Requirements for bunkering LNG
- Status and Outlook -

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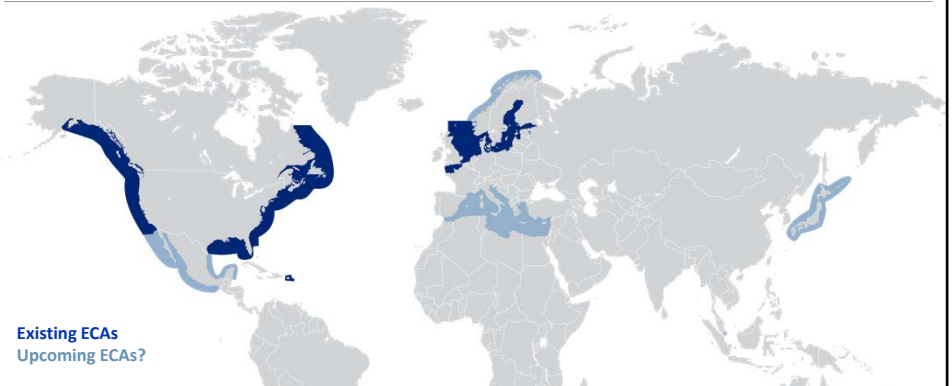
Global sulphur cap of 0.5% in 2020 will drive LNG fuel market globally



Global requirements	ECA sulphur requirements	NOx requirements
2020 / 2025*: Sulphur < 0.50% * Date TBD pending 2018 review – but 2020 will apply in EU waters	2010: Sulphur < 1.0% 2015: Sulphur < 0.1%	2011: NOx Tier II, -20% 2016: NOx Tier III, -80%* *New builds, only m ECA

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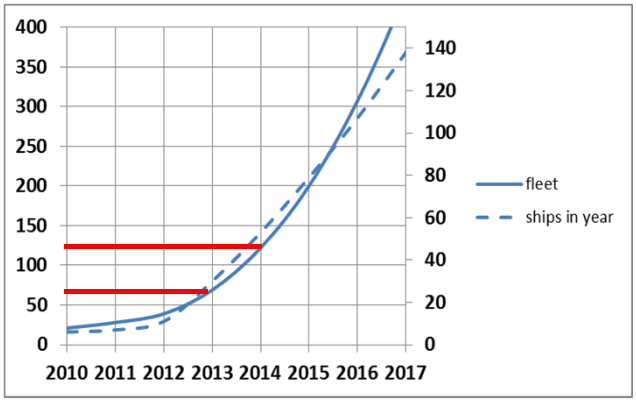
How many LNG fuelled ships and when? (1000 ship on LNG in 2020)

year	ships in year	fleet
2010	6	21
2011	7	28
2012	11	39
2013	30	69
2014	53	122
2015	79	200
2016	107	307
2017	138	445
2018	171	617
2019	207	823
2020	244	1068
2021	284	1351
2022	325	1676

- December 2012
  - Fleet 34 vessels
- On order Dec 2012
  - 2013: 22
  - 2014: 9
  - 2015: 3



- How many ships in which segment and in which regions in 2013/2014?
- 74% of all vessels are classed with DNV (in operation and confirmed orders)

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Needed LNG supply for shipping

				170000,00
year	vessels	t/a	m**/h	tanker/a
2011	30	92418	219000	1,29
2012	39	126151	298935	1,76
2013	69	233818	554070	3,26
2014	122	432208	1024190	6,02
2015	200	739344	1752000	10,31
2016	307	1182180	2801375	16,48
2017	445	1782127	4223050	24,84
2018	617	2565986	6080535	35,77
2019	823	3549467	8411060	49,48
2020	1068	4770617	11304780	66,50

