Mobile Fuelling at CNG ‘Daughter’ Stations:
Rules & Regulations on Safety & Distances

Israel Ministry of Energy & Water Resources
December 2015
Overview of Mother-Daughter CNG Station Report

- Background
- Findings
- Conclusions & Options
- Country-Specific CNG Stations & CNG station safety distances: Europe, N. America & others, at a glance
  - CNG stations overview
  - Standards/regulations used
- HAZOP study
- Regulations governing ‘the truck’

Annex 1: Suppliers of M-D CNG transport trucks
Annex 2: Supporting Standards & Documents (List)
BACKGROUND
Why M-D?

• M-D concept first developed in Italy, the first country to use NGVs starting in the mid-1930s.

• Concept is based upon helping to solve the ‘chicken & egg’ – fuelling & NGVs – particularly where there were/are no pipeline connections available.

• Also used as a strategy to deliver gas on a temporary basis to vehicles, commercial sector or small industrial gas consumers.
A variety of mobile fuel systems are available for CNG & LNG that allow the market to grow beyond the pipeline.

- **Proof of Concept Systems**
- **Packaged CNG Systems**
- **Emergency Breakdown Systems**
- **Packaged LNG Systems**

**Raufoss: Power Gen & mobile fuelling**

**Varieties of Chinese-built mobile fuellers**

**Pinnacle (U.S.)**

**Chart (US)**

**Korean All-in-one modular unit**

**IMW (U.S.A) mobile fuel dispenser**

**Tokyo Gas compressor truck**

**Gazprom L-CNG fuel truck**

**Xperion CNG truck**

**Dynetek portable fueller**
Focus of this survey:
Mobile gas delivery from a ‘central’ Mother station
(Virtual Pipeline)

Mother station

Virtual pipeline

Daughter station

A wide range of M-D transport systems are available worldwide

- Heavy duty truck-mounted gas transport and storage systems have been developed in compliance with ADR regulations or other stringent national standards/codes.
- Other transport systems are not ADR certified with manufacturing designs and practices applicable in national markets where implementation and enforcement of standards/regulations differs widely.
- (Refer to Annex I for manufacturer-specific products.)
Modern CNG transport systems are made with Type 4 cylinders on trailers in EU with ADR certification (pre-2015 running on diesel).

(Transport Gas, not Steel!)

LNG Trailers, double shell, ADR Cert.

There are a wide range of ‘technologies’ delivering CNG to daughter stations and as mobile fuellers.

- **CNG Tube Trailer - China**
- **M-D Emergency fuelling - Armenia**
- **M-D Supplier - India**

The downside of M-D delivery systems without auxiliary compressors (or hydraulic pumps)

- The pressure delivered from a storage system continues to drop until equilibrium is achieved with the recipient vessel. This can occur when only 40-50% of the gas is released from the delivery system.*
- Multiple vehicles will not fill to 200bar
- As such, daughter trucks must return to the mother station only half empty!
- On board compressors (i.e. portable compressor station) or hydraulic pump systems can maximize gas withdrawal.

*’Cascade systems’ normally associated with ground-storage using three ‘banks’ of cylinders (partially) mitigates this problem and could be designed into a daughter truck.
International regional use of M-D stations

- **Europe:** Italy historically has been the largest user of M-D stations and has national safety regulations for CNG stations and M-D systems. In most European countries M-D is not prevalent due to well-established pipeline network but is used on a limited basis for off-grid and remote stations but generally M-D is not covered by national standards or regulations.

- **North America:** Uses CNG M-D stations for various applications to service gas distribution to buildings, businesses and only some vehicle stations. Mobile *fuelling* systems (including compressors and dispensers) are more likely for fleets using CNG on a small-scale or test basis. NFPS-52 addresses M-D but not extensively.

- **South America:** Popular in various countries that lack a widespread natural gas pipe network. Argentina has national standards governing M-D.

- **Asia:** Not in the scope of this project but M-D is used extensively in China; also in India, Pakistan and some Indo-China countries.
International standards for CNG fuel stations have been a ‘work in progress’ for the past two decades

• The CEN CNG Fuelling Station draft standard prEN 13638 was begun in 1996 (CEN TC326).
• In September 2006 the standard was rejected for adoption by the European Union due to opposition to a relatively small number of technical and editorial issues. CEN work items were terminated in 2009.
• ISO took over work in 2009 (ISO/TC 252) and prEN 13638 became the basis for the ISO standard16923.
• WG1: CNG standard; WG 2: LNG & L-CNG standard. The CNG standard is anticipated to come into force in 2016.
International standards for CNG fuel stations have been a ‘work in progress’ for the past two decades (cont’d)

• In the absence of other alternative standards, prEN 13638 became the basis for CNG station standards in many European countries.

• Some countries ‘borrowed’ all or portions of the Italian standards (i.e. Russia, followed by several CIS countries)

• In North America, NFPA-52 is the leading standard for natural gas vehicles and fuelling systems for both CNG and LNG, including CNG for Vehicular Refueling Appliances (home fuelling)
FINDINGS
Results of M-D & CNG Station Standards and Regulations Survey

• International & regional standards
  - CEN prEN 13638 (no provisions for mobile fuelling)
  - ISO (DIS) 16923.2 (have provisions for mobile fuelling)
  - NFPA-52

• Information from 21 countries: Europe; N. America; S. America

• Copies of standards/regulations gathered from 11 countries (not all in English)

• Only one recent and relevant HAZOP study found for mobile fuelling (xperion)
Summary Findings

- The majority of European countries have been using the European Committee for Standardisation (CEN) draft fuelling station standard prEN 13638, which does not include provisions for M-D stations.
- The prEN likely will be replaced by the ISO fuelling station standard 16923.2 (or whatever number is assigned) when it comes into force (anticipated) 2016. This standard has provisions for M-D systems.
Summary of Findings

• Of the 21 countries surveyed, 9 do not use M-D strategies. The countries surveyed that use M-D most extensively (or have in the past) are those without an expansive natural gas pipeline network.

• Italy has the most rigorous and extensive standard for fuelling stations and M-D in Europe; one that exceeds requirements of either ISO or NFPA (including concrete holding ‘bunkers’ for M-D fuel trucks).

• UK has a very general standard or M-D.
Summary of Findings:
In Europe and the U.S. M-D systems tend to be used in specific cases

- Remotely located, off-grid CNG stations that are part of a larger national CNG station network
- Trucking biomethane from production or gas-cleaning facilities not connected to the grid
- Temporary fuelling or CNG delivered to trial fleets
- Portable fuelling systems with compressors and dispensers also are used to maximize gas withdrawal and provide flexibility as a completely independent mobile fuelling system
Summary of Findings

• Standards and regulatory experts engaged with CNG safety (those with 2-3 decades experience in the field) cannot authoritatively point to any quantitative studies or risk analysis that were the basis for the distances prescribed (ISO, NFPA, or CEN).

