EUROPEAN COMMISSION

DG MOVE

SEVENTH FRAMEWORK PROGRAMME

GC.SST.2012.2-3 GA No. 321592

National and European regulation impact

LNG Blue Corridors project is supported by the European Commission under the Seventh Framework Programme (FP7). The sole responsibility for the content of this document lies with the authors. It does not necessarily reflect the opinion of the European Union. Neither the FP7 nor the European Commission is responsible for any use that may be made of the information contained therein.

Deliverable No.	LNG BC D3.3	
Deliverable Title	National and European regulation impact	
Dissemination level	Public	
Written By	Philippe Desrumaux (DRIVE)	18/07/2014
Checked by	Milagros Rey (GNF)	21/07/2014
Approved by	Xavier Ribas (IDIADA)	21/07/2014
Issue date	21/07/2014	

Revision History

Author	Organisation	Date	Description
Philippe Desrumaux	DRIVE	16/03/2014	Written
Milagros Rey	GNF	25/03/2014	Suggested additional content
Gerard Balleste	GNF	25/032014	Suggested additional content
Jesús Gallego	IDIADA	10/04/2014	Suggested additional content
Curt Ganeles	ERDGAS	25/04/2014	Suggested additional content
Milagros Rey	GNF	29/04/2014	Checked
Judith Dominguez	IDIADA	05/05/2014	Format
Xavier Ribas	IDIADA	05/05/2014	Approved
Philippe Desrumaux	DRIVE	18/07/2014	Additional contents
Gerard Balleste	GNF	18/07/2014	Additional contents
Milagros Rey	GNF	21/07/2014	Review and format changes

Contents

1 Introduction

1.1 LNG Blue Corridors project

The LNG Blue Corridors project's aim is to establish LNG as a real alternative for medium- and long-distance transport—first as a complementary fuel and later as an adequate substitute for diesel. Up to now the common use of gas as fuel has been for heavy vehicles running on natural gas (NG) only for municipal use, such as urban buses and garbage collection trucks. In both types of application, engine performance and autonomy are good with present technologies, as they are well adapted to this alternative cleaner fuel.

However, analyzing the consumption data, the equivalence in autonomy of 1 liter of diesel oil is 5 liters of CNG (Compressed Natural Gas), compressed to 200 bar. Five times more volume of fuel prevents the use of CNG in heavy road transport, because its volume and weight would be too great for a long-distance truck. This opens the way for LNG (Liquefied Natural Gas), which is the way natural gas is transported by ship to any point of the globe. NG liquefies at 162º C below zero, and the cost in energy is only 5% of the original gas. This state of NG gives LNG the advantage of very high energy content. Only 1,8 liters of LNG are needed to meet the equivalent autonomy of using 1 liter of diesel oil. A 40-ton road tractor in Europe needs a tank of 400 to 500 liters for a 1.000 km trip; its equivalent volume with liquid gas would be 700 to 900 liters of LNG, a tank dimension that could easily be fitted to the side of the truck chassis. LNG therefore opens the way to the use of NG for medium- and long-distance road transport.

LNG has huge potential for contributing to achieving Europe's policy objectives, such as the Commission's targets for greenhouse gas reduction, air quality targets, while at the same time reducing dependency on crude oil and guaranteeing supply security. Natural gas heavy-duty vehicles already comply with Euro V emission standards and have enormous potential to reach future Euro VI emission standards, some without complex exhaust gas after-treatment technologies, which have increased procurement and maintenance costs.

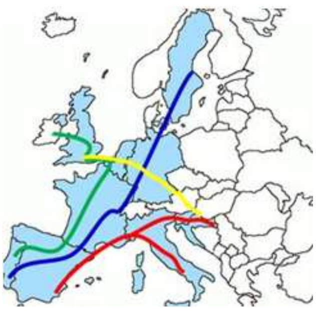


Figure 1-1. Impression of the LNG Blue Corridors

To meet the objectives, a series of LNG refuelling points have been defined along the four corridors covering the Atlantic area (green line), the Mediterranean region (red line) and connecting Europe's South with the North (blue line) and its West and East (yellow line) accordingly. In order to implement a sustainable transport network for Europe, the project has set the goal to build approximately 14 new LNG stations, both permanent and mobile, on critical locations along the Blue Corridors whilst building up a fleet of approximately 100 Heavy-Duty Vehicles powered by LNG.

This European project is financed by the Seventh Framework Programme (FP7), with the amount of 7.96 M€ (total investments amounting to 14.33 M€), involving 27 partners from 11 countries.

This document corresponds to the 3rd deliverable within Work Package 3. It is a document describing the impact on National and European regulations regarding the buildings LNG/LBG refuelling stations. This document will be available at the project website: http://www.lngbluecorridors.eu/.

1.2 Aim of this deliverable

The LNG Blue Corridors project has the ambition to demonstrate that LNG is an ecological and economical alternative to diesel fuel for long-distance goods transportation.

Outside of Europe, there is experience with LNG as truck fuel in USA, Australia and China. China has become one of the leading countries where LNG is used in day-to-day transportation; more than 50.000 LNG vehicles are in use. In Australia, LNG road trains run through the desert and show that the technology is mature and safe.

In Europe, the use of LNG is limited to some islands where a limited number of trucks run in a return-to-base type of operation. Spain has been a leading country, due to the experience with LNG satellite plants and the transportation of LNG by trailer. Spain now has more than 14 stations to refuel trucks.

Also UK, Sweden and the Netherlands have a reasonable network to allow operations on a regional scale.

The real challenge is to connect the different 'islands' and to enable international transportation powered by LNG. Therefore, we need not only the right trucks, but certainly also the network of fuel stations. This project will be the first in its kind to support the build-up of infrastructure.

If LNG trucking is to become a reality, more harmonization and standardisation is a must. This is handled in Work Package 4.

