7.1. The owner shall establish a maintenance plan following the recommendation from equipment manufacturer and an applicable standard, e.g., ISO 19880-1 “Table 4 for guidance on HFS periodic inspection and testing.”

7.7.2. The periodic inspection shall at least cover all of the following:

- Hydrogen leak check once per day;
- Calibration of each hydrogen detector, and function test on the overall detection system once per year; and

- Fixed electrical installation (Form WR2).

7.8. Hazardous areas

7.8.1. Only the tools and equipment with the correct type of protection for explosive gas atmospheres shall be used in the hazardous areas.

7.9. Hot work

7.9.1. While the station contains hydrogen, hot work shall only be performed in case of service necessity and with a portable or fixed hydrogen detector to continuously analyse the atmosphere in the work area.

7.9.2. A proper work permit system incorporating formal procedures shall be instituted for hot work.

7.10. Maintenance for skid mounted unit

7.10.1. If the skid mounted unit is to be out of service for a long period of time, equipment and pipelines shall be replaced with nitrogen until the hydrogen concentration does not exceed 0.4% v/v. The nitrogen pressure after replacement should be maintained above 0.3 MPa.

8. Incident Reporting and Investigation

8.1. Incident Reporting

8.1.1. Any of the following hydrogen incidents shall be notified to EMSD within one (1) hour through a telephone call or instant messaging after the incident occurs:

- Loss of containment of hydrogen from tube trailer or vehicle conveying hydrogen cylinder(s)/tank(s);
- Damage to hydrogen equipment or tube trailer or vehicle conveying hydrogen cylinder(s)/tank(s);
- Any leak or loss of containment of hydrogen above the design alarm level leading to the triggering of the emergency shutdown system or direct link system connecting to the Fire Services Communication Centre or such other premises as may be agreed with the Director of Fire Services;
- Smoke, fire or explosion of any magnitude;
- Injury of any personnel involving the HFS;
- Vehicle drive-away with hydrogen leakage and without leakage; or
- Other incidents that have attracted media attention

8.1.2. For all hydrogen incidents, including but not limited to those listed in the aforementioned clause, a preliminary written incident report with the following information shall be submitted to EMSD within two (2) working days after the incident occurs:

- the date and time of the incident;
- the location of the incident;
- summary of the incident;
- the suspected/preliminary cause of the incident;
- the identification number of the hydrogen sensors which were activated

during the incidents;

- the extent of the damage of the equipment or parts;
- the licence number of the hydrogen fuelled vehicle involved and contact details of the driver;
- the time when maintenance/emergency personnel arrived at the location of the incident;
- the action taken by such personnel to deal with the incident; and
- the rectification time for the incident and service restoration time.

8.1.3. Following the preliminary incident report, a detailed incident report with the following information in addition to the items in previous Clause 8.1.2 shall be submitted to EMSD not later than seven (7) working days after the incident occurs:

- the extent of the damage of the concerned equipment or parts;
- the date and time of despatch of personnel to deal with the incident;
- the time when such personnel arrived at the place of the incident;
- the actions taken by such personnel to deal with the incident;
- the causes of the incident; and
- the proposed measures to prevent recurrence of similar incident.

8.2. Incident Handling and Investigation

8.2.1. All hydrogen incidents shall be rectified by suitably trained and competent persons as soon as practicable.

8.2.2. The causes of the incidents shall be investigated thoroughly and preventive measures shall be implemented to avoid recurrence of similar incidents.