Terminal Nynäshamn (Sweden)
Source: Linde Group

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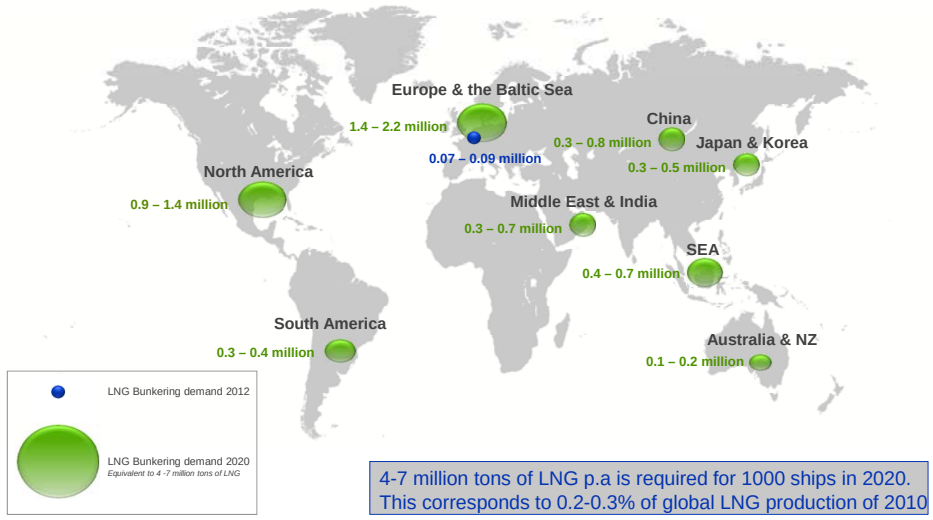
Global LNG bunker demand by 2020



4-7 million tons of LNG p.a is required for 1000 ships in 2020.
This corresponds to 0.2-0.3% of global LNG production of 2010

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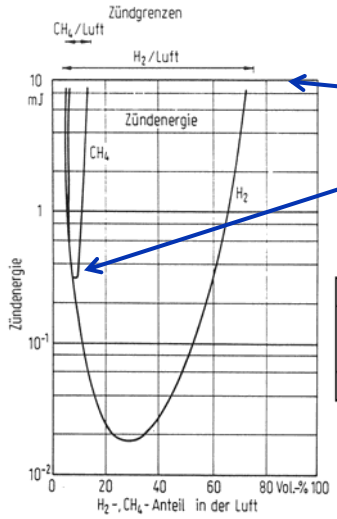
Gasoil and LNG - the similarity -



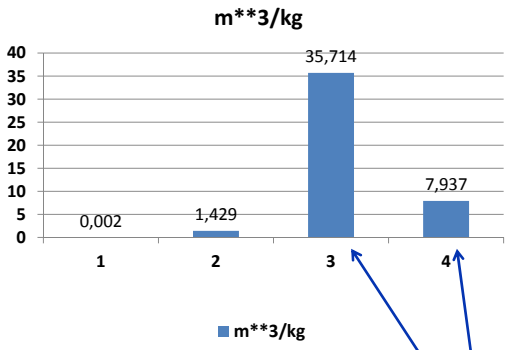
- Minimum ignition energy:
  - Static discharge of a human body: approx. 10 mJ
  - Gasoline: 0.24 mJ; CH4: 0.29 mJ;
  - H2: 0.02 mJ;

	Hydrogen	Methane	Propane	Gasoline
Flammability limits (vol. % in air)				
Lower limit (LFL)	4	5.3	2.1	1
Upper limit (UFL)	75	15	9.5	7.8
Minimum ignition energy (mJ)	0.02	0.29	0.26	0.24

Ignitable mixtures of all fuels are
Ignited by all technical ignition sources

Bunkering LNG – the difference -

m**3/kg	
0,002	liquid
1,429	gas at 0°C
35,714	gas at lel
7,937	gas at uel



HFO:
0.001 m**3/kg

- Short duration of cloud existence
- Cloud stays at the ground in most cases

Approx.
Tu - 30 °C
Tu – 10 °C

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Supply of LNG by truck/bunker vessel

Source: Eidesvik, Linde Group

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LNG fueled vessels can be built
- Legislative situation -

- Building LNG fuelled vessels today
  - IMO MSC.285(86) and class rules
  - Class rules: (DNV PART 6 CHAPTER 13 - Gas Fuelled Ship Installations (include IMO MSC.285(86)) DNV rules since the year 2000
  - DNV standard on required competences of crew (under development)
- Building LNG fuelled vessels using the IGF-Code
  - IGF-Code will be mandatory international law (after adopted by IMO)
  - IGF-Code not only for LNG but for low flashpoint fuels in general
    - Draft from BLG-17 (Feb 2013) exists
    - Adoption by Subcommittee is aimed for in 2014
    - Draft of SOLAS amendments exist
    - Adoption by MSC possible in 2014/2015 or 2015/2016
  - Class rules: (DNV PART 6 CHAPTER 13)

IGF-Code in an advanced stage

BLG 17-WP.5 - Add.1 - Report of the working group (Part_2).pdf

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Bunkering LNG
-Legislative situation -