• The ‘rationale’ for creating distances typically are based on:
  - Engineering judgements, knowledge of explosive and dispersion behavior of natural gas under different conditions, field experience, and best practices; or….
  - Borrowed from existing international standards (including NFPA) based on the fact that the provisions have involved scrutiny and debate from international experts, frequently taking years to develop! (i.e. don’t re-invent the wheel)
CONCLUSIONS & OPTIONS
Conclusions & Options

• Countries developing new NGV programs should *never* adopt standards and regulations from other countries because:
  - one set of country-specific provisions may not fit another country’s needs;
  - any shortcomings or mis-judgements in one country’s standards should not be transposed to another country’s standards or regulations.
Conclusions & Options

• It *always* is recommended that new NGV countries look to the highest level of international standards and/or regulations and use these proven, well-vetted provisions for guidance in developing national standards and regulations (ISO; CEN; NFPA; UNECE);

• Provisions from the leading standards or regulations can be modified to suit national concerns, preferences, best practices, ideologies, etc., *if necessary or desired*;

• This also promotes global harmonization, which can improve safety and reduce costs to equipment suppliers and customers.
Conclusions & Options for Israel Consideration

- ISO (to be concluded in 2016) would be the best ‘model’ to follow (based on prEN – 10 year development– and now 10 years in the making for ISO).
- Sweden (and to a lesser extent ISO) has segmented distances with some consideration to the fuel volume on-site, which might be a consideration for Israel.
- Italian (or Argentinean) requirements for containment walls around fuel tankers, while excessive and expensive, might be something considered to mitigate perceived risks of Israeli regulators. (Other Italian limits & distances considered too ‘Draconian’ by many experts should be avoided!!)
Regulatory Survey

Country-Specific CNG & M-D Stations & CNG station safety distances
7.2 Supply by Mobile Storage

- 1m required around mobile trailer from any security fence or enclosure
- Other separation distances are the same as stationary CNG cascades or buffer storage systems
- CNG external safety distances are not required to exceed those for other liquid fuels
- Provisions also provided for underground CNG fuel stations (not mobile systems)
**ISO (DIS) 16923.2**
**Internal Separation Distances**

<table>
<thead>
<tr>
<th>Hazard source</th>
<th>Dispenser</th>
<th>Storage cylinders and compressor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buildings openings</td>
<td>&gt; 3 m</td>
<td>&gt; 3 m</td>
</tr>
<tr>
<td>Building walls (non-combustible)</td>
<td>≥ 0 m</td>
<td>&gt; 1 m</td>
</tr>
<tr>
<td>Facility perimeter</td>
<td>&gt; 5 m</td>
<td>&gt; 5 m (&gt; 10 m for storage &gt;10 000 l)</td>
</tr>
<tr>
<td>Residence buildings</td>
<td>&gt; 10 m</td>
<td>&gt; 10 m (&gt; 15 m for storage &gt;10 000 l)</td>
</tr>
<tr>
<td>Public roads and footpaths</td>
<td>&gt; 5 m</td>
<td>&gt; 5 m</td>
</tr>
<tr>
<td>Storage of other fuel types</td>
<td>&gt; 5 m</td>
<td>&gt; 5 m</td>
</tr>
</tbody>
</table>

For illustration of separation distances refer to Figure B.1.
8.1.2 Mobile refuelling vehicles, temporary trailers (with or without tractors), and other means of providing vehicle refueling or onsite storage shall be subject to the same requirements as a permanent refueling or storage installation, with the exception of vessel requirements. (Same provision as in section 9.19. Refuelling from Transport Vehicles for compressed H2)

8.1.3 Mobile refuelling equipment shall meet the requirements of DOT or TC*. 

*U.S. Department of Transportation or Transport Canada
8.4.2.4 Compression, storage, and dispensing equipment located outdoors shall be not less than 10 ft (3 m) from the nearest public street or sidewalk line and at least 50 ft (15 m) from the nearest rail of any railroad main track.

8.4.2.5 A clear space of at least 3 ft (1 m) shall be provided for access to all valves and fittings of multiple groups of containers.

8.4.2.6 Readily ignitable material shall not be permitted within 10 ft (3 m) of any stationary container.

8.4.2.7 The minimum separation between containers and aboveground tanks containing flammable or combustible liquids shall be 20 ft (6 m).

8.4.2.8 During outdoor fueling operations, the point of transfer shall be located at least 10 ft (3 m) from any important building, mobile home, public sidewalk, highway, street, or road and at least 3 ft (1 m) from storage containers.

Exception: The point of transfer shall be permitted to be located at a lesser distance from buildings or walls constructed of concrete or masonry materials or of other material having a fire resistance rating of at least 2 hours, but at least 10 ft (3 m) from any building openings.
**PrEN 13638: Annex C, safety distances**

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>MINIMUM REQUIREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance between CNG dispenser and other fuel dispensers, should be determined according to the respective hazardous area requirements</td>
<td></td>
</tr>
<tr>
<td><strong>STORAGE – OTHER FUELS STORAGE</strong></td>
<td>5 m</td>
</tr>
<tr>
<td></td>
<td>(distance can be reduced to the respective hazardous areas by means of appropriate design or fire walls)</td>
</tr>
<tr>
<td><strong>STORAGE – OTHER FUELS DISPENSER</strong></td>
<td>5 m</td>
</tr>
<tr>
<td></td>
<td>(distance can be reduced to the respective hazardous areas by means of appropriate design or fire walls)</td>
</tr>
<tr>
<td><strong>STORAGE – BUILDING OPENING</strong></td>
<td>3 m</td>
</tr>
<tr>
<td></td>
<td>(distance can be reduced to the respective hazardous areas by means of appropriate design or fire walls)</td>
</tr>
<tr>
<td><strong>COMPRESSOR – BUILDING OPENING</strong></td>
<td>3 m</td>
</tr>
<tr>
<td></td>
<td>(distance can be reduced to the respective hazardous areas by means of appropriate design or fire walls)</td>
</tr>
</tbody>
</table>
Comparative overview of basic safety distances (internal & external to station)

<table>
<thead>
<tr>
<th></th>
<th>Residential Buildings</th>
<th>Building Openings</th>
<th>Borders</th>
<th>Other Fuel Storages</th>
<th>Other Fuel dispensers</th>
<th>Public Roads &amp; footpaths</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CNG Storage</strong></td>
<td>ISO: 10m (15m if &gt;10,000l) NFPA: 3m ITA: 20m</td>
<td>ISO: 3m PrEN: 3m</td>
<td>ISO: 5m (10m if &gt;10,000l) NFPA: 3m ITA: 5m</td>
<td>ISO: 5m PrEN: 5m ITA: 10m</td>
<td>PrEN: 5m ITA: 10m</td>
<td>ISO: 5m NFPA: 3m (15m from railway)</td>
</tr>
<tr>
<td><strong>CNG Compressor</strong></td>
<td>ISO: 10m NFPA: 3m ITA: 20m</td>
<td>ISO: 3m PrEN: 3m</td>
<td>ISO: 5m NFPA: 3m ITA: 5m (10 if not sealed)</td>
<td>ISO: 5m ITA: 10m</td>
<td>ITA: 10m</td>
<td>ISO: 5m NFPA: 3m (15m from railway)</td>
</tr>
<tr>
<td><strong>CNG Dispenser</strong></td>
<td>ISO: 10m ITA: 20m</td>
<td>ISO: 3m</td>
<td>ISO: 5m NFPA: 3m ITA: 10m</td>
<td>ISO: 5m</td>
<td>ITA: 8m (10 from LPG)</td>
<td>ISO: 5m NFPA: 3m (15m from railway)</td>
</tr>
</tbody>
</table>

- ISO: with a wall REI120, separation distance between CNG Equipment and property line could be 0m.
- ITALY: distances from buildings must be double if are pubblic facilities. Concrete walls are required for cylinder trucks.
Overview of external safety distances: country comparison

