Hydrogen bunkering standards, guidelines, procedures & checklists

WP4 Veiligheidsaspecten en risico's

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Aanleiding

WVIP WP 4 werkt aan kennisvragen voor het borgen van waterstofveiligheid en heeft als doelstelling:

1. Het inventariseren van alle mogelijke veiligheidsrisico's die gepaard gaan met de productie, opslag, transport en gebruik van waterstof.
2. Welke maatregelen zijn noodzakelijk 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 waterstofinfrastructuur en specifiek voor partijen die zich bezig houden met het bunkeren van waterstof. Dit document geeft handvatten om de vragen en antwoorden die er over dit onderwerp zijn centraal te ontsluiten met het doel de waterstofveiligheid te borgen.

Dit document beantwoordt een van de kennisvragen zoals die zijn geïnventariseerd door de deelnemers van WP4 in 2020. Voor meer informatie over en de totstandkoming van de kennisvragen zie WP4 Inventarisatie van kennisvragen 'veiligheidsaspecten en -risico's van het WVIP project.

Het doel van het behandelen van de kennisvraag is het geven van een overzicht van de huidige stand van zaken aangaande de regelgeving, procedures en standaarden voor het bunkeren van waterstof. Waterstof wordt als zeer kansrijk gezien voor de scheepvaart. Verschillende verschijningsvormen van waterstof zijn gasvormig, vloeibaar, in vaste vorm als natriumboorhydride ($NaBH_4$) en middels een waterstofdrager (LOHC)[1]. Voor zowel gasvormige als vloeibare waterstof geldt dat de waterstof middels een tankcontainer aan boord van het schip geladen kan worden. Waterstof kan in een container gevuld met drukhouders met een druk van 300 bar overgezet worden van de wal naar het schip (vanuit de containervoorraad of vanaf de trailer), maar in de toekomst mogelijk ook van schip naar schip. Een 40 voet container bevat dan 750 kg waterstof. Dergelijke containerwissel wordt "swappen" genoemd. Voor de uitwerking van dit kennishiaat focussen we op gasvormige waterstof gezien het technology readiness level (TRL) van deze toepassing.

2. Introductie

Bunkering procedures are essential to handle the specific details of the bunkering operation in a safe way. These procedures are typically based on (international) standards and bunkering guidelines. Bunker checklists are an important safety tool reflecting the requirements of ports with regard to bunkering operations in or near their port environment.

Bunkering standards, guidelines, procedures and checklists for bunkering gaseous, liquid hydrogen or hydrogen carriers, such as methanol and ammonia etc. (further referred to as: "bunkering hydrogen") do currently not exist.

This memo provides an overview of the documents that were developed in the last decade for bunkering LNG. Recommendations are formulated for further work needed to develop similar documents for bunkering hydrogen while taking into account current developments.

[1] EICB (2020), Waterstof in de binnenvaart. https://www.eicb.nl/wp-content/uploads/2020/07/2020-07-EICB-Rapport-Waterstof-in-de-binnenvaart-en-short-sea.pdf

3. Algemene omschrijving van de verschillende documenten

This section provides a brief overview of the differences between bunkering guidelines, procedures, standards and checklists and which organization(s) typically develop these documents. The overview includes a summary of the different topics that are covered in these documents including their level of detail. A more detailed description is given in the following sections.

The overview is presented in the table below.

Table 1: Overview of the different documents relevant for (hydrogen) bunkering

Document	Short description	Topics	Examples of responsible organizations
Standards	Provide the minimum requirements for the design and operation as (internationally) agreed by experts. Note: an international standard can also contain guidelines (less strict than requirements).	Safety, training, roles & responsibility, functional equipment requirements etc. The level of detail: low (because it must be general applicable)	ISO, CEN/CENELEC
Guidelines	Guidelines provide advice/instructions how to address important aspects that need to be further worked out in a bunkering procedure. They are usually based on best practices and/or provide a more concrete implementation of the requirements given in standards.	Same topics as in standards and in procedures. Level of detail: medium. More detailed or specific than standards, but less than a procedure.	IACS, SGMF, IAPH
Procedures	A procedural description of how bunkering should actually be carried out. This can be either in general for a bunkering configuration (e.g. ship-to-ship) or for a specific bunkering operation by e.g. a certain bunker vessel performed by a bunker operator. Note a bunkering procedure usually also contain checklists (included as appendix).	(Local) conditions & requirements, Safety, equipment, emergency operations, communications, detailed description of all operations before, during and after bunkering. Level of detail: high	Bunker operators
Checklists	Contains the numerous checks that need to signed off by the bunker operator, receiving vessel and possibly the terminal where the bunkering takes place. They usually contain **extra requirements of ports when bunkering takes place in a port environment. It is an important tool on an operational level.**	Checks relevant for planning stage, pre-transfer, after transfer recording of transfer data (quantity/pressure/transfer rate etc.). Many topics/aspects are covered but the main focus is safety.	IAPH, bunker operators

An example is given below to better understand the differences and level of detail between the different documents.
A safety zone is required to be established around the bunkering station to control ignition sources and to ensure that only essential personnel and activities are allowed in the zone.