This deliverable focuses on the impact of the regulation regarding LNG stations, both on national and international levels. We see that there are differences in national regulations and/or permitting requirements that imply different layouts of the stations in different countries. This can also have significant impact on investment and the operational cost of LNG stations.

From Deliverable 4.2, we have learned that there are very few countries with an integral regulation on the building and operation of LNG stations. It is common that such regulation will develop when a country has one or more stations in operation. It can also be expected that the ISO regulation on LNG stations will become a guideline for these regulations.

For these reasons, we will focus more closely to the 2 standards that are the most developed:

PGS 33 : afleverinstallaties van vloeibaar aardgas (LNG) voor motorvoertuigen

ISO Draft International Standard 16924, Status 02/2014: Enquire Stage

2 Abbreviations

ADR Accord européen relatif au transport international des marchandises Dangereuses par Route or European Agreement concerning the International Carriage of Dangerous Goods by Road

ATEX ATmosphères Explosibles, European directive describing what equipment and work environment is allowed in an environment with an explosive atmosphere

CNG Compressed Natural Gas

CPD Construction Products Directive

DIS Draft International Standard

EMC Electro-Magnetic compatibility

ESD Emergency Shut Down

LNG Liquefied Natural Gas

LVG Low-voltage Directive

MID Measuring Instruments Directive

NEN NEderlands Normalisatie instituut

PED Pressure Equipment Directive

3 LNG regulations for the building of LNG/LBG stations

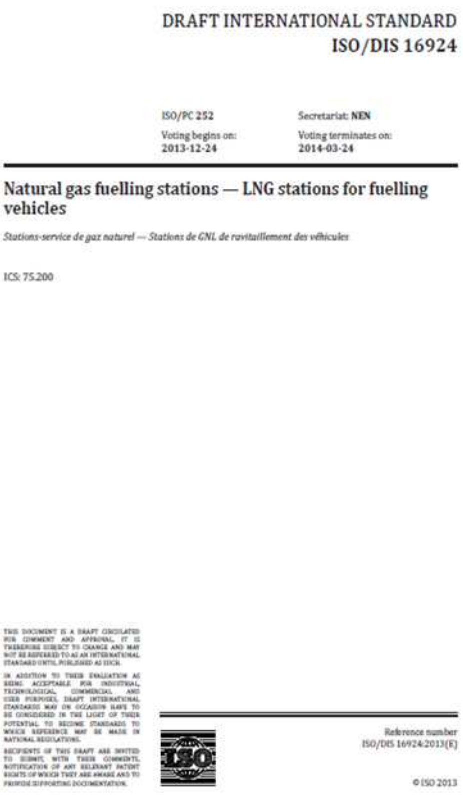
3.1 Introduction

In order to limit the scope of this overview, we will focus on the legislation that is specific for LNG fuelling stations. Please note that many other standards can be applicable (directly or indirectly) to the construction of an LNG station. For example:

- EN 13645:2001: Installations and equipment for liquefied natural gas – Design of onshore installations with a storage capacity of between 5t and 200t
- National or international CNG related standards (for the CNG part in case of L-CNG stations)
- Seveso regulations (Council Directive 96/82/EC) (in case of storage of more than 50 tons of LNG, equivalent to approx. 115.000 liters)
- Regulations on noise pollution, road safety, air quality, etc.
- ADR regulations (for transport of LNG)

3.2 ISO/DIS 16924 Natural gas fuelling stations – LNG stations for fuelling vehicles

Status: under development by ISO/PC 252. Enquiry stage, DIS registered (2013-10-16).


DRAFT INTERNATIONAL STANDARD
ISO/DIS 16924

ISO/PC 252 Secretariat: NEN
Voting begins on: 2013-12-24 Voting terminates on: 2014-03-24

Natural gas fuelling stations — LNG stations for fuelling vehicles

Stations-service de gaz naturel — Stations de GNL de ravitaillement des véhicules

ICS: 75.200

THIS DOCUMENT IS A DRAFT CIRCULATED FOR COMMENT AND APPROVAL. IT IS THEREFORE SUBJECT TO CHANGE AND MAY NOT BE REFERRED TO AS AN INTERNATIONAL STANDARD UNTIL PUBLISHED AS SUCH.

IN ADDITION TO THEIR EVALUATION AS BEING ACCEPTABLE FOR INDUSTRIAL, TECHNOLOGICAL, COMMERCIAL AND USER PURPOSES, DRAFT INTERNATIONAL STANDARDS MAY ON OCCASION HAVE TO BE CONSIDERED IN THE LIGHT OF THEIR POTENTIAL TO BECOME STANDARDS TO WHICH REFERENCE MAY BE MADE IN NATIONAL REGULATIONS.

RECIPIENTS OF THIS DRAFT ARE INVITED TO SUBMIT, WITH THEIR COMMENTS, NOTIFICATION OF ANY RELEVANT PATENT RIGHTS OF WHICH THEY ARE AWARE AND TO PROVIDE SUPPORTING DOCUMENTATION.

Reference number
ISO/DIS 16924:2013(E)

© ISO 2013

ISO DIS 16924

Target publication date: 2016-04-15.

Under the NEN secretary, an ISO norm is being developed regarding LNG stations for fuelling vehicles. The norm is still in Draft status, and is expected to be finalized and published in 2016.

This norm is voluntary, but it is probable that it will be adopted by several countries as part of the regulatory framework, or will be referred to in legislation for which they serve as the technical basis. This explains the importance and general interest in the development of this standard.

The standard has been prepared since 2010 by a committee of industry representatives from all over the world, that have met during 8 multi-day meetings in Amsterdam, Mumbai, Milan, Vancouver, Hessingue, Decin, The Hague, and Rotterdam.

The Draft version of the standard is currently shared with all the national members that are asked to comment. The process is based on consensus. If this 0consensus is reached, the final draft will be sent to all ISO members for final vote.