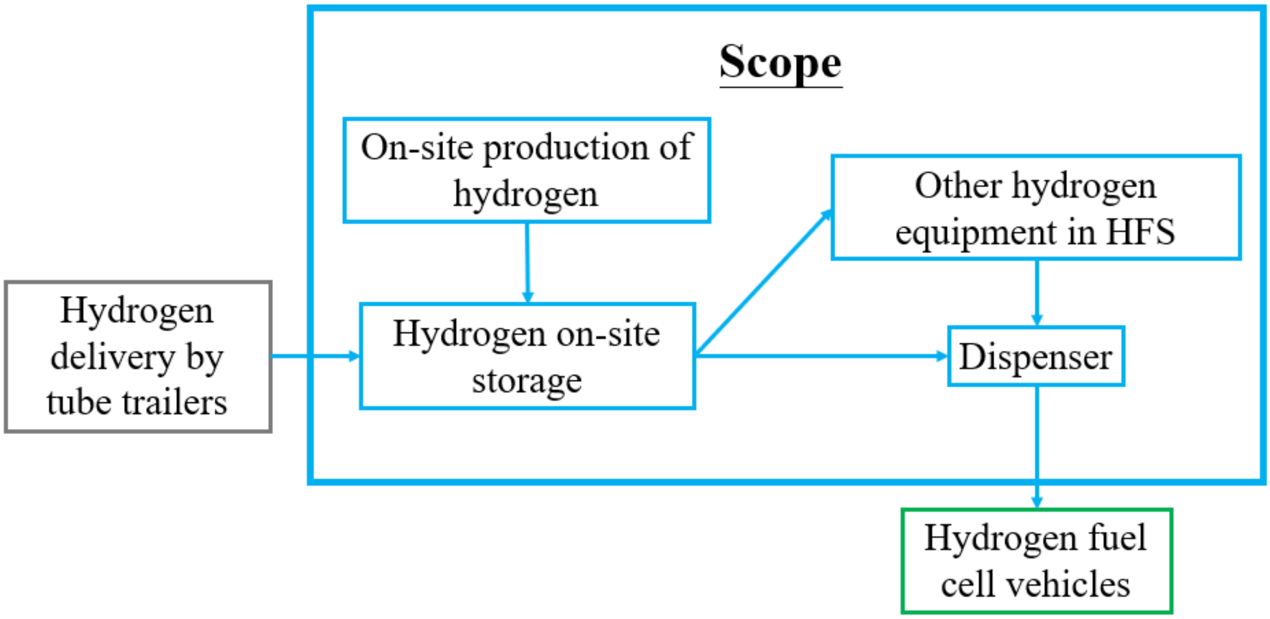
Appendix A – Pressure terminology

Hydrogen fuel cell vehicles	Hydrogen service level	Hydrogen filling stations
Maximum Developed Pressure (MDP)	1.5 x HSL	Maximum Developed Pressure (MDP)
	1.375 x HSL	Dispensing system MAWP
		(PSV set point should be between MAWP and MOP)
Maximum Filling Pressure (MFP)	1.25 x HSL	Maximum Operating Pressure (MOP)
Nominal Working Pressure (NWP)	HSL	
(100 % fill settled to 15 degC)		

Hydrogen service level (HSL)	Pressure class	Maximum operating pressure (MOP)	Dispensing system maximum allowable working pressure (MAWP) Minimum component pressure rating for dispensing system components
Equal to NWP of vehicle being filled	**-**	**1.25 × HSL** **Highest pressure during normal filling**	**1.375 × HSL** **Highest permissible setpoint for dispenser system pressure protection**
35 MPa	H35	43.75 MPa	48.125 MPa
70 MPa	H70	87.5 MPa	96.25 MPa

Appendix B – Typical hydrogen filling station

The scope of this Code of Practice is indicated in the below diagram of a typical hydrogen filling station:



RISK BASED SAFETY DISTANCES FOR HYDROGEN REFUELING STATIONS

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ABSTRACT

This paper introduces a risk-based methodology for hydrogen refueling stations. Momentarily, four stations are present in the Netherlands. This number is expected to increase to around twenty in the next years. For these stations, a quantitative risk analysis (QRA) must be carried out to account for spatial planning. The presented method identifies the loss of containment scenarios and failure frequencies. Additionally, the results of this study may be used in legislative context in the form of fixed generic safety distances. Using the risk analysis tool Safeti-NL safety distances are determined for three different kinds of hydrogen refueling stations, distinguished by the supply method of the hydrogen. For the hydrogen refueling stations, a maximum safety distance of 35 m is calculated. However, despite the relatively small safety distances, the maximum effect distances (distance to 1% lethality) can be very large, especially for stations with a supply and storage of liquid hydrogen. The research was overseen by an advisory committee, which also provided technical information on the refueling stations.

1.0 INTRODUCTION

Within the Netherlands, ambitious Tank-to-Wheel (TTW) objectives were agreed in order to reduce the CO_2 emissions of the mobility sector and transport sector. These agreements are stipulated in the Energy Agreement, signed under the auspices of the Social and Economic Council (SER) in September 2013 [1]. In order to realize the goals set, there must be 3 million zero-emission-vehicles (30 – 35% of all passenger cars) in the Netherlands by 2030. Therefore, a 'vision on a sustainable fuel mix' has been compiled in collaboration with more than 100 organizations [2]. At the same time, policy is made addressing the safety issues regarding the introduction of these new sustainable fuels.

Within the vision four different future scenarios were discussed with regard to the use of renewable fuels. The scenario "New and all renewable" is seen as the most promising. Within this scenario electrification of road traffic leads to big market shares for electrical driven cars. The use of plug-in hybrid cars is seen as a transitional phase in the transformation towards hydrogen fueled cars. For different kinds of fuels, such as petrol/diesel, LPG, LNG/CNG, bio-fuels, plug in electrical and fuel cell (hydrogen) electrical a development trajectory is presented within the vision.

Concerning third party risk, the Netherlands uses a risk-based approach. In order to determine these risks, specific software is used in combination with modelling guidelines. Within this paper the trajectory for the development of hydrogen powered transport, the Dutch risk calculation method, results and legislative strategy for hydrogen filling stations are described in more detail.

2.0 HISTORY AND PROJECT OUTLINE

Third party risk refers to the risk of storage, production, use and transport of dangerous substances for people living or working in the vicinity of the source of risk. The risk may be due to chemical incidents, such as fires, explosions or releases of toxic substances. Risk is defined as the probability of failure multiplied by its consequences (effect). In the Netherlands, risk policy is expressed in terms of location specific risk (PR) and societal risk (SR). Along with location specific and societal risk, effect distances (1% lethality) for accidents are important for fire brigades and other emergency services. The general rules of risk determination for a stationary establishment (not transport related) are laid down in the 'Reference Manual Bevi Risk Assessments' (RMBRA) [3]. The RMBRA is based on the so-called 'colored books' for use in risk and consequence modelling.

- The Yellow Book (PGS 2, 2005) describes the modelling of physical consequences such as discharge, dispersion, pool fires and heat radiation. In general these effects are dictated only by the laws of physics and chemistry [4].

- The Green Book (PGS 1, 2005) describes models for the impact of toxic and flammable effects on human beings [5]. Flammable effects imply both overpressure and heat radiation effects.

- The Red Book (PGS 4, 2005) describes methods for determining the probability of undesired events [6]. In contrast to the 'Yellow Book' the 'Red Book' deals with the determination of the probability of events in the future on the basis of data from the past and fault tree analysis.

- The Purple Book (PGS 3, 2005) was used to determine risk scenarios, failure frequencies and other risk parameters [7]. It is now replaced by the Reference Manual.