<table>
<thead>
<tr>
<th></th>
<th>Dispenser-Buildings</th>
<th>Storage/Compressor-Buildings</th>
<th>Dispenser-Borders/Streets</th>
<th>Storage/Compressor-Borders/Streets</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUSTRIA</td>
<td>5m / 8m</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BELGIUM</td>
<td>-</td>
<td>5m*</td>
<td>-</td>
<td>3m*</td>
</tr>
<tr>
<td>CZECH R.</td>
<td>-</td>
<td>-</td>
<td>4m</td>
<td>4m / 10m</td>
</tr>
<tr>
<td>FRANCE</td>
<td>17m</td>
<td>3m</td>
<td>5m*</td>
<td>10m*</td>
</tr>
<tr>
<td>ITALY</td>
<td>20m**</td>
<td>20m**</td>
<td>20m</td>
<td>20m</td>
</tr>
<tr>
<td>SPAIN</td>
<td>10m / 20m</td>
<td>-</td>
<td>3m / 7m</td>
<td>15m</td>
</tr>
<tr>
<td>SWEDEN</td>
<td>-</td>
<td>3m / 6m / 12m</td>
<td>3m (15m for railway)</td>
<td>3m (15m for railway)</td>
</tr>
<tr>
<td>SWISS</td>
<td>3m</td>
<td>3m</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>USA</td>
<td>3m</td>
<td>3m</td>
<td>3m (15m for railway)</td>
<td>3m (15m for railway)</td>
</tr>
<tr>
<td>ARGENTINA</td>
<td>-</td>
<td>10m</td>
<td>6m</td>
<td>3m</td>
</tr>
</tbody>
</table>

*Distances could be reduced with a presence of a concrete protection wall
**Distances could be double if the buildings are public facilities
### Overview of external safety distances: The Gamut

<table>
<thead>
<tr>
<th></th>
<th>PrEN 13638</th>
<th>ISO 16923.2</th>
<th>Italy DM 28/6/2002</th>
<th>Sweden TSA 06</th>
<th>NFPA-52</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispenser Buildings opening</td>
<td>-</td>
<td>3m</td>
<td>20m</td>
<td>3m</td>
<td>-</td>
</tr>
<tr>
<td>Storage/Compressor Buildings opening</td>
<td>3m</td>
<td>3m</td>
<td>20m</td>
<td>3m &lt;1000 lt 4m &lt;4000 lt 6m &gt;4000 lt</td>
<td>-</td>
</tr>
<tr>
<td>Dispenser Residence buildings</td>
<td>3m</td>
<td>10m</td>
<td>20m</td>
<td>3m</td>
<td>3m</td>
</tr>
<tr>
<td>Storage/Compressor Residence buildings</td>
<td>-</td>
<td>10m (15m for storage&gt;10.0000lt)</td>
<td>20m</td>
<td>3m &lt;1000 lt 4m &lt;4000 lt 6m &gt;4000 lt</td>
<td>3m</td>
</tr>
<tr>
<td>Dispenser Facility perimeter</td>
<td>-</td>
<td>5m</td>
<td>20m</td>
<td>-</td>
<td>3m</td>
</tr>
<tr>
<td>Storage/Compressor Facility perimeter</td>
<td>-</td>
<td>5m (10m for storage&gt;10.0000lt)</td>
<td>20m</td>
<td>-</td>
<td>3m</td>
</tr>
<tr>
<td>Dispenser Public roads</td>
<td>-</td>
<td>5m</td>
<td>20m</td>
<td>3m (15m for railway)</td>
<td>3m (15m for railway)</td>
</tr>
<tr>
<td>Storage/Compressor Public roads</td>
<td>-</td>
<td>5m</td>
<td>20m</td>
<td>3m (15m for railway)</td>
<td>3m (15m for railway)</td>
</tr>
</tbody>
</table>
COUNTRY SPECIFICS:
M-D experiences & standards
ARMENIA
345 CNG fuelling station

2.233 Km of Natural gas pipeline
CNG use as motor fuel described in Decision No. 1582-N

- Refueling station design, construction, connection, safe operation, and supervision are performed on the basis of Soviet regulations and technical specifications
AUSTRIA
Though majority of CNG stations are distributed along gas pipeline, some M-D stations are used.

4.736 km of National grid

177 CNG Stations (01/2015)

Source: Erdgasauto, September 2013

Source: CNG Europe
Example of daughter station in the Alps

Refuelling station in the Austrian Alps

idro meccanica s.r.l.
Austria is using national standards to regulate CNG usage. M-D is not regulated.

- OWGV G96: CNG small filling stations, setting up and operating (1/7/97)
- OWGV G97: CNG fueling systems. Design, manufacture, construction and operation of CNG fueling systems for NGVs (1/9/14)
Safety distances following OWGV G97

<table>
<thead>
<tr>
<th></th>
<th>Buildings made with combustible materials</th>
<th>Buildings made without combustible material</th>
<th>Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispenser</td>
<td>8m</td>
<td>5m</td>
<td>8m</td>
</tr>
</tbody>
</table>
BELARUS
A majority of the CNG stations are connected to the grid along principal pipelines.

5.386 km of gas pipeline

42 CNG Stations

Source: The GVR
27 ‘mother’ stations
18 ‘daughter’ stations
15 methane tank trucks

Source: Gazprom, June 2015
CNG accumulator: 100 cylinders clustered in four group, refilled by methane tanker

Source: Gazprom, June 2015
Belarus is using Russian standards for CNG

• GOST 27577-2000 on CNG for internal combustion engines
BELGIUM
All CNG stations, mostly in Flanders, are connected to the natural gas grid. M-D is not used. There will be one L-CNG daughter station installed in Antwerp.

3.139 km of National grid

36 CNG stations, 17 planned

Source: Fluxys
National standards adopted on the base of Flemish regulation

• Installations for the supply of compressed natural gas to motor vehicles, Sept 2013:
  – NBN D 60-001

• Gas cylinders - High pressure cylinders for the on-board storage of CNG:
  – NBN EN ISO 11439

Source: www.nbn.be
Fueling stations must be protected against vehicles collision by a crash barrier

- ATEX 95 and ATEX 137 as guidelines for fire safety in a CNG fuelling station
- ATEX 95 transposed in AR 22/06/1999
- ATEX 137 transposed in AR 26/03/2003
## Safety distances (part I)

<table>
<thead>
<tr>
<th></th>
<th>Dispenser</th>
<th>Reception point</th>
<th>Storage</th>
<th>Buildings</th>
<th>Border Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressor, Storage</td>
<td>5 m (1 m with a wall REI60 2 m high)</td>
<td>5 m (1 m with a wall REI60 2 m high)</td>
<td>5 m (1 m with a wall REI60 2 m high)</td>
<td>5 m (1 m with a wall REI60 2 m high)</td>
<td>3 m (1 m with a wall REI60 2 m high)</td>
</tr>
</tbody>
</table>

CNG Dispenser must have a distance of 10 m from dangerous objects:

- If more than 300 NGVs are fuelled, the distance shall be 15 m
- If more than 100 buses are fuelled, the distance shall be 20 m
## Safety distances (part II)

<table>
<thead>
<tr>
<th>Storage volume (m³)</th>
<th>Free distance (m)</th>
<th>Distance from elements fire resitant</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;3</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>&gt; 3, &gt;5</td>
<td>15</td>
<td>7,5</td>
</tr>
<tr>
<td>&gt;5, &lt;10</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>&gt;10</td>
<td>Risk analysis must be performed</td>
<td></td>
</tr>
</tbody>
</table>
BULGARIA
Most of the CNG stations are on the gas grid but there are some M-D stations as well as mobile compressor stations.