Below you will find the main structure of the DIS 16924. The full DIS is available on the LNG Blue Corridor website.

4.2.1. Scope

The scope is the design, construction, operation, maintenance and inspection of stations for fuelling LNG to vehicles and other liquefied methane rich gases which comply with local applicable gas composition regulations or with the gas quality requirements. The CNG equipment is covered in DIS 16923.

4.1.2. Normative references

In this part, there is a list of international (ISO and IEC) norms relating to cryogenic equipment, natural gas, electrical equipment, etc.

4.1.3. Terms and definitions

List of terms and definitions used in the text of this draft international standard.

4.1.4. Abbreviated terms

CNG compressed natural gas

ESD emergency shut-down

LCNG compressed natural gas, sourced from LNG

LEL lower explosive limit

LNG liquefied natural gas

MAWP maximum allowable working pressure

NGV natural gas vehicle

NPSH net positive suction head

4.1.5. General Principles of design and installation

The station should be assembled in a suitable manner, taking into consideration the pressures, temperatures, weather conditions, etc that can be expected under normal and fault conditions, and in compliance with the standards for cryogenic equipment.

Furthermore, in this section, attention is drawn to functional requirements, such as LNG supplied to the station, LNG supplied to the vehicle, LNG composition during the maintenance, odorization, environmental impact of the station, materials, site lay-out, security, buildings and civil works, station signs (LNG and CNG), equipment marking, risk management, separation distances, risk assessment, containment areas, safety devices, prevention of LNG spills and LNG venting, fire protection and emergency shutdown.

It is worth mentioning that currently, there is still some discussion ongoing on the need of containment and its area (compulsory or not) and on the safety distances. These issues can have a big impact on the cost and overall feasibility of LNG projects.

4.1.6. LNG supply interface

This section specifies the requirements of safe LNG delivery from the tanker to the station in order to prevent overfilling and over pressurizing. At least one qualified person (usually the LNG tanker driver) is required during offloading, and he shall control two independent systems of liquid level measurement. In case of emergency, a 'dead man's button' is provided. Provisions for the tanker are also listed (ant drive-away equipment, engine shut-off, potentials equalization, ESD).

4.1.7. LNG storage tank

This section states the design and functional requirements for the storage tank. It takes into consideration the MAWP, the relief valves and isolation valve, instrumentation, foundations and the design codes and identification plates. The piping has to be austenitic stainless steel, appropriate to service at temperatures of -196°C.

It takes in consideration buried tanks as well, also mobile tanks.

4.1.8. Connection of pumps to the LNG storage tank.

Correct connection of the storage tank and LNG pumps has to guarantee the correct function of the pumps. All return gases should be collected, preventing venting to the atmosphere.

4.1.9. LNG centrifugal pump

This pump should comply with ISO 24490 and ISO 13709, and should be well balanced to prevent vibrations, and should detect leakage and cavitations. Upon detection, the pump should be stopped.

4.1.10. LNG reciprocating pump for LCNG fuelling

This pump should comply with ISO 24490, have pulsation damping. It must be designed in order to prevent vibration and pulsation. The example of a typical installation can be found in Annex J.

4.1.11. Commonalities for LNG centrifugal and reciprocating pumps

This part states the requirements for the instrumentation, markings and for both centrifugal and reciprocating pumps.

4.1.12. Vaporizers and heaters

The purpose of the vaporizer is to convert the LNG to gaseous state. Heater serves to increase the temperature and/or pressure of the LNG, in order to reset the conditions of either the supplied LNG or the storage tank. There are different types of vaporizers, (ambient air, electric, water bath, fired & remotely heated), which need different design conditions to be assembled in the station

4.1.13. High pressure odorizers

The high pressure odorizers serves to inject odorant in the stream of the vaporized high pressure gas, in order to achieve the criteria for odorized CNG. Monitoring of the odorization is necessary, in order to prevent operation without odorization. There are a few different odorants depending on the country regulations. Therefore this system should be adapted for each odorant. Anyway, all odorants create a hazardous zone, which implies safety conditions and huge control for designs.

4.1.14. High pressure (CNG) storage

The high pressure CNG storage shall follow the requirements of ISO 16923. The buffer shall be protected from too low temperatures if the vaporizing system fails.

4.1.15. LNG dispenser

The functions of the dispenser are described, as well as the main components (safe fuelling of the LNG, safe handling of the LNG, vapor recovery from the vehicle tank (if possible) and metrology of supplied amount of LNG). Hazardous areas must be considered, as well as a breakaway system on the hoses, protection against collision, and isolation switch.. It takes in account designs of LNG fuelling nozzles and fuelling hoses.

4.1.16. CNG dispenser

This dispenser shall comply with ISO 16923

4.1.17. Natural gas compressor

Also the compressor should comply to the CNG filling station norm ISO 16923, with some specific considerations regarding minimum temperature allowed at the compressor inlet

4.1.18. Station pipework and ancillary devices

Valves has to comply with ISO 21011, and consideration should be given to specific problems such as thermal stress, prevention of pressurization by cryogenic liquid and drains and vents. The piping can be above or underground. In both cases, considerations like risk of damage, corrosion, inspections and distances have to be taken in account.

4.1.19. Instrumentation and control system

This section concerns pressure gauges, thermometers, gas & flame detection, and the control systems which controls the operation station as levels, pumps, vaporizers, etc.

4.1.20. ESD (emergency shutdown) and procedures

ESD shall be activated by:

- gas leak detection
- flame detection
- low temperature of the foundations
- failure of the power or instrumentation
- activation of a manual ESD device

Activation of the ESD shall put the station in a safe mode, and warn by audible and visual signs.

