TR 74 : 2020
(ICS 75.200)

TECHNICAL REFERENCE

# Code of practice for storage, land transportation and handling of LNG

Singapore Standards Council

**TR 74 : 2020**
(ICS 75.200)

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# Code of practice for storage, land transportation and handling of LNG

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The organisations in which the experts of the Working Group are involved are:

*Air Products Singapore Industrial Gases Pte Ltd*
*American Bureau of Shipping*
*Bureau Veritas Singapore Pte Ltd*
*Energy Market Authority*
*FueLNG Pte Ltd*
*Gashubunited Utility Pte Ltd*
*Industrial Gas Association of Singapore*
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## Foreword

This Technical Reference (TR) was prepared by the Working Group on Storage, Land Transportation and, Handling of LNG set up by the Technical Committee on Petroleum Processes and Products under the purview of CSC.

This TR helps to facilitate the storage, land transportation and handling of LNG for downstream end-users, as well as to support the sustainability of the industry by enabling the use of an alternative fuel and providing new growth opportunities to the growing trend of adopting small-scale LNG solutions in Singapore.

It also promotes the standardisation of equipment specifications and installation for storage tanks, transport tankers, and associated facilities, as well as ensuring personnel handling/operating the equipment are suitably trained and competent so as to enhance Singapore's current position as one of the world's largest bunkering port and its vision to become a major LNG trading hub in Asia.

This TR complements TR 56 which covers LNG delivery from LNG bunkering facilities to receiving ships through four modes of transfer (shore-to-ship, truck-to-ship, ship-to-ship bunkering and cassette bunkering).

This TR is expected to be used by any business entities that are interested in or involved with the storage, land transportation and handling of LNG in Singapore.

It is presupposed that in the course of their work, users will comply with all relevant regulatory and statutory requirements. Some examples of relevant regulations and acts are listed in the Bibliography. The Singapore Standards Council and Enterprise Singapore will not be responsible for identifying all of such legal obligations.

This TR is a provisional standard made available for application over a period of three years. The aim is to use the experience gained to update the TR so that it can be adopted as a Singapore Standard. Users of the TR are invited to provide feedback on its technical content, clarity and ease of use. Feedback can be submitted using the form provided in the TR. At the end of the three years, the TR will be reviewed, taking into account any feedback or other considerations, to further its development into a Singapore Standard if found suitable.

Permissions were sought from the following organisations to reproduce materials from their publications:

**Asia Industrial Gases Association**

| | |
|---|---|
| AIGA 027/06 | Cryogenic vaporisation systems – Prevention of brittle fracture of equipment and piping |
| AIGA 038/06 | Vertical cylinder handling and transportation |
| AIGA 039/16 | Road transport & product delivery emergency preparedness |
| AIGA 092/15 | Prevention of tow away accidents |
| AIGA SB 10/17 | Prevention of accidents due to overheated of burning tyres |
| AIGA SB 11/18 | Human behaviour within transport operations |

**European Industrial Gases Association**

| | |
|---|---|
| EIGA TS 03/13 | Training: Induction and refresher training of drivers, management & other transport function personnel |



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**International Organization for Standardization**

ISO 16924 Separation distances of stationary LNG fuelling installation

Table 4 of this TR was adapted from Table B.2 of ISO 16924. The following items were omitted from Table 4 as they are beyond the scope of this TR.

- LNG storage tanks 120 $m^3$ to 300 $m^3$
- LNG storage tanks >300 $m^3$
- Boundary limit – LNG tank offloading connection
- Overhead electric power lines, above 600 V
- Dispenser – Onsite buildings
- If dead man's button limits the accidental discharge to LNG to 60 s

Acknowledgement is made for the use of information from the above publications.

Attention is drawn to the possibility that some of the elements of this TR may be the subject of patent rights. Enterprise Singapore shall not be held responsible for identifying any or all of such patent rights.

**NOTE**

1. *Singapore Standards (SSs) and Technical References (TRs) are reviewed periodically to keep abreast of technical changes, technological developments and industry practices. The changes are documented through the issue of either amendments or revisions. Where SSs are deemed to be stable, i.e. no foreseeable changes in them, they will be classified as "Mature Standards". Mature Standards will not be subject to further review, unless there are requests to review such standards.*

2. *An SS or TR is voluntary in nature except when it is made mandatory by a regulatory authority. It can also be cited in contracts making its application a business necessity. Users are advised to assess and determine whether the SS or TR is suitable for their intended use or purpose. If required, they should refer to the relevant professionals or experts for advice on the use of the document. Enterprise Singapore and the Singapore Standards Council shall not be liable for any damages whether directly or indirectly suffered by anyone or any organisation as a result of the use of any SS or TR. Although care has been taken to draft this standard, users are also advised to ensure that they apply the information after due diligence.*

3. *Compliance with a SS or TR does not exempt users from any legal obligations.*



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# Technical Reference – Code of practice for storage, land transportation and handling of LNG

## 0 Introduction

### 0.1 Properties of LNG

Liquefied natural gas (LNG) is a colourless, odourless, non-toxic and non-corrosive fluid. During the liquefaction process, the natural gas (NG) is treated to remove most of the heavy hydrocarbons, water and other impurities such as carbon dioxide and hydrogen sulphide. LNG is maintained in a liquid state when it is stored at its boiling temperature of around -162 °C. In this condition, it can be maintained at near atmospheric pressure. In liquid form, the volume of NG is reduced by approximately 600 times. Storing and transporting LNG represents different challenges when compared to traditional oil-based liquid fuels, both as a cryogenic liquid and as a flammable gas. As a liquid, these challenges are primarily associated with the cryogenic hazards of a liquid stored at -162 °C. They include brittle fracturing of unprotected structures, cryogenic burns, pressure increases caused by rapid transition to a gas and possible asphyxiation hazards if collected in confined spaces.