2.887 Km of gas pipeline

102 CNG Stations

Source: www.remixbg.com
Bulgarian M-D Stations

Source: Remixbg, daughter station in Burgass - Lukoil
Bulgarian M-D Stations

Mother station in Kameno

CNG is transported 25km to station in Burgos

Containment bunker separates truck from fuelling
Galileo Project: Virtual Pipeline

- Station in Maritza, 8,000 m³/day
- 1 Transport Trailer, 2 Regulator Plants, 14 MAT, 1 Booster, 2 Dispensers

Source: Galileo
Bulgaria is using international standards both for construction and security dustances

- Filling stations: PrEN 13638, IGEUP5 Part1 and PrEN 13945
- Gas cylinders: ISO 11439:2000
- NGV: ISO 15500:2004 and EN 13 423
- CNG as motor fuel: 15403:2000
CNG stations are incorporated into the normal gasoline station network and are connected to the gas grid

7.160 km of natural gas pipeline network

72 CNG stations (08/2015)

Source: CNG Europe
CNG fuelling via truck is not widely used in Czech Republic and there is no standard for M-D

- M-D is not widespread and used only in temporary situations when CNG is brought to a fuelling station before it is fully operational
- CNG stations installation is done as part of the classical petroleum fuelling system with all fuels available on a single fuel ‘island’ at the station.
- The standard is TPG 304 02
CNG Refuelling stations in Czech Republic regulated by national law

• TPG 304 02 in effect since 1/2/2012, supersede earlier regulation TDG 304 02 approved in 2006
• This TPG only applies to fast-fill CNG stations for motor vehicles, where the requirements for the station and the construction and maintenance thereof are subject to Act Number 183/2006 on land use planning and building regulations

Source: http://www.cng4you.cz
Minimum safety distances are regulated in TPG 304 02

<table>
<thead>
<tr>
<th></th>
<th>CNG Dispensers</th>
<th>Other Fuel Dispensers</th>
<th>Station Border Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNG Dispenser</td>
<td>-</td>
<td>6,5m</td>
<td>4m</td>
</tr>
<tr>
<td>CNG Storage &lt;10m³</td>
<td>6,5m</td>
<td>5m</td>
<td>4m</td>
</tr>
<tr>
<td>CNG Storage &gt;10m³</td>
<td>6,5m</td>
<td>5m</td>
<td>10m</td>
</tr>
</tbody>
</table>
FINLAND
Gasum has developed the CNG station network in areas covered by the existing gas pipeline network. The launch of biogas (in 6 stations) enables the expansion of the filling station network beyond the Finnish gas pipeline network.

1.689 Km of gas pipeline
26 CNG stations

In the future, liquefied natural gas (LNG) can serve as a reserve fuel needed at biogas-based filling stations.

European standards accompanied by national standard

- SFS-EN 12583: describes the specific functional requirements for the design, construction, operation, maintenance and disposal activities for safe and secure gas compressor stations
- Safety distance in accordance with PrEN 13638
Extensive national coverage of the natural gas pipeline network

15.322 Km of gas pipeline

311 CNG stations

Source: The GVR
Mother – daughter applications not allowed

• Gas filling stations must be connected to the natural gas pipeline
• A validation from GdF is required to receive the permit to build the station

Source: Guide du GNV, Ou comment rouler vert, SMED13, 2013
La réglementation des Installations Classées pour la Protection de l’Environnement (ICPE)

• CNG stations regulated by part 1413 of this regulation:
  – From 80 to 2000 m³/h or if the mass of CNG is more than 1 ton, for the installation a declaration is required
  – More than 2000 m³/h or if the mass of CNG is more than 10 ton, for the installation an autorisation is required

• The introduction of a station requires also the application of regulations for Explosive Atmospheres (ATEX)

Source: Guide du GNV, Ou comment rouler vert, SMED13, 2013
## Safety distances for ICPE 1413

<table>
<thead>
<tr>
<th>Distance between</th>
<th>Dispenser</th>
<th>Compressor</th>
<th>Storage</th>
<th>Dispenser at 5m of a firewall of 2h and 2.5 m high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opening of a public building</td>
<td>17m</td>
<td>3m</td>
<td>3m</td>
<td>12m</td>
</tr>
<tr>
<td>Opening of a station building</td>
<td>5m</td>
<td>3m</td>
<td>3m</td>
<td>-</td>
</tr>
<tr>
<td>Emergency Exit of the station buildings</td>
<td>17m</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Limit of property</td>
<td>5m</td>
<td>10m</td>
<td>3m with a fire proof cowling</td>
<td>Length of the filling hose increased by 2m</td>
</tr>
<tr>
<td>Nearest parking place</td>
<td>-</td>
<td>6m</td>
<td>6m, 2m with a fire proof cowling</td>
<td>-</td>
</tr>
<tr>
<td>Another fuel storage</td>
<td>-</td>
<td>-</td>
<td>3m</td>
<td>-</td>
</tr>
<tr>
<td>Dispenser</td>
<td>-</td>
<td>-</td>
<td>5m</td>
<td>-</td>
</tr>
</tbody>
</table>
French CNG station distances

Issues d'un immeuble habité ou occupé par des tiers, extérieur à l'établissement

Issues d'une installation extérieure à l'établissement présentant des risques d'incendie ou d'explosion

Issue principale d'un établissement recevant du public de la 5e catégorie

Station de distribution GNV

Appareil de distribution remplissage

Issues d'un établissement recevant du public de 1re, 2e, 3e ou 4e catégorie

Issues d'un immeuble habité ou occupé par des tiers sous lequel est implantée l'installation

Limites de la voie publique et des limites de l'établissement

Distances d'implantation des stations

5 m

17 m
GEORGIA
100 CNG stations in Georgia

1.596 Km of gas pipeline
CNG fuelling stations vary in quality across Georgia.

CNG Storage at a station in the Marneuli Municipality, Village of Jandara

CNG Storage at a station in the Zestaphoni Municipality, Village of Argveta

Existing standards and regulation based on Russian GOST

- The only rules found are “Rules of Safety for Automobile Compression Stations working on Natural Gas"
GERMANY
921 CNG stations supported by an extensive pipeline network – no M-D

26,985 Km of gas pipeline

Source: The GVR, Fuel station data May 2014
German standards G 651 A
vdTÜV

• The DVGW accompanied the construction of the natural gas infrastructure to the promotion of technological developments, as well as with standardization work at national and international levels.

• Maintenance and operation of an CNG fuelling station is done according to DVGW Standard G 651.

Source: https://www.dvgw.de
• For all CNG fuelling stations an individual explosion proof safety document has to be produced

• Fuel quality standard: DIN 51624
Safety distances

- Safety distances between compressor, CNG storage and dispenser: 5m
- The distance could be reduced if a protection wall is present
- Compressor could be in the same places as storage if they have the certification
ITALY
Italy has a long tradition with CNG fuelling station.
History of CNG cylinder trucks

1880

1940

1970

2010

Source: Federmetano
Italian network: gas pipelines & CNG fuelling stations

8.779 km of National grid: 22.695 km of Regional grid

1,049 CNG stations (July 2014)

Image source: ENI 2007 & 2008
The use of mobile fuel systems (M-D) has declined over time as more stations had access to a growing natural gas pipeline network

- Due to the cost of building a natural gas pipeline, connection of the CNG refuelling station to the natural gas pipeline becomes unaffordable beyond 1-2 kilometres and is eligible as a daughter station.
- Tube trucks serve daughter stations and also operate for industrial and residential markets in case of a natural gas supply emergency.
- Early 1970s: each mother station served ~3 daughter stations. Of 200 CNG stations at the time almost 150 were daughter stations.
- Early 2000s about 130 cylinder trucks of various dimensions owned by 17 different operators were in service in Italy.
- Today there are fewer than 10 daughter stations as most CNG stations are connected to the gas grid.