4.1.21. Electrical equipment and wiring

This section describes the relevant norms that should be taken in account as IEC 60204-1, IEC 60079-14 and other relevant parts of this one and IEC 62305. Provisions for safe use of electricity with natural gas are contemplated with use of seals between zones with potential presence of flammable fluids and electrical equipment

4.1.22. Installation and construction

Specific attention is drawn to the welding operations, that should be done by only qualified people. Welding shall be performed in accordance with a procedure specified in ISO 15609-1 or ISO 15609-2.

Traceability of materials, components and accessories must be established, as well as a quality manual.

4.1.23. Inspection and testing

All pressure equipment shall be visually inspected and pressure tested by a competent person with a recognized qualification authorized by a national authorizing body, before being put into service. Besides pressure systems, items specially treated too are leak system and electrical systems.

Special attention is drawn to the commissioning provisions with functional testing and purging4.1.24. Moveable LNG fuelling station

Specific provisions for anchoring and containment of movable (skid mounted) stations.

4.1.25. Mobile LNG fuelling station

Mobile LNG fuelling stations are possible, but should comply with general standard except for some provisions, like anchoring, containment, design and operation.

4.1.26. Operation

In this section, different processes are described, in order to guarantee safe operation. Items reflected are the offloading of LNG from the tanker, fuelling, training, instructions, emergency plan, etc.

4.1.27. Periodic inspection

This section describes the periodic inspections of all the equipment according to applicable standards, especially cryogenic pressure equipment and safety systems, A table with the different periods is included.

4.1.28. Maintenance

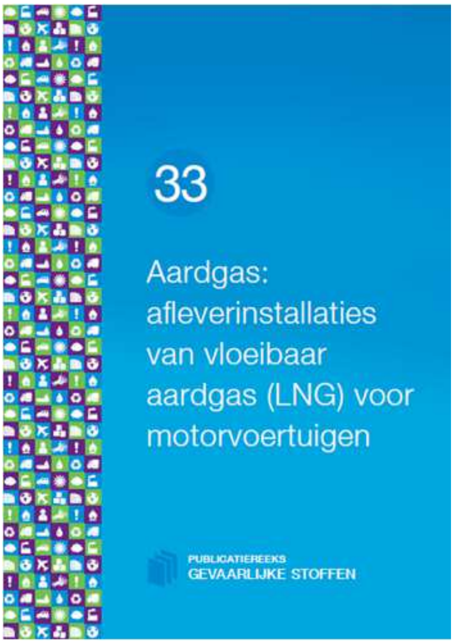
The maintenance should be carried out by qualified personnel. Specific provisions for the draining of the LNG storage tank are included in this section.

4.1.29. Annexes

Annexes A to K.

3.3 PGS 33-1 Aardgas: afleverinstallaties van vloeibaar aardgas (LNG) voor motorvoertuigen.

Translation: Natural Gas: installations for the supply of Liquefied Natural Gas (LNG) to motor vehicles.



PGS 33-1

PGS 33 is a Dutch guideline for LNG stations. PGS 33 is part of the PGS publications, which serve as guidelines for companies that produce, store, transport or use dangerous goods. Other PGS publications handle on e.g. LPG or CNG. PGS publications will also serve as a basis for the permitting of dangerous facilities. The PGS publications are set up by a team of representatives of both the authorities and the industry.

PGS33-1 is focussed on LNG stations for motor vehicles. PGS33-2 will be the directive for LNG bunkering stations for marine applications. This standard is under development.

The recommendations in the PGS 33 are not absolute, and it is possible to propose alternative solutions, provided they guarantee similar results.

Warning: below overview of PGS33 is not the translation of PGS 33, but merely an abstract with focus on some specific elements of interest for anyone building an LNG station.

Structure of PGS 33:

1. Scope of the directive
2. Construction and execution of the LNG station
3. The operation of the LNG station
4. Inspections, servicing, registration and maintenance
5. Safety measures
6. Incidents and incident response

Annexes

In this overview, we will focus on part 1 (Scope), part 2 (construction), part 3 (operation) and on part 5 (safety measures).

3.3.1 Scope of the directive

PGS33-1 is a non-binding norm, but becomes binding when it is referred to in official documents, e.g. an environmental permit. Its target is to provide a reasonable and sufficient level of protection for people and for the environment. This includes e.g. safety distances and the process requirements about boil-off gas. The limits of the PGS33-1 are the fill connection to the storage tank, and on the other side the fill connection to the vehicle tank.

The L-CNG process is included in the scope up to the exit of the vaporiser. Storage and dispensing of CNG are included in PGS 25.

PGS 33-1 adopts the principle of equivalence. This means that measures can be taken other than those provided by PGS if they provide equivalent means of protection. The authority in charge will always make the final evaluation of the equivalence.

3.3.2 Construction of the LNG installation

3.3.2.1 General requirements

All parts used in an LNG station should have CE marking when applied within the scope of following directives:

- Electro-magnetic compatibility (EMC)
- Low voltage Directive (LVD)
- Pressure Equipment Directive (PED)
- Machinery Directive
- Construction Products Directive (CPD)
- ATEX directive

Main parts: (more detailed information in Deliverable 3.2: State of the Art)

- Fuel Tank
- Safety relief valves
- Saturation vaporiser
- Level measurement
- Valves
- Pump
- Vaporisers
- Piping
- Dispenser
- Break-away coupling

- Refuelling hose
- Filling hose

3.3.2.2 Construction requirements

- Special attention is needed to insulation, typically vacuum insulation from the tank and the piping, in order to avoid heat in leak.