- EMSA: European Union wide guidelines and standards on bunkering
  - EMAS Gap analysis: 16 identified gaps (published beginning of March)
- Bunkering LNG fuelled vessels
  - IGF-Code
    - 8.5 Requirements for bunkering system
    - 6.5 [Portable tanks for liquefied gas fuel]
- ISO Technical Standard on LNG bunkering requirements
  - Work headed by DNV
  - First draft available for public in 2 QA 2013

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Portable Tank requirements
- Current version of IGF-Code (BLG 17/WP.5/Add.1Annex) -

- 6.5 [Portable tanks for liquefied gas fuel]
- 6.5.1 The design of the tank shall comply with the requirements of 6.4.15.3 (Type C Independent Tanks). The tank support (container frame or truck chassis) shall be designed for the intended purpose.
- 6.5.2 Portable gas fuel tanks shall be located in dedicated areas fitted with:
  - mechanical protection of the tanks depending on location and cargo operations
  - if located on open deck: spill protection and water spray systems for cooling
  - if located in an enclosed space: the space is to be considered as a tank connection space
- 6.5.3 Portable gas fuel tanks shall be secured to the deck while connected to the ship systems. The arrangement for supporting and fixing the tanks shall be designed for the maximum expected static and dynamic inclinations, as well as the maximum expected values of acceleration, taking into account the ship characteristics and the position of the tanks.

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Portable Tank requirements
- Current version of IGF-Code (BLG 17/WP.5/Add.1Annex) -

- 6.5.4 Consideration shall be given to the strength and the effect of the portable fuel tanks on the ship's stability.
- 6.5.5 Connections to the ship piping systems shall be made by means of approved flexible hoses or other suitable means designed to provide sufficient flexibility.
- 6.5.6 Arrangements shall be provided to limit the quantity of fuel spilled in case of inadvertent disconnection or rupture of the non-permanent connections.
- 6.5.7 The pressure relief system of portable tanks for liquefied gas shall be connected to a fixed venting system
- 6.5.8 Control and monitoring systems for portable gas fuel tanks shall be integrated in the ship's gas control and monitoring system. Safety system for portable gas fuel tanks shall be integrated in the ship's gas safety system (e.g. shut-down systems for tank valves, leak/gas detection systems).

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Portable Tank requirements
- Current version of IGF-Code (BLG 17/WP.5/Add.1Annex) -

- 6.5.9 Safe access to tank connections for the purpose of inspection and maintenance shall be ensured.
- 6.5.10 After connection to the ship's fuel piping system,
  - with the exception of the pressure relief system in 6.5.6 each portable tank shall be capable of being isolated at any time; and
  - isolation of one tank shall not impair the availability of the remaining portable tanks; and
  - the tank shall not exceed its filling limits as given in 6.8.
- 8.5.1 For tanks not permanently installed in the vessel the connection of all necessary tank systems (piping, controls, safety system, relief system etc.) to the gas system of the vessel is part of the "bunkering" process and shall be finished prior to ship departure from the bunkering station. Connection of portable tanks during the sea voyage or maneuvering is not permitted.

Portable tanks → It is more than connecting Type 2.1 Standard ISO Containers to the ship system

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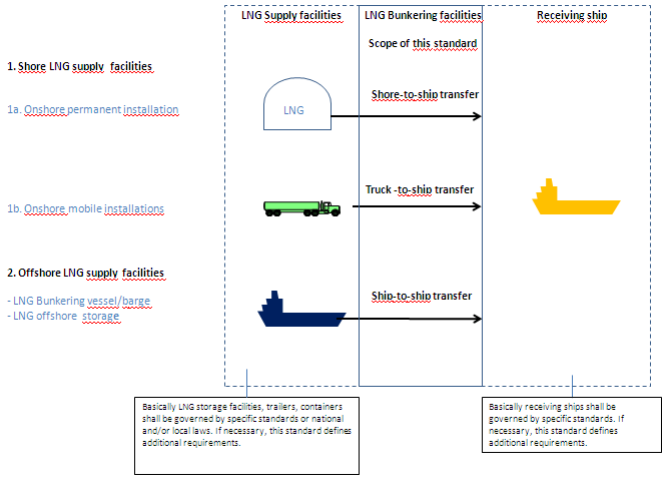
General principles and bunkering scenarios



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LNG supply

- Supply from trucks
  - Limited volumes (generally 100 m**3 per truck)
  - Expensive (road transport of limited volumes)
- Supply by bunker vessel
  - Most cost efficient
  - Most feasible solution for fuel supply of larger volumes (200, 600, 1000, some 1000 m**3)
- Supply by terminal
  - Operating costs not feasible for commercial ships
  - Costs of terminals to high
- Supply by container
  - Limited volume (30 to 40 m**3 per Container)
  - High costs (Containers on board and in transfer (2 containers for 30 to 40 m**3 LNG), transport costs)