Italian regulations have developed over many years and have been amended consistently

- 1983: original regulations required concrete walls installed between each CNG dispenser
- 1993: requirements for concrete barriers was removed
- 28 June 2002: national decree concerning the fire safety of NGV filling stations and allowances for mobile fuelling, requiring 15cm thick concrete walls not less than 2.5 m high
- 2008: a modification of the legislation allowed the construction of multi-fuel CNG stations, a major step forward and the possibility to install self-service (during the station opening, not during the night)
Rooms with CNG equipment have 2 levels of security that dictate safety levels: if the walls are sealed (level 1) or if they are not sealed (level 2):

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Metering and pressure regulator room</th>
<th>Compressor room</th>
<th>Storage room</th>
<th>Bottle storage box</th>
<th>Automatic dispenser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security level</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Protection distance</td>
<td>2m</td>
<td>2m</td>
<td>5m</td>
<td>10m</td>
<td>1</td>
</tr>
<tr>
<td>Inside security distance</td>
<td>-</td>
<td>10m</td>
<td>-</td>
<td>10m</td>
<td>-</td>
</tr>
<tr>
<td>Outside security distance</td>
<td>10m</td>
<td>10m</td>
<td>20m</td>
<td>20m</td>
<td>20m</td>
</tr>
</tbody>
</table>

Source: Biogasmax project, Synthesis Report on Normative Regulatory Requirements
Italian view on stations: history & background

• The Italian NGV regulations have a long history and are subject to periodic revisions (e.g. to eliminate concrete walls, introduce self-service, multi-fuel dispensers, a bit shorter safety distances).

• Before 1993 the regulation required reinforced concrete walls even to separate each CNG dispenser from the others.

• The vehicle separation concrete walls have survived in the present regulation only to separate the cylinder truck from the rest of the station, be it mother or daughter.

• The cylinder truck is not under control of DM 28 June 2002.

Source: private communications w/F.Mariani (fmrly ENI)
Italian view on stations: history & background (part II)

• Many things can contribute to the rationale of the safety distances; mainly:
  – Heat radiation from fire
  – Distance possibly reached by fragments projected in case of cylinder or component rupture
  – Protection from vandalism and tampering
  – Noise emissions
  – Leak gas cloud dispersion

• The problem is how one considers them:
  – Statistically unlikely
  – Likely
  – Dangerous for people
  – Destructive

Source: private communications w/F.Mariani (fmrly ENI)
Today concrete enclosures (‘boxes’) are required to house CNG tube trailers at both M&D stations

- Same regulation both for safety level 1 and safety level 2.
- The boxes must be have two walls of reinforced concrete: with a minimum thickness of 15 cm; at least one meter higher than the top of the cylinders on the truck; the length of the walls must exceed the cylinders at both ends by at least 1 meter. For the sides adjacent to other parts of the plant, the walls shall have a thickness of at least 20 cm and be free of openings.
- The roof must be constructed of beams or by continuous slab of reinforced concrete or steel to protect against any possible material projected upward in an explosion. Continuous slab roofs must be open to allow natural ventilation. Ventilation apertures must be protected by a continuous metallic fence.

Source: DM 28 June 2002
Italian regulations can slow or stop the development of NGV fuel stations

• Stations cannot be installed everywhere because they have to keep compressors far from buildings: sometimes it’s impossible to install a station in an existing fuelling station.

• In France and Sweden the distances are similar as Italy but they can be reduced with simple measures, which are not so flexible in Italy.

• The gas company (ENI) and fuel station installers complain that safety distances in Italy are impractical and excessive.

Source: ENI; & private conversations w/former ENI NGV staff designing CNG fuel stations.
Mother-daughter stations are not used in the Netherlands. All stations are connected to the natural gas pipeline (or will use biogas directly or from the grid mixture).

8,531 Km of gas pipeline

147 CNG Stations

Source: CNGNet

Source: The GVR
Source: LNG as a Substitute for Diesel, Rolande LCNG, LNG in Ships and Trucks, 2012
Caption: Mobile LCNG fuel station, Siriusstraat, Tilburg, Netherlands
National standard in line with international standards

• CNG for vehicles published in PGS 25, based on prEN and ISO standards
• Liquefied natural gas (LNG) fuelling stations for vehicles: PGS 33-1
• Safety distance in line with PrEN 13638
NORWAY
Norway’s gas pipeline is limited to coastal areas. 2 LNG tankers and 13 CNG trailers are used to deliver gas where stations are not connected to the network.

8,044 km of gas pipeline

22 CNG stations

Source: The GVR
European norms used in Norway but not specifically transposed as a Norwegian standard

• There are no standards for CNG fuelling stations although the CEN standard PrEN 13638:1999 is used as the guideline but have not been transposed into Norway national standards.

• Safety distance also in line with PrEN
POLAND
The fuelling station locations tend to follow the main gas pipelines

14.198 km of gas pipeline

88 CNG stations

Source: The GVR
NGV FUELLING INFRASTRUCTURE

CNG infrastructure is targeted mostly to fleet customers

- Existing filling stations are mainly adapted to serve big fleets running on CNG, not individual customers
- Stations mainly located within gated, private property of local gas distributors or bus companies in industrial areas at the outskirts of the cities
- Only two stations are along motorways
- Lack of possibility to pay for gas with credit cards; limited hours of operation; not enough distributors; long and bureaucratic procedures

Source: GasHighWay
National regulations apply to all subjects related to CNG stations

- KT 277 covers gas supply systems and compressor stations (transmission lines)
- Functional requirements based on PN-EN 12583:2005
RUSSIA
CNG stations follow national pipeline network

163.872 km of gas pipeline

253 CNG Stations

Source: The GVR
No specific regulations or norms governing daughter stations

- Daughter station strategy not in use
- All stations connected with the grid
GOST regulates CNG filling stations

- Sanitary distances between station and residential building are up to one kilometer: It has (and will) be changed because such a rule excludes CNG business from city limits.
- Fire safety distances are a maximum 35 meters.
CNG stations are connected to the grid but there are some L-CNG stations (liquefied-to-compressed gas)

10.481 km of gas pipeline
86 CNG stations

Source: The GVR
ISO Standards are the models used in the Spanish NGV market. PrEN 13638 for stations

- Cylinders: UNE-EN 11439:2001
- Filling stations: UNE 60631-1 and PrEN13638
## Safety distances based on PrEN

<table>
<thead>
<tr>
<th></th>
<th>CNG Compressor</th>
<th>CNG Storage</th>
<th>CNG Dispenser</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Station office / store</strong></td>
<td>3 m</td>
<td>&lt;4m³: 3m, &lt;10m³: 4m, &gt;10m³: 10m</td>
<td>-</td>
</tr>
<tr>
<td><strong>Station border lines</strong></td>
<td>3 m</td>
<td>-</td>
<td>3 m if closed access, 7 m if free access</td>
</tr>
<tr>
<td><strong>Railway and streets</strong></td>
<td>15 m</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Other fuels storage</strong></td>
<td>5 m (2 m if underground)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>CNG Storage</strong></td>
<td>-</td>
<td>-</td>
<td>2 m</td>
</tr>
<tr>
<td><strong>Public buildings</strong></td>
<td>-</td>
<td>-</td>
<td>10 m if closed access, 20 m if free access</td>
</tr>
</tbody>
</table>
SWEDEN
Of the countries surveyed, Sweden is ‘most like’ Israel

- The natural gas pipeline is only developed in a small portion of the western part of Sweden;
- There is a high priority on renewable energy;
- There is a strong ‘safety culture’ related to governance & society

Relative size: Israel & Sweden
Many CNG stations are not linked to the very limited national gas network. Biogas is a high priority and M-D is used to bring gas to stations from biogas cleaning facilities. Approximately half the gas delivered is via Mother-Daughter trailers.