3.3.2.2.1 LNG storage tank

- The storage tank should comply with the Pressure Equipment Directive
- The storage tank should be supported by a suitable construction, with fire resistance of at least 1 hour. (Asphalt may be considered not suitable, since it may not provide enough stability in a fire).
- In the connecting lines to the storage tank, there should be manual valves as close as possible to the tank. Safety valves should indicate the position (open or closed) and should close automatically in case of ESD or if power is shut down.
- A containment is considered not to increase the safety. Calculation learned that in case of failure of a connection, the maximum diameter of an LNG spill will be 12 meters.
- There should be 2 independent level measurement systems in order to prevent overfilling, keeping in mind the increase in volume due to saturation of the LNG.
- The central vent stack should:
  - Be protected against blocking due to water freezing
  - Be impossible to close
  - Have vertical exhaust
  - Have detection of fluid (temperature)
  - Generate ESD in case of fluid detection
- The level (height) of the exhaust of the vent stack should be determined to
  - Avoid heat radiation above 3KW/m^2 on ground level
  - Avoid heat radiation above 35kW/m^2 on the tank surface
  - Avoid formation of an LNG splash on the surface due to LNG spray
- The relief valves should be according to NEN EN 13645 and be connected to the vent stack.
- The site should be constructed to avoid spillage of LNG towards sewwage, other dangerous installations, access roads, the LNG installation, the LNG supply truck or the refuelling vehicles.

- Care should be taken to the general construction of pipes and fittings, in order to avoid excessive mechanical tension due to installation, difference in temperature or prolapse.
- Prevention of pressurization of cryogenic LNG trapped in sections between 2 valves should be addressed. Relief should be directed to the central vent stack.
- The filling connector of the storage tank should be above ground and protected against collision. and from the filling area the driver should have a clear view on the filling level from the filling area.
- There should be a check valve in the filling line
- The installation should be protected against unauthorised persons, except for the dispenser, by means of a fence. There should be 2 doors with free exit.

3.3.2.2.2 Constructions of LNG piping:

- Piping should be according to PED.
- LNG piping in a gully should be from one piece, protected against mechanical, chemical and thermal stress. Gullies shall be dry under normal climatologic circumstances, and accessible for visual inspection.
- If installed underground:
    - Special care should be taken to control mechanical and thermal stress, and pipes should be double-skinned
    - There should be a leak detection system
    - The piping should be from one piece, or welded and have a corrosion protection system
    - The piping should be buried at least 0.6m deep, and 0.1m around the piping there should be sand that is free from any stones or hard objects

3.3.3 Operation of the station

3.3.3.1 General requirements

- During normal operation, emission of methane is not allowed. The installation should have a provision to collect the boil-off gas, or a system to prevent the formation of boil-off gas. The dispenser should have a vapour return system, or should be a closed system without vapour return.
- If the station is closed, all valves should be in a safe position.

3.3.3.2 The filling of the storage tank

- This process is considered as the most critical process.

- Internal distances to be considered (see further).

- Requirements on the LNG trailer:
  - See ADR
  - Position: should be so that in case of emergency the truck has a free exit to the public road
- Filling of the storage tank:
  - The driver of the supply truck has to be present at all times. This can be guaranteed by a dead-man's-button with 3 minute interval.
  - Filling has to be according to a written and fix procedure.
  - The operator has to monitor the filling level and assure that the maximum filling level will not be exceeded.
  - The expansion due to saturation of the LNG during the stay in the storage tank should be considered. Maximum filling level should 95% at all times. If this cannot be guaranteed, the maximum filling level should be according to ADR provisions.
  - As soon as the maximum level is achieved, the filling must stop automatically.
  - At the disconnection, the amount of gas vented should be limited to a minimum, and should not exceed the corresponding volume of the LNG filling hose.
  - As a minimum, the filling hose should be replaced every 3 years, unless it withstands a hydraulic test, which should be repeated every year.
  - The filling line for the storage tank should have a manual valve at the connector. It should only be accessible by authorised personnel.
  - Unless at a distance of more than 25 meters, there should be no supply of other motor fuels at the same time.
  - The engine of the supply truck should be stopped during connection and disconnection of the filling hose, and can only be in operation during the filling of the tank if this is necessary. The mechanical brake should be activated.
  - The filling can only be possible if the connection between the station ESD system and the trailer safety system is made.

3.3.3.3 Refuelling of vehicles

3.3.3.3.1 General

- Personal protective equipment should be used during refuelling: at least safety glasses and gloves, both suitable for cryogenic operation. Should be CE marked. Note: full face shield is preferred.
- Following marking should be on the dispenser:
  - Turn off engine
  - Smoking and fire prohibited
  - If pictograms are used, they should comply with international standards.
- Lighting should be sufficient for a safe refuelling operation
- At least one 9kg fire extinguisher should be available near the dispenser, for first response to fire incidents. If more vehicles can fuel simultaneous, there should be one for each location.
- Cell phone use should be prohibited

3.3.3.3.2 Dispenser

- The dispenser should have suitable ventilated by upper and lower ventilation vents on opposite sides (min. $50cm^2$)
- Dead man's button: The dispenser should have a button that is set up in such way that LNG can only be dispensed if this button is pushed. The filling should stop latest 3 seconds after the release of this button.
- The filling should stop automatically if the vehicle tank is full. This can be detected by e.g. maximum pressure or minimum flow.
- Both supply and vapour return hose have a break-away coupling with integrated valves to prevent escape of LNG of vapour. The return hose should have a check valve to prevent flow of vapour back to the vehicle tank.
- The supply hose and the vapour return hose should be at least 3 meters, but no longer than 5 meters, and comply with NEN-EN 12434 or NEN-EN 13766.
- The nozzles should only open upon connection to the vehicle tank, then close immediately and automatically upon disconnection. The nozzles should eliminate electrostatic risk by equalization of electrical potentials between the station and vehicle tank.
- The dispenser should have:
  - clear user instructions
  - effective protection against collision
  - emergency shut-down button on the dispenser and nearby

3.3.3.3.3 Supervision

A distinction is made between supply of LNG under operator supervision, and supply of LNG without direct supervision.