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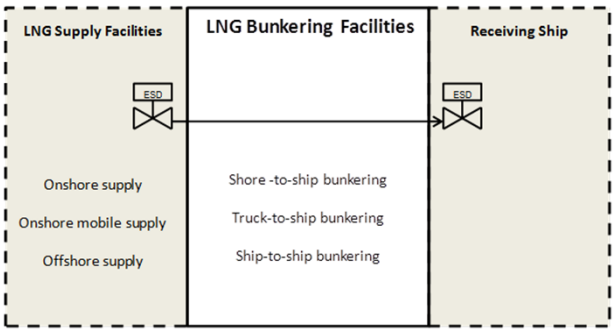
ESD protection of Interfaces between bunkering facility and supply/receiving facilities



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ISO Guideline
- Document philosophy -

- The guideline will be a high level document outlining main principles and functional requirements.
- The document will define the procedures to design, to install, to operate and to maintain the bunkering loading facility with regard to safety aspects and environmental conditions
- The document shall promote standardisation of the interface between the LNG supplier and the ship both with regard to operations and hardware as an effective safety measure
- The document will give guidance for the use of risk assessment as part of the design and planning process.

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ISO Technical Standard on LNG bunkering

- 6.3 The safety targets for the design, procurement, construction and for the operation for the bunkering scenarios defined in Clause 4 shall be demonstrated by meeting the requirements as defined in Clauses 8, 9, 10, 11 qualified by a risk assessment as outlined in Clause 7.
- The risk assessment shall be carried out in agreement with recognized standards, such as ISO 31010, ISO 17776 and ISO/DTS 16901.
- The main steps in the risk assessment shall be to:
  - a) identify what can go wrong? (hazard identification)
  - b) assess the effect? (consequence and impact assessment)
  - c) assess the likelihood? (frequency assessment)
  - d) decide if the risk tolerable, or identify risk reducing measures.

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Bunkering – main items -

- Exclude spills in normal operation
- Minimum spill in case of incidents
  - Exclude hose failure even if bunker vessel and bunkered vessel are drifting apart → dry break couplings
  - Exclude gas release from connections and possibility of human error → easy to handle dry couplings (avoid flange connections)
  - Use adequate ESD systems
- Minimize valve closing time in case of ESD
- Exclude gas venting from the receiving and supplying vessel
- Exclude the possibility of large long duration spills
  - Only case left should be: A severe collision of a third party vessel with the moored bunker barge resulting in large scale LNG spill.

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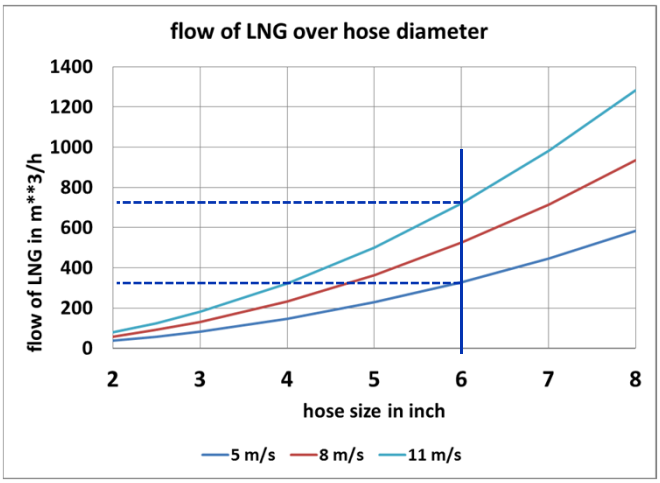
Bunkering LNG – flow -

		8 m/s
m**3 in 20 m hose	inch	m**3/s
0,041	2	0,02
0,063	2,5	0,03
0,091	3	0,04
0,162	4	0,06
0,253	5	0,10
0,365	6	0,15
0,497	7	0,20
0,649	8	0,26



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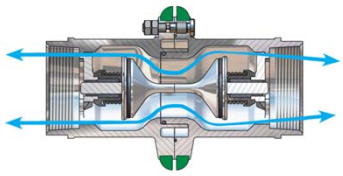
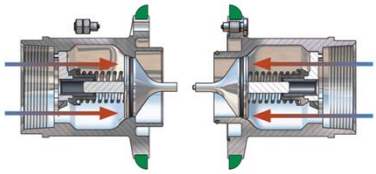
Excluding hose ruptures by movements - Dry break coupling -