- A standard provides the generic methodology to determine the safety zones and the minimum requirements. E.g. for LNG bunkering: ISO/TS 18683, annex B;
- A guideline provides more detail on how to calculate a safety zone and the considerations (and operational limitations) important for establishing/implementing the zone. E.g. for LNG bunkering: SGMF bunker guidelines;
- A procedure for a specific bunker operation will provide the (calculated) safety zone and all practical (and local) limitations with respect to for instance simultaneous operations that could take place. For instance, a safety zone of 25 m distance from the bunker manifold needs to be established for bunkering receiving vessel X with bunker vessel Y at location Z. Example: a bunkering procedure of a bunker operator, which will be available on board the bunker vessel.
- A checklist will contain the physical check whether the safety zone (as given in the procedure, e.g. 25 m) has actually been established (and marked) before bunkering starts. To be checked and signed off by bunker operator, receiving vessel and possibly the terminal. Example: IAPH LNG bunker checklists or specific checklists included as appendix in the procedure.

4. Internationale standaarden

ISO has developed a technical specification (TS)[2] for LNG bunkering: ISO/TS 18683:2015 - Guidelines for systems and installations for supply of LNG as fuel to ships. A similar technical specification (further referred to as standard) is needed for bunkering hydrogen.

The standard should clarify the aspects of bunkering of hydrogen fuel in a port environment. Guidance on the minimum requirements for the design and operation of a hydrogen bunkering facility, including the interface between the hydrogen supply facilities and receiving ship, needs to be included. The standard should include requirements and recommendations for operator and crew competency training, for the roles and responsibilities of the ship crew and bunkering personnel during hydrogen bunkering operations, and the functional requirements for equipment necessary to ensure safe hydrogen bunkering operations of hydrogen-fuelled ships. The standard would need to be applicable to bunkering of both seagoing and inland navigational vessels. It should cover different hydrogen bunkering configurations, i.e. from shore (e.g. bunker station, truck-to-ship) or ship. Methodology to calculate operational safety zones during bunkering needs to be developed and included in this standard.

New developments
CEN/CENELEC considers developing standards on gaseous compressed hydrogen, liquefied hydrogen, methanol and ammonia refuelling points and bunkering for maritime and inland waterways hydrogen-fuelled vessels. This is currently still at proposal and funding stage and the work will be covered by CEN/TC 268/WG 5. For each type of fuel there will be a separate standard. The standard shall describe the technical specifications for the refueling points for maritime and inland waterways vessels. The standard will include the technical specification for the refueling system, including the nozzle and connection, male and female flanges, their geometry, dimensions and fail-safe features. In addition, the standard shall include the relevant functional requirements for the different

[2] A technical Specification addresses work still under technical development, or where it is believed that there will be a future, but not immediate, possibility of agreement on an international standard (source: www.iso.org)

equipment necessary for the bunkering operation, procedures, responsibilities and risk assessment scope taking into consideration the specific hazards in handling and bunkering. The standard will be made in cooperation with the international maritime organizations to ensure the interoperability of the connection in other ports outside the European Union.

The standard will be written for both seagoing and inland vessels, but a European standard for seagoing vessels is not very useful (ISO standard would be more appropriate). Furthermore, the scope is very similar to that of ISO 20519:2017 and ISO/TS 18683 for LNG bunkering. Industry bodies, such as IACS, SGMF and IAPH (see paragraph below) could develop more practical and detailed guidance based on these standards. For instance, the bunkering guidelines they have developed for LNG bunkering are described below.