If there is no direct supervision from the station operator for the supply of LNG, there is always a supervisory person in charge.

This person:

- Can be the driver of the truck
- Should be minimum 18 years old
- Should have received instructions for safe refuelling, and be registered by the operator
- Should release the installation for dispensing and supervise the refuelling

The LNG installation should be 'automatic' and have following features:

- A provision to release the dispenser for refuelling only after identification of the supervisory person
- A provision for the registration of data of the refuelling (name, date, time, volume)
- A push button for communication of the supervisory person with the operator of the station
- An ESD button for a safe shut down within 15 seconds
- A system to prevent the refuelling by a high-pressure system to a low pressure vehicle tank. This can be by means of e.g. an RFID system, different connector or electronic safety system.

3.3.3.3.4 Users

LNG can only be provided to registered and approved users.

The operator of the station should:

- Register all trained users (names / vehicles)
- Keep record of training of safety instructions and dispenser use
- Register all data of the refuelling operations (name, date, time, volume)

3.3.3.4 Instructions for the function of LNG installations

The start-up of the installation and the restart after ESD can only be performed by the operator of the station or by person that is appointed and instructed by the operator. The station should be executed in such way that it can only be (re)started by the authorised person.

The station should be executed in such way that:

- If no LNG is supplied (A):
  - The identification and registration system is ready for use
  - The ESD-button(s) and button for communication are ready for use
  - The safety systems are operational (temperature sensors, detection on valve closing, thermal protection of engines, ...)
  - Gas detection is active
- During refuelling (B):
  - The identification and registration systems are active
  - The remote operated valves are open
  - The dead man's button is pushed
  - The pump engine is connected to the electric grid
  - The ESD-button(s) and button for communication are ready for use
  - The safety systems are operational
  - Gas detection is active
- At the end of the refuelling:
  - By release of the dead man's button, the installation goes to status A.
- If incidents occur:
  - The station automatically shuts down in case automatic safety systems are activated (e.g. temperature sensors, detection on valve closing...)
  - The station automatically shuts down in case that the ESD button is pushed
  - Indication of ESD is visible for the user of the station
  - The operator (or person appointed and instructed by the operator) is warned automatically
    (min. acoustically) if an ESD button is pushed or if an automatic ESD is generated
  - The operator (or person appointed and instructed by the operator) can be warned by the communication system
- The dispenser should be shut down if:
  - the supervisory person (or a person appointed and instructed by the operator) are not present

and

  - o the supervisory person (or a person appointed and instructed by the operator) cannot be warned by the communication system or cannot be on site within 3 minutes

- The station should remain shut down if the automatic ESD has been engaged and the root cause has not been fixed. If the station is shut down, it should be clearly visible for the user.

3.3.3.5 Instructions for the L-CNG installation

- The L-CNG part should comply with local PED regulations
- The gas supplied to the storage should be minimum 0° Celsius
- The gas supplied to the CNG installation should be odorised
- If the gas does not comply with PGS 25 and the 2 above criteria, the gas supply should be stopped automatically.

3.3.3.6 Monitoring of the LNG installation

- Under normal conditions, permanent monitoring is not necessary. However, in case of disturbed processes, monitoring and subsequent action can be necessary in order to prevent e.g. ESD or extended venting of gas to the atmosphere.
- Every station should have a system to notify the process controller (person in charge).
- Every station should have a competent person in charge for the interpretation and possible solution of problems during the operation. This can be local or remote.
  Safety measures

3.3.3.7 General

The site should be designed in view of safe and clear flow of users and supply of LNG. Consideration should be made to:

- Good overview on the installation
- Clear and safe driveways with regards to possible accidents
- A well thought out position for the LNG supply trailer with minimal obstruction
- Good access for operation and maintenance
- Good access for fire fighting
- Safe exits in case of incidents

3.3.3.8 Safety distances

- Internal safety distances

Internal safety distances should prevent the escalation of a small incident to a major accident. In PGS33, the calculation of the internal safety distances are calculated with consideration to accidents that can happen with certain relevant frequencies (in the order of 10-3 to 10-5 per year), such as leakages or vehicles running into part of the installation.

Major, catastrophic failure of the installation or other rare accident scenarios (with frequencies in the order of 10-6) are not considered in the calculation of internal distances.

The potential danger sources of an LNG station are:

- The storage tank
- The supply installation
- The dispenser (incl. refuelling vehicle)
- The unloading point
- The supply trailer on its position

Following objects are vulnerable:

- Buildings that can accommodate people or dangerous goods
- Installations for the supply of fuels as petrol, gasoil, propane, LPG, CNG or LNG (the LNG station can be danger source and vulnerable object at the same time)
- Other installation parts with dangerous goods
- The 2 base scenarios are a leak of 1 mm with equivalent release of 10g/s at 18 bar (scenario 1 and 2) and a leak of 5mm at 18 bar at a filling hose during filling of the storage tank (scenario 3 and 4)
- These objects should be protected against radiation of 10kW/m^2, except LNG carrying parts with double skinned vacuum insulation (35kW/m^2). In scenario 2 and 4, a conservative calculation is made with 10 kW/m^2 on all parts, also insulated parts.