The fire and explosion hazards presented by LNG are primarily a result of these factors:

- A lower flashpoint (the lowest liquid temperature at which, under certain standardised conditions, a liquid gives off vapours in quantity such as to be capable of forming a flammable mixture in the presence of air). For NG, this is approximately -187 °C, compared to traditional fuel oils, which have a flashpoint in excess of 60 °C.
- A higher auto-ignition temperature (the lowest temperature of a hot surface at which, under specified test conditions, an ignition occurs of a flammable gas or vapour in a mixture with air or air/inert gas). For NG, this is in the region of 580 °C to 600 °C.
- A flammable range of between a lower explosive limit (LEL) of 5 % and an upper explosive limit (UEL) of 15 % when mixed with air.
- Lower ignition energy. For natural gas/air mixtures, this is 0.25 mJ, which is lower than most other hydrocarbons.

The principal difference between LNG and oil-based liquid fuels, that drives the different statutory requirements, is the lower flashpoint of NG. Furthermore, low energy sparks have a higher risk of ignition for NG releases.

### 0.2 Formation of LNG

Unrefined NG is a naturally occurring hydrocarbon gas mixture of methane and smaller fractions of other heavier hydrocarbons, (such as: ethane; propane; and butane), as well as various contaminants (such as: moisture (water); mercury; carbon dioxide; nitrogen; and hydrogen sulphide). LNG is NG that has been treated (to remove the contaminants, as well as excess heavy hydrocarbons) and then converted to its liquid state to make its storage and transportation more efficient.

As LNG is stored in its liquid state, the equipment used for transporting and storage of LNG is usually double-jacketed pressure vessels that are specially designed to be vacuum insulated.

Conversion of LNG to NG is typically undertaken by an ambient vaporiser, where the LNG is evaporated or vaporised from its liquid state to a gaseous state. The NG then passes through a pressure control manifold (PCM) which controls the pressure and flow to supply the downstream users via pipeline.



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# 1 Scope

This TR sets out the design and operational requirements and recommendations for the inland handling, storage and land transportation of LNG.

This TR covers portable liquid cylinders (PLC), stationary storage facilities (e.g. microbulk tanks/bulk storage tanks) and the various means for transporting LNG applicable to bulk delivery and packaged gas delivery.

The maximum capacity of an individual stationary storage tank under this TR is 100,000 litres water capacity. Refer to 4.2.1.

This TR specifies the minimum requirements for the design, construction and operation of an onshore LNG storage tank farm and does not cover the following:

- LNG liquefaction plant design and installation;
- off-shore LNG installations (e.g. floating installations);
- facilities such as a PLC trans-fill terminal (with exception of the storage tank), or temporary LNG/NG facilities being used for activities such as equipment commissioning;
- underground LNG storage tanks;
- design and specification for LNG vehicle fuel tanks and fuel stations.

The operators/service providers conduct a risk assessment on the overall project design to ensure any potential risks are being addressed and mitigated.

Key hazardous scenarios in a risk assessment for the storage, land transportation and handling of LNG would be expected to include, but not limited to, the following:

- Tank over pressure;
- Tank over filling;
- Cold embrittlement of carbon steel equipment and/or structures;
- Loss of containment (leak) of LNG during unloading or loading operations;
- Formation and dispersion of cold vapour clouds of LNG via poor vent stack design or discharge of NG gas in the tank farm;
- Pipeline over pressure due to regulator failure;
- Rapid phase transition.

# 2 Normative references

The following referenced documents are indispensable for the application of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| AIGA 08/17 | In-cab camera and how does it help to improve road safety |
| AIGA 038/06 | Vertical cylinder handling and transportation |
| AIGA 039/16 | Road transport and product delivery emergency preparedness |
| AIGA 092/15 | Prevention of tow-away incidents |
| AIGA SB 10/17 | Prevention of accidents due to overheated of burning tyres |
| AIGA SB 11/18 | Human behaviour within transport operations |
| ASME | Boiler and Pressure Vessel Code Section VIII Division 1 |
| ASTM A240 | Standard specification for chromium and chromium-nickel stainless steel plate, sheet, and strip for pressure vessels and for general applications |



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| | |
|---|---|
| BS EN 13458-2 | Cryogenic vessels. Static vacuum insulated vessels. Design, fabrication, inspection and testing |
| CGA 341 | Specification for insulated cargo tank for nonflammable cryogenic liquids |
| EIGA TS 03/13 | Training: Induction and refresher training of drivers, management and other transport function personnel |
| IEC 60079 series | Explosive atmosphere standard |
| IMDG | International Maritime Dangerous Goods Code |
| ISO 10497 | Testing of valves – Fire type-testing requirements |
| ISO 1496 series | Series 1 freight containers – Specification and testing |
| ISO 16924 | Natural gas fuelling stations – LNG stations for fuelling vehicles |
| ISO 21013-3 | Cryogenic vessels – Pressure-relief accessories for cryogenic service – Part 3: Sizing and capacity determination |
| ISO 21029-1 | Cryogenic vessels – Transportable vacuum insulated vessels of not more than 1 000 litres volume – Part 1: Design, fabrication, inspection and tests |
| IP 15 | Area classification code for installations handling flammable liquids |
| SS 555 series | Protection against lightning standard |
| SS 586 series | Specification for hazard communication for hazardous chemicals and dangerous goods standard |
| SS 608 | Code of practice for gas installation |



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