The location specific risk is expressed as the risk of fatality per year; this is defined as the probability that an unprotected person residing permanently at a fixed location will be killed as a result of an incident. The location specific risk is displayed as a contour around an establishment or transport route. The societal risk is defined as the probability that a certain number of deaths will be exceeded during a single accident; it is expressed as the relationship between the number of people killed (*N*) and the frequency (*F*) that this number of fatalities will be exceeded. For both the location specific risk and societal risk, criteria limits are set. For dwellings and other vulnerable objects like schools and hospitals, the location specific risk limit is set at 10^{-6} per year. For less vulnerable objects like small office buildings, restaurants, shops and recreation facilities, the location specific risk contour of 10^{-6} per year is a guidance value. For societal risk, an indicative limit is set. For establishments, the indicative limiting frequency (F_{ind}) of an accident with *N* or more deaths is:

$$F_{ind} = \frac{10^{-3}}{N^2} \tag{1}$$

This means, for example, that the probability of 10 or more deaths must be less than one in a hundred thousand years. The probability of a hundred deaths must be less than one in 10 million years.

The history of risk calculations for hydrogen filling stations in the Netherlands goes back to 2006, when safety distances were determined for a hydrogen filling station by Matthijsen and Kooi [8]. They determined safety distances based on the PR 10^{-6} contour for a small (10 cars per day), medium (40 cars per day) and large (200 cars per day) hydrogen filling station operating at a filling pressure of 350 bar. At that time, the technical guidelines for hydrogen refueling stations were still under development. In 2010 the 'Dutch practical guideline for fire safety, human safety and environmental safety of installations for distribution of hydrogen to road vehicles and water vessels' (NPR 8099) [9] was published. This guideline served as a basis for development of the present guideline within the Dutch 'Hazardous Substances Publication Series'. This guideline 'Hydrogen; installations for delivery of hydrogen to road vehicles' (PGS 35) [10] was published in 2015. Additionally, within the PGS 35 project group a report is produced with regard to internal safety distances for hydrogen filling stations [11]. An internal safety distance is defined as the minimal separation distance between a potential hazardous source (e.g. equipment involving dangerous substances) and an object (human, equipment or environment). It will mitigate the effect of a likely foreseeable incident and prevent a minor incident escalating into a larger incident (also known as domino effect). Both reports can be downloaded in English from the website of the PGS-series.

(http://www.publicatiereeksgevaarlijkestoffen.nl/publicaties/PGS35.html)

At the same time the guideline PGS 35 was developed, the Dutch vision on a sustainable fuel mix [2] was compiled. Within this vision a development trajectory is presented for different kinds of transportation. The development trajectory for passenger cars for instance is given in Figure 1. The same kind of figures exists within the vision for delivery vans, trucks, busses, ships, airplanes and trains. Figure 1 shows that in the Dutch vision the plug-in hybrid car is seen as transitional phase until ca. 2030. After that time it will be rapidly replaced with full electric cars and hydrogen fueled cars.

In the meantime the European Directive for the deployment of alternative fuel infrastructure (2014/94/EU) [12] demands that member States, which decide to include hydrogen refueling points accessible to the public in their national policy frameworks, shall ensure that by 31 December 2025 an appropriate number of such points are available. This, to ensure the circulation of hydrogen-powered motor vehicles within networks determined by those Member States, including, cross-border links where appropriate. This led to the intention of the Dutch government to have at least 20 public hydrogen refueling stations in the Netherlands in 2020. Before building these stations, however, it is necessary to determine the safety distances for the hydrogen stations. Therefore, the Dutch Ministry of Infrastructure and the Environment (I&M) asked the National Institute of Public Health and the Environment (RIVM) to advice in this matter.