- Installed as part of the hose
- Coupling breaks before hose break
- No liquid flow

Source: Mann Teknik AB

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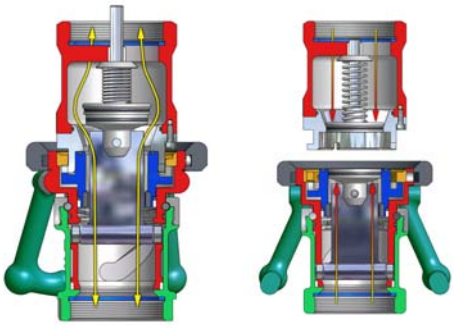
Dry quick release/disconnect couplings



- Flow path opened as part of connection process
- No acess of air into the system
- Prevent spillage.
- Keep hazardous liquids and vapors in-line
- Connect and disconnect under pressure and flow
- Remove human error elements
- Currently available up to 8 inch

Source: Mann Teknik AB

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Flow rates during LNG bunkering

- Bunker capacities today
  - 30 to 100 m**3
  - 200 to 300 m**3
- Future
  - 400 to 1000 m**3
  - 1000 to 2000 m**3
  - Above 2000 m**3 → up to 10000 to 20000 m**3

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Sailing LNG fuelled vessels, examples

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Larger ships and new ship types for gas as ship fuel

Sea Cargo Express; Nov 2012

New ferry of Buquebus

LNG Tanks on Deck

Viking Grace: 2*200 m**3
Bit Viking: 2*500 m**3

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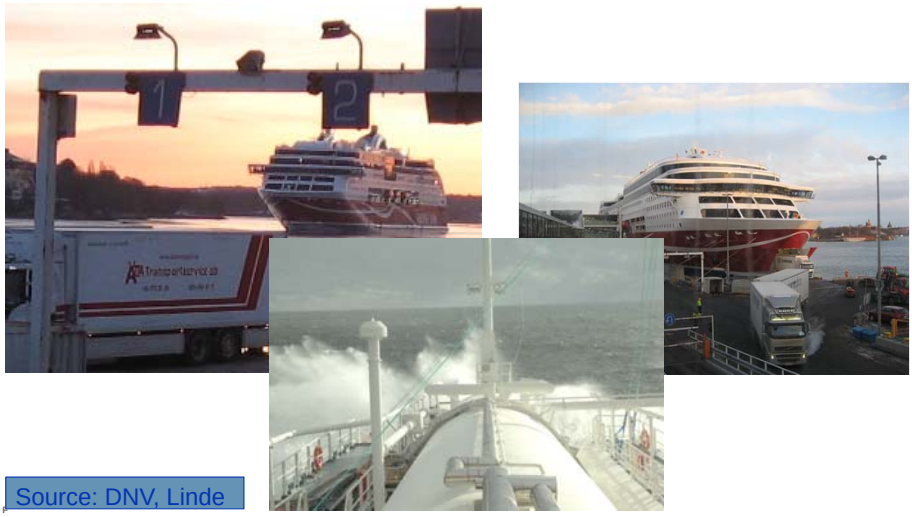
Viking Grace in Stockholm



Source: DNV, Linde

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Bunkering LNG today

http://www.youtube.com/watch?v=oZWuTWtp5Rs

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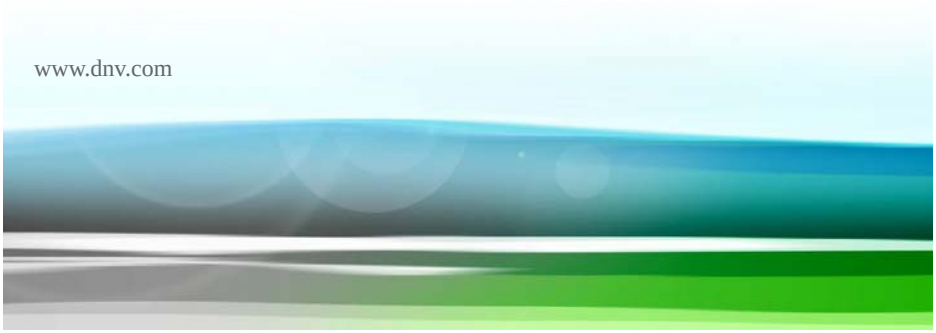

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