5. Richtlijnen bunkeren

Over the last years, several guidelines designed to handle LNG bunkering have been published that provided a more practical and detailed guidance based on the international guidelines/standards mentioned above:

- IACS LNG bunkering Guidelines (No. 142) was published in June 2016. The document provides recommendations for the responsibilities, procedures and equipment required for LNG bunkering operations and sets harmonised minimum baseline recommendations for bunkering risk assessment, equipment and operations
- The Society for Gas as a Marine Fuel (SGMF) has released the “LNG Bunkering – Safety Guidelines” (Feb 2015). The document includes chapters on LNG hazards, safety systems, bunkering and specific safety guidance for truck-to-ship, ship-to-ship and bunker station to ship bunkering;
- Bureaus Veritas (BV) has published LNG Bunkering Guidelines;
- DNV developed recommended practice DNV-RP-G105: Development and operation of liquefied natural gas bunkering facilities provides guidance to the industry on development, organizational, technical, functional and operational issues in order to ensure global compatibility and secure a high level of safety, integrity and reliability for LNG bunkering facilities. This recommended practice provides a more in-depth practical implementation of the guidance outlined in ISO/TS 18683.

Similar guidelines for bunkering hydrogen need to be developed by e.g. IACS, SGMF and the class societies.

Procedures bunkeren

Based on the bunkering guidelines, bunker operators need to develop bunkering procedures with the purpose to perform a specific bunkering operation at a specific location in a safe way. The purpose of this document to provide guidance to the bunker operators undertaking the bunkering operation.

The bunkering procedure covers the full transfer or bunkering sequence from the moment in which e.g. a bunkering vessel is navigating to the bunkering area until, and including, the disconnection of the hoses after completing the supplying operation, including:

- Communication aspects (in the port) between all involved parties
- Navigational aspects in the port
- Technical aspects and requirements
- Operational aspects to allow for safe transfer

- Pre-transfer phase
- Transfer phase
- Post-transfer phase
- Standards for training and qualification of the crew and involved port personnel
- Emergency procedures
- Location specific and metrological requirements with potential impact on safety (e.g. safety zones)
- Simultaneous operations and associated requirements

Specific procedures could have been developed to bunker the hydrogen vessels in the numerous pilot projects, but these would still lack the requirements from the to be developed guidelines.

6. Checklists

Bunker checklists reflect the extra requirements of ports with regard to bunkering operations in or near their port environment. It is an important safety tool on an operational level. By using bunkering checklists, a high level of quality and responsibility of the bunker operators can be obtained. Harmonized checklists need to be developed as they currently do not exist for bunkering hydrogen. Implementing harmonized bunker checklists in ports will be of great benefit to the vessels (and their crew) bunkering hydrogen in other ports because it will reduce the potential confusion caused by having to comply with different rules and regulations in different ports.

The IAPH-WPSP bunker checklists for bunkering LNG could be adapted for bunkering hydrogen**.**

7. Conclusies

Bunkering guidelines, procedures, standards and checklists for bunkering hydrogen do currently not exist. Further work in document development is needed as recommended below (in chronological order):

1. ISO and/or CEN/CENELEC need to develop bunkering guidelines/standards. An ISO guideline would be preferred as the guideline should be applicable on an international level and not (only) European. CEN/CENELEC already considers developing standards for bunkering hydrogen.
2. Development of more specific bunkering guidelines by e.g. IACS, SGMF and/or the class societies, which will provide a more practical implementation of the international guideline(s).
3. Development of bunker procedures by the bunker operators (e.g. with support from class societies)
4. Development of harmonized bunker checklists by e.g. IAPH.

Relevant for the development is the work done for bunkering LNG in the last decade (all of the above is available). The basic principles and topics addressed in the documents are similar, although the operational and safety requirements could be quite different.

For bunkering of compressed hydrogen gas, experience and standards used in land-based applications could be relevant. A starting point will be the currently available systems for filling of hydrogen on hydrogen cars, trucks and buses, but one must be careful as filling installations for vessels could be quite different and it is a common misconception that maritime bunkering will (always) be similar to automobile/truck dispensing.

For bunkering ammonia and methanol, reference could be made to the potentially relevant experiences with loading and unloading of tankers. Maritime transport of ammonia and methanol in tanker ships is common practice. For instance, Yara Sluiskil imports ammonia via seagoing vessels. BASF in the Port of Antwerp is a large ammonia producer and exporter. Horisont Energi and Koole Terminals are currently working on the development of an ammonia storage terminal at the Port of Rotterdam[3].

8. Referenties

1. DNV, RH2INE Sub-study 1a/b, SuAc 1.1d & SuAc A1-2 & B1-2 Regulatory & Standards Gap Assessment, March 2021.

[3] Source: https://www.maritime-executive.com/article/agreement-to-develop-rotterdam-s-first-ammonia-storage-and-terminal (accessed on 2022-03-17)