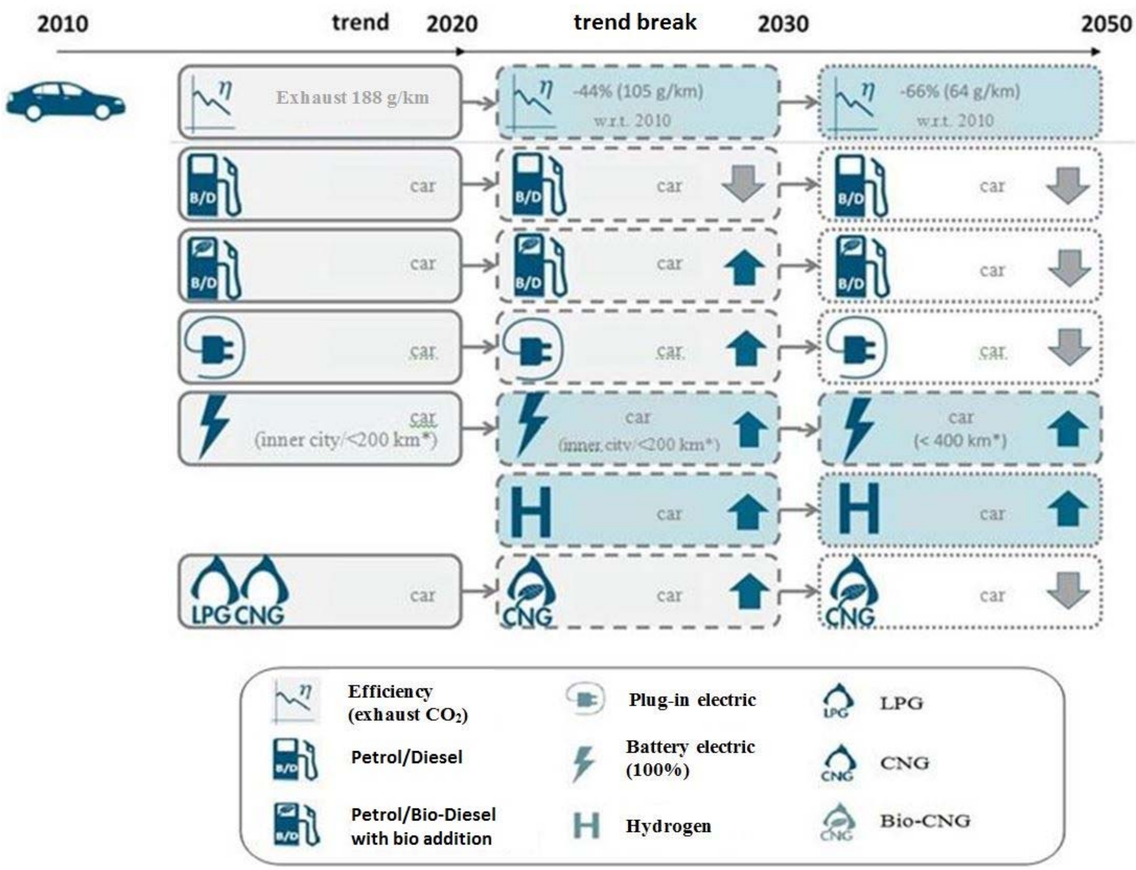

Figure 1. Development trajectory for cars according to the Dutch vision on a sustainable fuel mix [2]
Blue box indicate an objective. Arrow up = increase, Arrow down = decrease
(*daily distance)

By means of calculations on representative scenarios the safety distances with regard to third party risk and the effect distances for emergency response purposes are determined for three types of hydrogen refueling stations. Based on these indicative distances the government can decide to apply fixed safety distances or to develop a new guideline for calculating safety distances for hydrogen refueling stations.

Within the Dutch technical guideline ‘Hydrogen; installations for delivery of hydrogen to road vehicles’ (PGS 35) several types of hydrogen refueling stations are described, based on the supply of hydrogen. Three of these types are used to calculate the safety distances. Type 1 is supply of gaseous hydrogen by pipeline or by local production. Type 2 is supply of gaseous hydrogen by a tube- or cylinder-trailer and type 3 is supply of liquid hydrogen by tank car. These three types are schematically given in Figure 2. Although the supply differs for the different types, every type has the same technical installations and a dispenser.

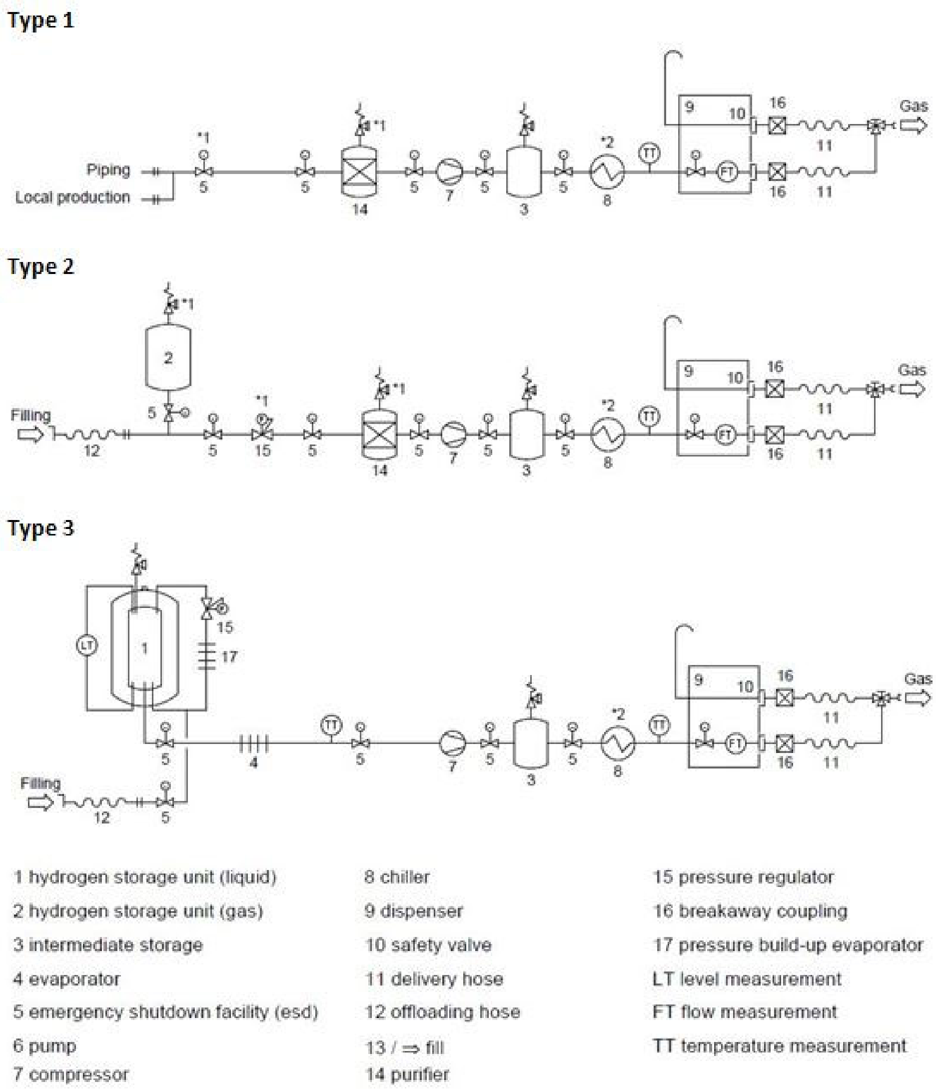

Figure 2. Schematic drawing of three types of hydrogen refueling stations [10] that are used to calculate he safety distances: Type 1 with gaseous supply by means of pipeline or local production. Type 2 with gaseous supply by tube- or cylinder-trailer. Type 3 with supply of liquid hydrogen by means of a tank car.