1.626 km of gas pipeline

213 CNG stations

Map Source: The GVR; Information: NGVA Europe
TSA 06 regulates NGV and filling stations with little differences from PrEN

- Compressors: requirements contained in the Machinery Directive SS-EN 1012-1 and the ATEX directive, and they must bear the CE mark in accordance with both directives
- Gas storage: inside a building must be separated from other parts of the building by walls that fulfil, at a minimum, fire resistance classification REI 60
- Dispenser: The filler hose must be equipped with a break-away valve. The break-away valve must stop the flow of gas at a tensile stress of less than 500 N for dispensers at public filling stations and 850 N for facilities that use the larger nozzle for buses and other heavy vehicles
- Filling station: Pressure in excess of 230 bar must undergo a special review by the Swedish Rescue Services Agency for each filling station

Source: Biogasmax project, Synthesis Report on Normative Regulatory Requirements
Risk area must to be in accordance with SS-EN-60079-10, taking into consideration the volume of gas in relation to safety distances.

### Distances between parts of the system:

<table>
<thead>
<tr>
<th>Geometric volume of gas store, $V$</th>
<th>Compressor, Storage, combustible materials or other fire hazardous activity or building</th>
<th>Activities with high fire load density</th>
<th>Large vehicles parked for filing or simply parked</th>
<th>Private cars parked for filing or simply parked</th>
</tr>
</thead>
<tbody>
<tr>
<td>$4000 &lt; V$</td>
<td>12 (1)</td>
<td>25 (1)</td>
<td>8 (1)</td>
<td>6 (1)</td>
</tr>
<tr>
<td>$1000 &lt; V &lt; 4000$</td>
<td>6 (1)</td>
<td>12 (1)</td>
<td>8 (1)</td>
<td>6 (1)</td>
</tr>
<tr>
<td>$60 &lt; V &lt; 1000$</td>
<td>3 (2)</td>
<td>12 (2)</td>
<td>8 (2)</td>
<td>6 (2)</td>
</tr>
<tr>
<td>Filling point for gas trailers</td>
<td>3 (3)</td>
<td>12 (1)</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### Geometric volume of gas store, $V$ including mobile gas stores

<table>
<thead>
<tr>
<th>Geometric volume of gas store, $V$ including mobile gas stores</th>
<th>Compressor, Storage, combustible materials or other fire hazardous activity or building</th>
<th>Activities with high fire load density</th>
<th>Large vehicles parked for filing or simply parked</th>
</tr>
</thead>
<tbody>
<tr>
<td>$4000 &lt; V$</td>
<td>12 (1)</td>
<td>25 (1)</td>
<td>8 (1)</td>
</tr>
<tr>
<td>$1000 &lt; V &lt; 4000$</td>
<td>6 (1)</td>
<td>12 (1)</td>
<td>8 (1)</td>
</tr>
<tr>
<td>$60 &lt; V &lt; 1000$</td>
<td>3 (2)</td>
<td>12 (2)</td>
<td>8 (2)</td>
</tr>
</tbody>
</table>

1. With fire separation of the lowest fire resistance classification, EI 60, the distance can be reduced by half.
2. With fire separation of the lowest fire resistance classification, EI 60, no minimum distance is required.
3. Does not apply between two mobile gas stores.

NOTE: GAS VOLUMES ARE IN LITERS
Bus daughter refuelling station in Sweden

idro meccanica s.r.l.
SWITZERLAND
CNG stations are connected to the gas grid and do not use M-D

1.800 km of gas pipeline, mostly in the northern part of the country

167 CNG stations

Source: The GVR
Switzerland generally follows European standard (prEN 13638) to develop national regulations

- Regulation G1: Installation of Gas Appliances Subjected to Pressures up to 5 bar.
- Regulation G8: Guidelines for the Construction, Maintenance and Operation of Small Filling Stations for Compressed Natural gas (CNG).
- No standards or regulations related to M-D.

Source: Swiss Gas & Water Industries Association
Refuelling Station Requirements

• Buildings with openings must be at the minimum at 3m of the station
• Refuelling station’s open venting area must measure at least 30% of the building’s floor surface
• “Swiss requirements appear to be significantly less demanding than those of France and Sweden”

Source: Biogasmax Synthesis report

Some Swiss CNG stations have compressors above the fuel court.
Safety distances required: no automatic payment system can be nearby

<table>
<thead>
<tr>
<th>Device</th>
<th>Explosive Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressor, Gas Storage</td>
<td>1 Meter (outside station)</td>
</tr>
<tr>
<td>Dispenser</td>
<td>1 Meter</td>
</tr>
<tr>
<td>Fuel Connector and Nozzle</td>
<td>1 Meter</td>
</tr>
<tr>
<td>Exhaust Valve</td>
<td>3 Meters on the sides and above; 1 meter below</td>
</tr>
</tbody>
</table>
UNITED KINGDOM
Most of the NGVs are heavy duty fleet trucks: LNG and dual-fuel. Biogas is transported to some stations via truck.

28.603 Km of gas pipeline
22 CNG stations

Source: gasvehiclehub
New national regulation on CNG stations published in 2014

- CNG stations (also fuelling stations supplied from mobile CNG storage units) covered by IGEM/UP/20, Dec 2014

- Before this regulation, a standard on fuelling station was missing in the UK: there were many standards related to CNG but nothing about stations
SECTION 10: MOBILE STORAGE SUPPLY

10.1 The capacity of the mobile storage supply unit shall be sufficient to satisfy the stations storage and delivery requirements. The design of the connection system shall permit safe and secure connection and disconnection.

10.2 The compressor or storage facility on the station shall be compatible with supply from a mobile storage unit with regards to pressure and quality.

10.3 The mobile storage unit connection point shall be separated from any public or private vehicle fuelling facility and shall be used for mobile storage unloading only.

10.4 The docking area should accommodate at least two mobile storage trailers to enable efficient change-over of supply.

10.5 Docked storage trailers must be secured to prevent movement and suitably earthed during the unloading operation.

10.6 The docking area shall be secure to prevent interference.

Text is from IGEM UP/5, draft of UP/20.
Mother station criteria language

FILLING MOBILE STORAGE UNITS

Where a facility is provided to fill mobile storage units, the following shall apply:

- a suitably designed self-sealing filling connection system shall be provided and a break away device shall be installed
- a suitable system for grounding the trailer during filling shall be used
- filling shall only be undertaken by suitably trained operatives
- a suitable control system shall prevent overfilling of the mobile storage
- the filling operation shall be attended or left in a safe and secure manner to prevent interference.