Table 3-1 PGS 33-1 internal safety distances

Risk source ->	Scenario1 35kW/m^2 LNG installation exc. Fill. Point	Scenario 2 10kW/m^2 LNG installation exc. Fill. Point	Scenario 3 35kW/m^2 Fill. Point + trailer pos.	Scenario 4 10kW/m^2 Fill. Point + trailer pos.
Risk victim				

LNG installation	0m	n/a	10m	n/a
LNG dispenser / Refuelling truck	n/a	0m	n/a	0m
Sales premises / shop within establisment	n/a	3m	n/a	15m
Other vulnerable parts (on site)	n/a	3m	n/a	15m
Filling point / parking space for LNG tanker	Is determined by accident scenario 3 from LNG filling point to LNG installation component	n/a	n/a	n/a
Boundary limit	n/a	3m	n/a	3m

The assumptions for the internal safety distances are the following:

	Accident scenario	Decisive effect	Protection	Protection value	Conditions
Scenario 1	1 mm leak in flange, piping or stationary vessel (perceptible, no pool formation). This corresponds to 10 g/s source strength at 18 barg. Direct ignition. Flare fire	Heat readiation due to flare fire	Prevent failure of neighbouring installation / Domino effect	Max. 35 kW/M^2 heat radiation to neighbouring LNG installation (protected by twin-walled design)	Use of technical measures to minimise the chance of the accident scenario. Use of self-closing filler coupling, break-away coupling delivery hose. Twin-walled design and insulation material offer extra protection against heat radiation.
Scenario 2	1 mm leak in flange, piping or stationary vessel (perceptible, no pool formation). This corresponds to 10 g/s source strength at 18 barg. Direct ignition. Flare Fire.	Heat radiation due to flare fire.	Prevent failure of neighbouring installation/ domino effect	Max. 10 kW/m2for other neighbouring (unprotected) installations	Use of technical measures to minimise the chance of the accident scenario. Use of self-closing filler coupling, break-away coupling delivery hose.Twin-walled design and insulation material offer extra protection against heat radiation
Scenario 3	5 mm leak from offloading hose (10% of 2 inch diameter) at 18 barg during LNG transfer at filling point/ parking space LNG tanker. Direct ignition. Flare fire	Heat radiation due to flare fire	Prevent failure of neighbouring installation/ domino effect	Max 35 kW/m2 heat radiation flux to neighbouring LNG installation (protected by twin-walled design).	Use steel or composite hoses.
Scenario 4	5 mm leak from offloading hose (10% of 2 inch diameter) at 18 barg during LNG transfer at filling point/ parking space LNG tanker. Direct ignition. Flare fire	Heat radiation due to flare fire	Prevent failure of neighbouring installation/ domino effect.	Max. 10 kW/m2 for other neighbouring (unprotected) installations	Use steel or composite hoses.

Other safety distances:

- The LNG installation should be at least 10 meters from the nearest high voltage power lines, and not be under high voltage power lines.
- The LNG installation should not be within 5 meters of a route of pipelines for dangerous products.
- Measures should be taken to prevent damage by plants or other objects in the direct surroundings of the LNG installation
- External safety distances will be addressed in the request for a permit. Probable, a risk analysis (QRA) will probably be requested to prove that the risks toward vulnerable external objects are acceptable.

3.3.3.9 Electrical installation

- Every LNG installation should be equipped with a switch to switch off the electrical installation, and installations should comply with NEN 1010, NEN3140, NEN-EN-IEC 60079-14 and NEN-EN-IEC 60204. The electrical components must also be protected against weather influence.
- The piping, storage tank, relief instruments and vent stacks must be earthed independently.
- The electric and electronic equipment in zoned areas must be explosion safe according to ATEX regulation, and certificates of independent certification organisations must state that the equipment is safe for use in the explosive atmospheres.
- The LNG storage tank and other parts of the LNG installation must be equipped with a connection for grounding. All parts of the installation must be electrically bonded for equalization of electrical potentials according to NEN-EN-IEC-62305.
- The LNG storage tank should be examined on lightning impact.
- In zoned areas, there should be adequate marking according to NEN 3011.

3.3.3.10 Fire safety

A fire extinguisher should be suitable for fire classification B and C according to NEN-EN 2 and NEN-EN 3. They should also be protected against weather influence. At least one extinguisher per vehicle refuelling position.

3.3.3.11 Emergency Shut Down (ESD)

- At the activation of ESD, all components should automatically go to a safe mode. All liquid piping should be blocked in order to close supply and exit pipes
- At the end of the ESD, the installation can only be restarted if the root cause of the ESD is known and if this has been resolved by an on-site visit.

- The emergency buttons must be constructed in such way that they cannot be restored with additional tools. Incidents should be logged.

3.3.3.12 Detection systems

- An LNG installation should have at least 2 gas detectors in continuous operation. These should generate an alert to the station operator at 10% LEL and generation an ESD at 20% LEL.
- There should be at least 2 temperature detectors, one close to the dispenser and one near the tank. Temperatures above 70°C and under -30°C should generate an ESD.
- In the vent stack, there should be temperature detection. This should generate an ESD at the detection of liquid methane.

3.3.3.13 Signalling

- Activation of the ESD should generate an audible and visual alarm on site, and generate an alarm towards the operator of the station.

4 Comparison between DIS 16924 and PGS 33-1

4.1 Most important differences in content

In general, the DIS 16924 is more complete in the possible layouts of an LNG station. It includes movable and mobile stations, underground tanks, etc.. Some of the equipment requirements are more detailed in DIS 16924. For example, all kinds of vaporisers are considered (ambient air, electric, water bath, fired and remotely heated vaporisers).

We will only consider the most obvious differences.

4.1.1 Containment

PGS 33-1 states that LNG containment will not increase the safety level, because possible pool dimensions will be smaller than 12 meters, and thus the added value of a containment basin is minimal. So LNG containment is not required.

DIS 16924, under 5.8.2.1.1, states the following: " The parts of the station containing LNG should be located inside containment, an area surrounded with a liquid tight wall resistant to the temperature of –162 °C, so arranged that any leak of LNG will be held inside that area. Areas for transfer of LNG from the LNG tanker and areas at LNG dispensers may be excluded from this requirement in those cases where these operations are executed under supervision of operator. Provisions for drainage of potential spillage to the containment, if possible, are recommended."

The size of the containment can vary depending on local regulations, but in many cases will consider the maximum volume of the storage tank.