3.0 QUANTITATIVE RISK ANALYS

For the three types of hydrogen refueling stations given in figure 2 the safety distances and effect distances (1% lethality) are calculated. For the calculations of the safety- and effect distances the basic assumptions, with regard to the standard calculation methods, of the 'Reference Manual Bevi Risk Assessments' are met. Also, the Dutch standard calculation methods for LPG stations [13] and LNG stations [14] are taken as a reference. However, some deviations from the standard calculation methods were inevitable. For instance, the probability of direct ignition of hydrogen during a release is set higher as the standard values. Also, a different version of the calculation model is used. As the reference manual legislatively prescribes Safeti-NL 5.4, the calculations are done with Safeti-NL 6.7.

3.1 Assumptions on all calculations

For every type of hydrogen refueling station the following specific assumptions and basic principles exist:

- All system parts of the refueling station are modelled on the same location;
- For weather type, wind speed and wind direction the mean value for the Netherlands is used;
- The roughness length is defined as an artificial length scale describing the wind speed over a surface and characterizing the roughness of the surface. For these calculations it is set at 0.3 m;
- The site border for the hydrogen refueling station is set at a square of 10 x 10 meter. The incident scenarios are located in the center of this square;
- The probability of direct ignition of gaseous hydrogen during a release is set at 1.0;
- The probability of direct ignition of liquid hydrogen during a release is set at 0.9;
- Environmental temperature is set at 9°C;
- The settings deviate from the basic settings for SAFETI-NL 6.7 on the following points:
  - The 'relative tolerance for dispersion calculations' is changed from 0.001 to 0.01. This change was necessary to avoid failure messages in the numerical simulations.
  - The 'atmospheric expansion method' describes the expansion from orifice conditions to ambient pressure and is changed from 'Closest to Initial Conditions' to 'Conservation of Energy'. Validation experiments showed that this setting is more appropriate for hydrogen calculations [15].
  - Since the speed of sound in hydrogen is much higher than for most other gases, the 'Maximum release velocity' is changed from 500 m/s to 1500 m/s.
- All safety- and effect distances are rounded up towards the nearest 5-fold.

3.2 Assumptions on the hydrogen refueling plant installations

With regard to the modelling of the installation parts, the following assumptions are made:

- For the failure probability of automatic emergency shutdowns (ESD) the 'Reference Manual Bevi Risk Assessments' gives a target value of 0.001 per use in combination with a reaction time until the release is stopped of 120 s. The advisory board of the project, however, recommended a higher failure probability of 0.01 in combination with a shorter reaction time of 5 s (semi-automatic ESD). In the calculations both settings are included.

- In line with the Dutch standard calculation method for LNG stations for the loading scenario's it is assumed that composite hoses are used for which a reduced failure rate can be applied. This implies a factor 10 lower failure rate for the scenario 'breaking of the hose' with respect to the standard failure rates in the 'Reference Manual Bevi Assessments'.

- Calculations are based on a throughput of 1000 kg hydrogen a day, 500 kg is delivered to cars and 500 kg is delivered to buses. For cars, 5 kg hydrogen per fill up is assumed at a pressure of 700 bar. The delivering time is 3 minutes. For buses, per fill up 20 kg is delivered in 11 minutes.

- It is assumed that the compressor is running for 10 hours per day.

- It is assumed for the calculations that two buffer storages are present. One buffer storage at a pressure of 440 bar (40 kg) and one buffer storage at a pressure of 950 bar (20 kg).

3.3 Scenarios and failure frequencies

For the three types of hydrogen refueling stations, the only difference is in the supply of hydrogen to the station. The delivery side of the station is equal for all three types. Table 1 gives the models and scenarios and the failure frequencies for the different scenarios for the situation where the failure rate for the ESD is set at 0.01.

Table 1. Scenarios and failure frequencies of a hydrogen refueling station with a throughput of 1000 kg/day: ESD failure rate 0.01 and reaction time ESD is 5s.

Scenario	**General failure frequency**	**Length or fraction per year used**	**ESD**	**Failure frequency per year**	**Source reference**
TYPE 1: Gaseous supply by pipeline or local production					
Supply pipeline break – ESD succeeds	$1.00 \cdot 10^{-6}$ m^{-1} year^{-1}	10 m [1]	0.99	$9.90 \cdot 10^{-6}$	[3]
Supply pipeline break – ESD fails	$1.00 \cdot 10^{-6}$ m^{-1} year^{-1}	10 m	0.01	$1.00 \cdot 10^{-7}$	[3]
Supply pipeline leak	$5.00 \cdot 10^{-6}$ m^{-1} year^{-1}	10 m		$5.00 \cdot 10^{-5}$	[3]
TYPE 2: Gaseous supply by tube- or cylinder trailer					
Tubetrailer: instantaneous release	$5.00 \cdot 10^{-7}$ year^{-1}	2435 hour per year[2]		$1.39 \cdot 10^{-7}$	[3]
Tubetrailer: largest connection fails	$5.00 \cdot 10^{-7}$ year^{-1}	2435 hour per year		$1.39 \cdot 10^{-7}$	[3]
Delivery hose breaks – ESD succeeds	$4.00 \cdot 10^{-7}$ h^{-1}	1825 hour per year	0.99	$7.23 \cdot 10^{-4}$	[3]
Delivery hose breaks – ESD fails	$4.00 \cdot 10^{-7}$ h^{-1}	1825 hour per year	0.01	$7.30 \cdot 10^{-6}$	[3]
Delivery hose leaks	$4.00 \cdot 10^{-5}$ h^{-1}	1825 hour per year		$7.30 \cdot 10^{-2}$	[3]
Tubetrailer: fire during supply - fireball	$5.80 \cdot 10^{-10}$ h^{-1}	1825 hour per year		$1.06 \cdot 10^{-6}$	[3]
Tubetrailer: fire in	$4.00 \cdot 10^{-8}$ h^{-1}	2435 hour		$9.74 \cdot 10^{-5}$	[13]