Text is from IGEM UP/5, draft of UP/20.
Separation distances at CNG stations from IGEM/UP/20 (see diagram, below)

<table>
<thead>
<tr>
<th>Hazard source</th>
<th>Dispenser incl. vehicle filling point</th>
<th>Storage cylinders including gas delivery trailers</th>
<th>Compressor</th>
<th>Vents normal use &amp; relief valves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separation distances</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>Buildings</td>
<td>&gt;4m</td>
<td>&gt;4m</td>
<td>&gt;4m</td>
<td>&gt;4m</td>
</tr>
<tr>
<td>Canopies &amp; over structures</td>
<td>not above</td>
<td>not above</td>
<td>not above</td>
<td>not above</td>
</tr>
<tr>
<td>Public access ways</td>
<td>NA</td>
<td>&gt;5m</td>
<td>&gt;2m</td>
<td>&gt;5m</td>
</tr>
<tr>
<td>Facility perimeter</td>
<td>&gt;4m</td>
<td>&gt;2m</td>
<td>&gt;2m</td>
<td>&gt;5m</td>
</tr>
<tr>
<td>Roads and footpaths</td>
<td>&gt;4m</td>
<td>&gt;3m</td>
<td>&gt;3m</td>
<td>&gt;5m</td>
</tr>
<tr>
<td>Storage of other fuel types</td>
<td>&gt;4m unless certified for both</td>
<td>&gt;5m</td>
<td>&gt;5m</td>
<td>&gt;5m</td>
</tr>
<tr>
<td>Service Access</td>
<td>&gt;2m</td>
<td>&gt;2m</td>
<td>&gt;3m</td>
<td>na</td>
</tr>
<tr>
<td>Combustible materials</td>
<td>&gt;4m</td>
<td>&gt;4m</td>
<td>&gt;4m</td>
<td>&gt;4m</td>
</tr>
</tbody>
</table>

Source: Text is from IGEM UP/5, draft of UP/20.
IGEM UP/20 CNG station layout for distances

The layouts shown below are informative and may differ according to design.
Crewe virtual gas pipeline project

- Mother station in Crewe, CNG compressed to 250 bar and stored in trailers which hold 7-10 tons
- CNG delivered to customers not connected to the grid

Source: CNG Services Ltd
Brit European Transport Ltd. Drive a project to reduce CO2 emissions

- To develop a portable CNG fuelling facility, the concept being a “Daughter Station” supplied from the “Mother Station” by road via gas tube trailers (but with a compressor)

Source: Low Carbon Truck Demonstration Trail, Brit European, Environmental Efficiency project
Ukraine has the third largest NGV population in Europe (170,000) and fourth largest fuel infrastructure (325 stations) connected to the grid.

36,720 Km of gas pipeline

325 CNG stations

The market is mostly for used and converted NGVs with 60% buses and 35% trucks.

Sources: The GVR and "Legal and Regulatory Environment for the Construction and Operation of CNG Filling Stations in European Countries"; European Business Congress, 2012,
NGV FUELLING INFRASTRUCTURE

Ukrainian Fuelling Station
older style with concrete walls based on Italian standards
Majority of the standards are GOST (or borrowed Italian station standards)

- Mostly it is the Russian standards for safety distances
- Standards are becoming a bit more advanced today than in the past. The old standards required a CNG station to be 60 meters from another building; now it is 30 meters to a private house and 25 meters to a commercial or industrial facility
- Standards for daughter stations would be based largely on those for Mother station

Source: private conversation with CNG Stakeholder and fuel station installer.
UNITED STATES
A vast majority of US CNG stations are connected to the extensive pipeline grid

1,984,321 Km of gas pipeline  
876 CNG stations

Source: Alternative Fuels Data Center
M-D stations are being used specifically in areas where temporary re-fueling is needed.

Source: Change Energy Service, Off-Pipeline Natural Gas Network project
Off-Pipeline Natural Gas Network - 2013

• Daughter stations:
  – Decanting equipment: Multiple decant lanes (3-4) with continual pressure and temperature control
  – Drive-through and back-in configurations to accommodate individual customer requirements

• Mother Station:
  – Compressor: 9,200 scfm total
    (4 compressors @ 2,300 scfm each)
  – Dryer: 11,500 scfm
  – Fuelling lanes: 4 lanes w/ dual hose fill posts

Source: Change Energy Service
NFPA-52 is the principle NGV standard and includes CNG stations

- NFPA-52 2015 revision in process
- Other documents:
  - Section 2308.3.1 of International Fire Code: Compressed Natural Gas Motor Fuel Dispensing Facilities
  - "Recommended Permitting Guide for Refuelling Stations for Vehicle Fueled by Compressed Natural Gas", prepared by the Conference of Northeast Regional Fire Officials, Fall 2000
NFPA-52 Mobile refuelling (version 2010)

- 8.1.2 Mobile refueling vehicles, temporary trailers (with or without tractors): same requirements as a permanent refueling or storage installation, with the exception of vessel requirements
- 8.4. Outdoors:

<table>
<thead>
<tr>
<th></th>
<th>Station border lines</th>
<th>Public buildings</th>
<th>streets</th>
<th>containers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressor, storage, dispenser</td>
<td>3 m</td>
<td>3 m</td>
<td>3 m street 15 m railway</td>
<td>-</td>
</tr>
<tr>
<td>Fueling operations</td>
<td>3 m</td>
<td>3 m</td>
<td>3 m</td>
<td>1 m</td>
</tr>
<tr>
<td>Tanks with combustible liquids</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>6 m</td>
</tr>
</tbody>
</table>

- The point of transfer shall be permitted to be located at a lesser distance from buildings having a fire resistance REI120
- A clear space of at least 1 m shall be provided for access to all valves and fittings of multiple group of containers
In addition to the requirements of Section 2303.1, compression, storage and dispensing equipment not located in vaults complying with Chapter 53 shall be installed as follows:

- Not beneath power lines.
- 3 m or more from the nearest building or lot line that could be built on, public street, sidewalk or source of ignition (Exception: Dispensing equipment need not be separated from canopies that are constructed in accordance with the International Building Code and that provide weather protection for the dispensing equipment)
- 7.5 m or more from the nearest rail of any railroad track and 15 m or more from the nearest rail
- 15 m or more from the vertical plane below the nearest overhead wire of a trolley bus line.
Great number of stations not connected to the grid, making M-D systems very popular

29,930 Km of gas pipeline  
1,939 CNG stations

Source: The GVR
Regulations for CNG Stations: NAG 418 (ex GE-N1-118)

• Mother/daughter stations shall comply with the requirements set forth in NAG 418 and in the provisional standards GE- N°1-142 and GE-N°1-143

• For daughter station required a reinforced concrete wall on both sides, parallel to the semi-trailer with the same characteristic indicated for storage
Compressors and storage surrounded by a wall at least 50 cm higher than the highest component subject to high pressure, with a minimum height of 3m

<table>
<thead>
<tr>
<th></th>
<th>Site party walls</th>
<th>Station border lines</th>
<th>Buildings with &gt;150+ people</th>
<th>Dispenser</th>
<th>Other fuel storage</th>
<th>Streets</th>
<th>Open flames</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage &lt;10.000 lt</td>
<td>5 m</td>
<td>3 m</td>
<td>10 m</td>
<td>5 m</td>
<td>5 m</td>
<td>-</td>
<td>3 m</td>
</tr>
<tr>
<td>Storage &gt;10.000 lt</td>
<td>10 m</td>
<td>3 m</td>
<td>15 m</td>
<td>5 m</td>
<td>5 m</td>
<td>-</td>
<td>3 m</td>
</tr>
<tr>
<td>Dispenser</td>
<td>5 m</td>
<td>4 m</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>6 m</td>
<td>-</td>
</tr>
</tbody>
</table>

In daughter stations the filling and discharge site will be at least 6 meters wide, with a metal gate.
Galileo Project: Virtual Pipeline

• South Cordoba, Transgas
  – 8 CNG stations, 25,000 m³/day
  – 2 Microbox, 2 Transport Trailer, 60 MAT, 8 Boosters, 8 Regulating Plant

• Buenos Aires, Camuzzi
  – 6 Transport Trailer with fix modules, 12 Extra MAT modules as fix storage

• Salta, Minera del Altiplano
  – 62,000 m³/day
  – 2 microbox, 14 Transport Trailer with fix modules, 1 Regulation Plant

Source: Galileo
Sample of Galileo mother-daughter and transport modules in Argentina

Mother Station – General Levalle, Argentina

TRANSPORT SYSTEM

CNG DAUGHTER STATION – JOVITA, ARGENTINA

DAUGHTER STATION – SERRANO, ARGENTINA

Source: Galileo
HAZOP STUDIES
HAZOP

• Very few Hazardous Operations (HAZOP) studies have been performed on CNG stations or on mobile fuelling and M-D stations.
Different types of accidents on CNG transport trailers have different safety concerns