It is clear that he budget for the civil works of an LNG station will depend a lot on the requirement or not of this containment. It concerns not only the concrete floor and walls, but also implies (stronger) foundations, drainage system and more complicated piping and wirings.

4.1.2 Safety distances

PGS 33-1 has focus on internal safety distances between:

- LNG installation / shop or other buildings accommodating people
- LNG installation / storage of other dangerous goods
- LNG installation / LNG storage tank filling point

Most relevant distances are following:

- Distance LNG installation to property line: 3m
- Distance LNG storage tank filling point to storage tank: 10 m
- Distance LNG installation to shop or buildings accommodating people: 3m / 15m

(depending on the chosen scenario of max. allowed heat radiation (35kW/m^2 or 10kW/m^2))

Underground tanks are not considered in PGS33-1.

DIS 16924 focuses on external distances (depending on the storage capacity) and distance between LNG storage tanks.

Most relevant distances are following:

- Distance LNG installation to offsite building or property line that can be built upon: 15m (in case of tank size 56.8 – 114m^3)

- Distance LNG installation to buildings: 3m

(in case of tank size 56.8 – 114m^3)

- Distance of storage tank filling point to building / property line that can be built upon / fixed source of ignition: 7.6m

In the Dutch standard, external safety distances should be examined in a Quantitative Risk Assessment (QRA).

We cannot say that PGS is more stringent than the DIS 16924. They cannot be compared on a one-to-one basis, since they make different considerations for distance calculations.

4.1.3 Safety Systems – ESD

DIS 16924 does not require ESD for stations with storage capacity lower than 5 tons.

PGS thresholds for ESD activation are lower for low temperature / leak detection (-75°C against -30°C for PGS33-1)

PGS 33-1 threshold for temperature of CNG for supply to the CNG storage is 0°C. Below 0°C it cannot be supplied. In DIS 16924, this threshold is -40°C, the design limit for CNG equipment. This seems more logical.

5 Missing gaps in both DIS 16924 and PGS 33-1

5.1 LNG nozzles (& receptacles):

There is currently no standardization of the nozzles used on the stations. There are 3 types of nozzles (JC Carter, Parker Kodiac, and Macrotech). These nozzles are not always compatible:

Parker Kodiac nozzle don't comply with JC Carter or Macrotech receptacles.

There is currently an international standard in development for the receptacles (ISO/DIS 12617).

It is clear that this issue is obstructing the development of the market of LNG as transportation fuel.

Urgent standardization is required in order to find suitable filling systems that can be the standard for all the stations in the LNG Blue Corridor and beyond. It is not acceptable that some trucks cannot refill due to nozzle problems, considering the small network of public stations.

Please also consult deliverable 4.3 Recommendations for future standardization.

5.2 Weight & Measures standardization:

DIS 16924 and PGS 33-1 don't reflect on the issue of standardization of weight & measures. There is currently no regulation on this matter.

The most obvious question is if gas returned from the vehicle tank to the station storage tank should be measured and deducted from the gas supplied. This issue should be addressed as soon as possible, in order to give the end user some distinctness on the price of the fuel.

This issue will be solved under the MID (Measuring Instruments Directive)

5.3 Gas quality

Especially for dual fuel applications, the methane number (MN) is a relevant parameter for the quality of the gas supplied to the trucks.

If the MN is below a certain value (e.g. 90), than there is a risk for detonation and engine damage.

Other values (e.g. Wobbe index) can also be important for a customer, in order to make an objective appreciation of the quality.

5.4 Unattended stations

Taking in account that the most of stations are unattended, it should appear a point which explains the safety systems that permits the operation of the station 24 hours without qualified personnel. These safety systems include all the installed equipment in order to control the correct operation, to prevent risk situations and a permanent connection on line with a Dispatching as well. In case of emergency, the system is smart enough to put the station in complete safety state and warn a maintenance service, which need to provide permanent availability. At least in a minimum time.

From the other point of view, according to the previous point, the system must control as well transactions for the payment system. It needs to count with an established protocol which offers huge confidence.

Without qualified personnel in unattended stations, driver's knowledge on fuelling operation and especially on safety procedures must be assured. Maybe this point could be taken in account by ISO 16924.

6 Conclusions

In general, there very few regulations in Europe that are specific to LNG-LBM stations. We have addressed 2 of them:

- Draft International Standard (DIS) 16924
- PGS 33-1 (published June 2013)

The first document is a draft version of the future ISO norm for refuelling stations, which has an international focus. It describes all possible variants of filling stations, including mobile and moveable stations. This document will serve as a reference for anyone involved in the building and operation of LNG-LBM (and L-CNG / L-CBG) stations. It can be expected that it will also serve as a reference in national legislation, or for the approval of projects by the competent authorities.

PGS 33-1 was developed partially in parallel to the DIS 16924. Although the structure of the document is different, we see that the content is quite similar. On most topics, we see that the requirements may be formulated differently, but in the end provide the same level of safety.

The main important difference – with impact – is the requirement for a containment (spill area) which is not withheld in the Dutch PGS 33-1. The reasoning is that this containment is not adding safety to the station.

The ISO standard for LNG stations is still not final, and possibly the text could be amended with regards to the containment.

The relevance for any upcoming project depends on whether or not the competent authorities will use the (Draft) International Standard.
Other aspects are still not covered by any norm or legislation, even apart from ISO/DIS 16924 or PGS 33-1. We addressed the issues of standardisation of nozzles, weight & measures standardisation, fuel quality and unattended stations.

Some of these issues are addressed in deliverable 3.4 'Recommendation of future standardization'.
LNG BC project will monitor and verify during the project life the evolution of ISO (GNF is participating in the ISO/PC 252/WG 2 discussing ISO/DIS 16924) and any other eventual further development of draft norms and standards. This document will be updated with relevant information at the end of the project.

References

List of Tables

Partners