[1] Failure of connections like flanges and welds are supposed to be part of the failure frequency of the pipeline. For that reason a minimum length of a pipeline of 10 m is prescribed.

[2] A tube trailer takes 1.5 h for the supply of 300 kg and is present for 2.0 h per supply. With a throughput of 1000 kg per day: 1000/300*2*365.25 = 2435 hours per year present of which (1000/300*1.5*365.25=) 1825 hours supplying.

surrounding - fireball		per year			
Tubetrailer: external interference – fireball	$9.60 \cdot 10^{-10}$ h^{-1} [3]	2435 hour per year		$2.34 \cdot 10^{-6}$	[13]
TYPE 3: Liquid supply by tank car					
Tank car instantaneous release	$5.00 \cdot 10^{-7}$ $year^{-1}$	365 hour per year[4]		$2.08 \cdot 10^{-8}$	[3]
Tank car largest connection fails	$5.00 \cdot 10^{-7}$ $year^{-1}$	365 hour per year		$2.08 \cdot 10^{-8}$	[3]
Tank car: fire during supply – BLEVE	$5.80 \cdot 10^{-10}$ h^{-1} *0.05[5]	219 hour per year		$6.35 \cdot 10^{-9}$	[14]
Tank car: fire in surrounding – BLEVE	$4.00 \cdot 10^{-8}$ h^{-1} * 0,05 * 0,19[6]	365 hour per year		$1.39 \cdot 10^{-7}$	[14]
Tank car: external interference – instantaneous release	$9.60 \cdot 10^{-10}$ h^{-1} [7]	365 hour per year		$3.50 \cdot 10^{-7}$	[14]
Delivery hose breaks – ESD succeeds	$4.00 \cdot 10^{-7}$ h^{-1}	219 hour per year	0.99	$8.67 \cdot 10^{-5}$	[3]
Delivery hose breaks – ESD fails	$4.00 \cdot 10^{-7}$ h^{-1}	219 hour per year	0.01	$8.76 \cdot 10^{-7}$	[3]
Delivery hose leaks	$4.00 \cdot 10^{-5}$ h^{-1}	219 hour per year		$8.76 \cdot 10^{-3}$	[3]
General parts for all types					
Purifier instantaneous release	$5.00 \cdot 10^{-6}$ $year^{-1}$			$5.00 \cdot 10^{-6}$	[3]
Purifier 10 minutes release scenario	$5.00 \cdot 10^{-6}$ $year^{-1}$			$5.00 \cdot 10^{-6}$	[3]
Purifier 10 mm leak	$1.00 \cdot 10^{-4}$ $year^{-1}$			$1.00 \cdot 10^{-4}$	[3]
Compressor supply line breaks – ESD succeeds	$1.00 \cdot 10^{-4}$ $year^{-1}$	10 hour per day	0.99	$4.13 \cdot 10^{-5}$	[3]
Compressor supply line breaks – ESD fails	$1.00 \cdot 10^{-4}$ $year^{-1}$	10 hour per day	0.01	$4.17 \cdot 10^{-7}$	[3]
Compressor supply line leaks	$4.40 \cdot 10^{-3}$ $year^{-1}$	10 hour per day		$1.83 \cdot 10^{-3}$	[3]
Storage/Buffer instantaneous release	$5.00 \cdot 10^{-7}$ $year^{-1}$			$5.00 \cdot 10^{-7}$	[3]
Storage/Buffer 10 minutes release scenario	$5.00 \cdot 10^{-7}$ $year^{-1}$			$5.00 \cdot 10^{-7}$	[3]
Storage/Buffer 10 mm leak	$1.00 \cdot 10^{-5}$ $year^{-1}$			$1.00 \cdot 10^{-5}$	[3]
Process pipeline break – ESD succeeds	$1.00 \cdot 10^{-6}$ m^{-1} $year^{-1}$	15 m	0.99	$1.49 \cdot 10^{-5}$	[3]
Process pipeline break – ESD fails	$1.00 \cdot 10^{-6}$ m^{-1} $year^{-1}$	15 m	0.01	$1.50 \cdot 10^{-7}$	[3]
Process pipeline leak	$5.00 \cdot 10^{-6}$ m^{-1} $year^{-1}$	15 m		$7.50 \cdot 10^{-5}$	[3]
Dispenser delivery hose 440	$4.00 \cdot 10^{-7}$ h^{-1}	1691 hour	0.99	$6.70 \cdot 10^{-4}$	[14]

[3] Incorporation of this scenario is in line with the Dutch standard calculation methods for LPG-stations and LNG-stations and is conservative with respect to the Reference Manual Bevi Risk Assessments. The RMBRA states that, when crash prevention measures are taken, this scenario wouldn't be incorporated. For this scenario it is assumed that the placement of the tube trailer is on a lane with maximum speed limit 70 km/h.