Xperion HAZOP Study

Car crash

Truck crash

Tipping over

Fire
HAZOP Study X-STORE
Gas transport trailer modules
„Hazard and Operability Study“

19/08/2009
ADR REGULATIONS FOR CNG TRUCKS
Regulations governing ‘the M-D truck’ as an ADR (dangerous goods) carrier

International
• UNECE, Working Party 15, ADR

Europe
• ADR, DIRECTIVE 98/91/EC, transport of dangerous goods by road
• TPED, DIRECTIVE 99/36/EC, transportable pressure equipment
Working Party 15 (ADR) regulates the carriage of dangerous goods by truck

- ADR is applicable for UNECE Contracting Parties
- ADR sets out the requirements for the classification, packaging, labeling and certification of dangerous goods.
- It also includes specific vehicle and tank requirements and other operational requirements.
- All drivers of vehicles carrying dangerous goods (including those with a gross vehicle weight of 3.5 tons or less) must have an ADR training certificate.
Many mobile fuel storage systems are not in compliance with ADR regulations, which are very specific.
ADR regulations amended to allow LNG, CNG & LPG to fuel ADR-certified trucks 2014 & 2015

- November 2014 NGV Global succeeded in amending ADR to allow LNG as fuel for ADR trucks
- November 2015 NGV Global/AEGPL succeeded in amending ADR to allow CNG and LPG as a fuel for ADR trucks
- New ADR regulation in force January 2017
- Countries allowed to adopt rules in advance individually or through multi-lateral agreement
ANNEX 1

SAMPLE OF SUPPLIERS OF CNG FUEL TRANSPORT VEHICLES
Mother Daughter (Portable Storage Cascades)

- Luxfer (including Dynetek)
- Hexagon/Lincoln (Raufoss)
- Pinnacle
- IMW
- Galileo
- xperion
- Many others
Mother Daughter

- ‘Mother Daughter’ concept began in Italy to deliver CNG to fuelling stations not near gas distribution network
- Large tank trailers refuel at ‘Mother’ CNG station; transported to site to hook up with on-ground dispenser to enable vehicle fueling
- When pressure equalized (~40% remaining capacity) truck returns to mother station for fuelling
- Much less complex than mobile fuelling system
- Industry ‘debating’ (competitive marketing) of cylinder systems Type 1 (all steel) to Type 4 (full composite) on basis of weight and fuel capacity (and fuel extraction capability)
Mother Daughter Systems

CNG Road Train (Australia) : Dynetek
Capacity 25,245 scm

Many different mobile fuel systems are available worldwide

Raufoss tube trailer (Type 4 cylinders)

Mobile fueling unit, India (manufacturer unknown?)
Dynetek Bulk Storage System

- Supplies CNG to fuelling stations as mother-daughter
- Transports natural gas from remote or abandoned natural gas reserves
- Provides temporary supply of natural gas to pipelines undergoing scheduled or unscheduled maintenance
- Services customers not connected to existing gas distribution systems
- Offers emergency distribution service

<table>
<thead>
<tr>
<th>Each Gas Transport Module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal Volume (W.C. litres):</td>
</tr>
<tr>
<td>Volume of CNG (SCF/kg):</td>
</tr>
<tr>
<td>Service Pressure (bar/psi):</td>
</tr>
<tr>
<td>Dimensions (meters):</td>
</tr>
<tr>
<td>Cylinders:</td>
</tr>
</tbody>
</table>
Dynetek Mobile Systems

**Portable Refueller:**
- **Internal Volume (W.C. litres):** 4,160
- **Volume of CNG (SCF/kg):** 41,133/791
- **Service Pressure (bar/psi):** 223/3240
- **Cylinders:** 16

**Bulk Transport Systems are available in two configurations:**

<table>
<thead>
<tr>
<th></th>
<th>BT-30</th>
<th>BT-60</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Internal Volume (W.C. litres):</strong></td>
<td>30,420</td>
<td>60,840</td>
</tr>
<tr>
<td><strong>Volume of CNG (SCF/kg):</strong></td>
<td>300,000/5,780</td>
<td>800,000/11,560</td>
</tr>
<tr>
<td><strong>Gas Transport Modules:</strong></td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td><strong>Service Pressure (bar/psi):</strong></td>
<td>223/3240</td>
<td>223/3240</td>
</tr>
<tr>
<td><strong>Full System Weight (kg)*:</strong></td>
<td>25,000</td>
<td>50,000</td>
</tr>
</tbody>
</table>

*Weight of trailer may vary*
- 20 ft frame with ISO dimensions
- Low weight Type-4 CNG cylinders
- Geometric volume up to circa 19,000 ltr.; up to circa 5,500 Nm³ capacity
- Operating pressure 25 Mpa (250 bar); temperatures -40°C to +65°C
- Commodity: CNG or Compressed Bio-Methane (UN 1971)
- 40 ft frame with ISO dimensions
- Low weight Type-4 CNG cylinders
- Operating pressure 25 Mpa (250 bar); temperatures -40°C to +65°C
- Commodity: CNG or Compressed Bio-Methane (UN 1971)
Luxfer Mobile CNG Storage

20-foot roll-on containers
- Available capacity up to 19,250 liters.
- Features lightweight G-Stor Pro Type 3 cylinders.
- Fast-filling capability.
- Compliant with TPED, ADR and MEGC.
Galileo

Source: US distribution by Mobile Fueling Systems (MFS) New Jersey, (Also see ‘Argentina’ section of this report)
Czech Republic: Vitkovice
ANNEX 2
STANDARDS & DOCUMENTS PROVIDED
Supporting standards & documents provided separately as part of this project

- Argentina reg NAG(e) 406 (mobile fuel carriers-satellite stations)
- Argentina-Nag 418 (standard for filling stations) (English)
- Biogasmax normative regulations 21 07 2009 (compares side-by-side certain fuelling provisions in: prEN, CH, SWE, F, It)
- CNG Fueling Station in the heart of city Pronin 2013 05 13 (provides pictures of European fuel station proximity to exterior buildings, used by NGVRUS to advocate for reducing Russian/GOST distances)
- Czech Rep-TPG 304-02 (CNG stations & distances) (Czech only)
- Fuelling Stations prEN13638(E)7-12-2006 rev
- German G 651 CNG Fuel Stations Standards 2009 (full text-German)
- Guide to Permitting CNG Fuelling Stations USA (Fall 2000)
- International Fire Code CNG Stations 2308.3.1 (2012)
Supporting standards & documents provided separately as part of this project

- Italy DECRETO 28 giugno 2002 (decreto definitivo), national decree concerning the fire safety of NGV filling stations and allowances for mobile fuelling (Italian only)
- Italy Tube trailers norms .22.03.04
- Netherlands-PGS 25 CNG Fuel Stations (Nov 2012) (Dutch only)
- NFPA 52 Revised to Include HAZOP for CNG Stations (2013) (announcement only)
- NFPA 52 2010 Vehicular Gaseous Fuel Systems
- Poland-kt 277 (CNG Stations & other gas systems) (2012) (Polish only)
- Swedish Code for NGV and BGV Filling Stations, (Description-English) 1 June 2006
- Swedish Handbook for handling exp fuels at stations 2008 (Swedish only)
- Switzerland G9d 2010 Richtlinie für Erdgastankstellen (German only)
Mobile Fuelling at CNG ‘Daughter’ Stations: 
*Rules & Regulations on Safety & Distances*

Israel Ministry of Energy & Water Resources

December 2015