[4] A tank car delivers 1000 kg per supply in 40 minutes and is present for 1 hour. With a throughput of 1000 kg per day, this means 365 hours per year present of which 219 hours per year supplying.

[5] For a double-walled tank car, in line with the standard calculation method for LNG tank stations, for the scenario failure due to fire the reduced failure frequency for a coated LPG tank car is used (reduction factor 0,05).

[6] For a double-walled tank car, in line with the standard calculation method for LPG- and LNG tank stations, a reduction factor of 0.19 is applied that can be justified by the fact that in 90% of the incidents the tank wall will be cooled by the liquid inside the tank.

[7] Incorporation of this scenario is conform the standard calculation method for LPG- and LNG tank stations but conservative with respect to the Reference Manual Bevi Risk Assessments which states that, when protection measures are taken, this scenario can be left out.

bar breaks - ESD succeeds		per year [8]			
Dispenser delivery hose 440 bar breaks - ESD fails	$4.00 \cdot 10^{-7}$ h^{-1}	1691 hour per year	0.01	$6.76 \cdot 10^{-6}$	[14]
Dispenser delivery hose 440 bar leaks	$4.00 \cdot 10^{-5}$ h^{-1}	1691hour per year		$6.76 \cdot 10^{-2}$	[14]
Dispenser delivery hose 950 bar breaks - ESD succeeds	$4.00 \cdot 10^{-7}$ h^{-1}	1826 hour per year[9]	0.99	$7.23 \cdot 10^{-4}$	[14]
Dispenser delivery hose 950 bar breaks - ESD fails	$4.00 \cdot 10^{-7}$ h^{-1}	1826 hour per year	0.01	$7.31 \cdot 10^{-6}$	[14]
Dispenser delivery hose 950 bar breaks	$4.00 \cdot 10^{-5}$ h^{-1}	1826 hour per year		$7.31 \cdot 10^{-2}$	[14]

4.0 RESULTS

For all three types of hydrogen refueling stations, the following results have been generated:

- The distance to the PR 10^{-6}, 10^{-7}, 10^{-8} and 10^{-9} contour is given in Table 2.
- A graph with location specific risk level as function of distance to the incident (Figure 3).
- The distance to the location specific risk value 10^{-6} per year (10^{-6}-contour) and the representative scenario's that set this risk level with their maximum effect distances. The effect distance is equal to the 1%-lethality level. These results are given in Table 3.
- The three scenario's with the largest effect-distances (1% lethality) (Table 4).

Figure 3 shows a gradual decrease of location specific risk with distance for the type 3 refueling station. The risk for type 1 and 2 refueling stations drops to 10^{-9} around 30 and 60 meter. No additional loss of containment scenarios with a frequency above 10^{-9} and with effect distances beyond 30 and 60 meter exist.

Table 2. Distance to the location specific risk contour of 10^{-6}, 10^{-7} and 10^{-8} for three types of hydrogen refueling stations with a throughput of 1000 kg hydrogen per day.

Type of station	Distance to PR 10^{-6} (m)	Distance to PR 10^{-7} (m)	Distance to PR 10^{-8} (m)
Supply of gaseous hydrogen by piping or local production	30	35	35
Supply of gaseous hydrogen by tube- or cylinder trailer	35	55	55
Supply of liquid hydrogen by a tank car.	30	95	130

[8] It is assumed that ca. 500 kg per day is delivered to buses and trucks. A bus takes ca. 20 kg hydrogen and 11 minutes per fill. This results in use of the dispenser during 4,63 hours per day.
[9] It is assumed that ca. 500 kg per day is delivered to cars. A car takes ca. 5 kg hydrogen and 3 minutes per fill. This results in use of the dispenser during 5 hours per day.

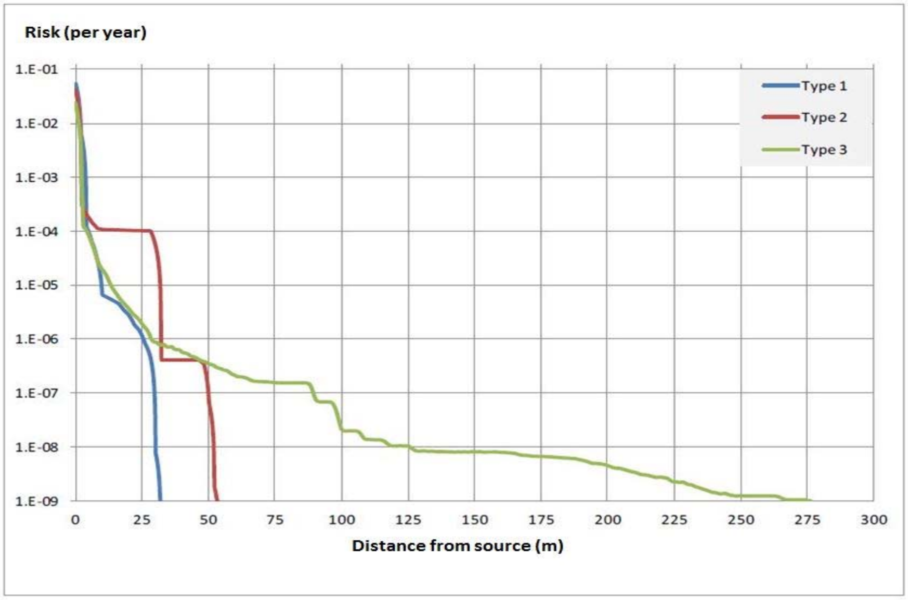

Figure 3. Location specific risk level as a function of the distance from the source, for three types of hydrogen refueling stations with a throughput of 1000 kg hydrogen per day.

Table 3. Distance to the location specific risk contour of 10^{-6}, the risk determining scenarios and their effect distances for three types of hydrogen refueling stations with a throughput of 1000 kg hydrogen per day.

Type of station	**Distance to PR 10^{-6}**	**Risk determining scenarios** (% that scenario contributes to IR 10^{-6})	**Effect distance (1% lethality)**
1. Supply of gaseous hydrogen by piping or local production	30 m	Intermediate storage (20 kg) at 950 bar – leak (83%)	35 m
		Intermediate storage (40 kg) at 440 bar – instantaneous release (17%)	30 m
2. Supply of gaseous hydrogen by tube- or cylinder trailer	35 m	Tube trailer – fireball as a result of fire in the surrounding (96%)	35 m
3. Supply of liquid hydrogen by a tank car.	30 m	Tank car – instantaneous release asa result of external interference (33%)	1200 m
		Delivery hose breaks – ESD working (17%)	90 m
		Intermediate storage (20 kg) at 950 bar – leak (17%)	35 m
		Tank car – BLEVE as a result of fire in the surrounding (13%)	130 m

The sharp, almost discrete, drop in risk for type two refueling stations around 32 meters in figure 3 is caused by the loss of containment scenario's for the tube trailer. The fireball, associated with failure scenarios of the tube trailer, has an effect distance of 31 meter with a total location specific risk around 10^{-4} per year). At a distance of 32 meter the only remaining loss of containment scenario is failure of the buffer, with a location specific risk of $5 \cdot 10^{-7}$ per year. The effect distance of failure of the buffer is 54 meter, explaining the second sharp drop in the graph.

The results are determined for the situation with 5 s ESD reaction time as well as the 120 s ESD reaction time. Both results are comparable. This can be explained by the fact that the model Safeti-NL for jet fires always assumes a time of exposure of 20 s, independent of the actual release duration.

Table 4. Overview of the scenarios with largest effect distance (1% lethality) for three types of hydrogen refueling stations with a throughput of 1000 kg hydrogen per day.

Type of station	**Scenario**	**Effect distance (m)**
1. Supply of gaseous hydrogen by piping or local production	Intermediate storage (20 kg) at 950 bar – leak	35
	Intermediate storage (40 kg) at 440 bar – instantaneous release	30
	Intermediate storage (40 kg) at 440 bar – leak	25
2. Supply of gaseous hydrogen by tube- or cylinder trailer	Storage (400 kg) at 80 bar – instantaneous release	55
	Tube trailer - Fireball	35
	Tube trailer – instantaneous release	35
3. Supply of liquid hydrogen by a tank car.	Tank car – Instantaneous release (weather type F1.5)	1200
	Tank car – Instantaneous release (weather type D1.5)	490
	Tank car – Instantaneous release (weather type E5)	370

5.0 EVALUATION AND CONCLUSIONS

From the results it can be concluded that the safety distances, based on the PR 10^{-6} contour, for a hydrogen refueling station with a throughput of 1000 kg per day, is around 35 m. Figure 3 shows that for a hydrogen refueling station with supply by pipeline or local production, or supply by tube- or cylinder trailer the risk level is 10^{-9} or lower at a distance of 50 m from the station. When supply of liquid hydrogen is applied the risk level of 10^{-9} is reached at a much larger distance; 270 m from the source. This can be explained partly by the fact that delayed ignition is excluded for gaseous hydrogen, but not for liquid hydrogen. In the modelling of delayed ignition it is assumed that delayed ignition occurs outside the plant boundary and furthermore when the maximum cloud dimensions are reached. This results in relatively large effect distances. For type 3 hydrogen refueling stations, the scenario of instantaneous release of the content of the tank car as a result of external interference results, under calm weather conditions (F1.5), in an effect distance of 1200 m. Further research is recommended to investigate whether this (conservative) modelling assumption is valid for hydrogen.

When looking in more detail on the effect distances (1% lethality), it seems obvious that the delivery of liquid hydrogen by a tank car plays an important role for type 3 hydrogen refueling stations. The scenario of instantaneous release of the content of the tank car (2900 kg) as a result of external interference results in large effect distances of up to 1200 m. However, delayed ignition doesn't significantly contribute to the safety distance. This can be explained by the relatively low frequency of occurrence of this scenario. The frequency of this scenario is $3.5 \cdot 10^{-7}$ per year (Table 1). Since the probability of direct ignition is set at 0.9 this will, in 90% of the occasions, result in a flash fire with a much smaller effect distance. Delayed ignition, which gives a maximum effect distance of 1200 meter, occurs in only 10% of the occasions (probability of $3.5 \cdot 10^{-8}$ per year). It is obvious that delayed ignition therefore will not significantly contribute to the safety distance (IR 10^{-6}). It will only contribute to the PR 10^{-8}-contour or lower risk levels.

In the Netherlands, the government is setting up new regulations with regard to safety distances and third party risk. There is a large preference for prescription of a fixed set of safety distances for different kind of activities. The results of this study make it relatively easy to set a fixed safety distance for hydrogen refueling stations with gaseous supply. The safety distance for a hydrogen refueling station with supply of liquid hydrogen by a tank car is still under discussion. This type of refueling station is momentarily not widely spread and more research on the mechanism and changes of direct or delayed ignition is necessary to get a more well founded safety distance for this type of hydrogen filling stations.

6.0 REFERENCES

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