REGASIFICATION VESSELS

MAY 2011

The content of this service document is the subject of intellectual property rights reserved by Det Norske Veritas AS (DNV). The user accepts that it is prohibited by anyone else but DNV and/or its licensees to offer and/or perform classification, certification and/or verification services, including the issuance of certificates and/or declarations of conformity, wholly or partly, on the basis of and/or pursuant to this document whether free of charge or chargeable, without DNV's prior written consent. DNV is not responsible for the consequences arising from any use of this document by others.
FOREWORD

DET NORSKE VERITAS (DNV) is an autonomous and independent foundation with the objectives of safeguarding life, property and the environment, at sea and onshore. DNV undertakes classification, certification, and other verification and consultancy services relating to quality of ships, offshore units and installations, and onshore industries worldwide, and carries out research in relation to these functions.

Classification Notes

Classification Notes are publications that give practical information on classification of ships and other objects. Examples of design solutions, calculation methods, specifications of test procedures, as well as acceptable repair methods for some components are given as interpretations of the more general rule requirements.

All publications may be downloaded from the Society’s Web site http://www.dnv.com/.

The Society reserves the exclusive right to interpret, decide equivalence or make exemptions to this Classification Note.

Background

As an alternative to onshore production of gas where liquid natural gas delivered from a LNG Carrier is vaporized to produce natural gas for consumption this process can take place onboard a purpose built vessel located offshore. In areas where it is proven difficult to obtain permission to build new onshore terminals due to environmental or safety restrictions such a concept enabling offshore gas production can be an option.

In order to vaporize the liquid gas onboard a vessel Regasification plants must be installed and means for unloading the vaporized gas need to be provided. Unloading could be arranged via a submerged turret buoy delivering to a subsea pipe grid or through dedicated gas export manifolds connected to a receiving installation placed on an external platform, jetty or similar.

Classification Note 61.3 is applicable for all vessels engaged in regasification operation. This includes both permanently moored LNG carriers doing more or less continuous regasification of LNG received from shuttle tankers and LNG carriers involved in both trading and periodically regasification operation. The class notation REGAS will be given upon demonstrated compliance with recommendation outlined in this Note. It is intended to introduce requirements for regasification vessel in DNV’s Rules for Classification of Ships after gaining further experiences with such installations.

Main changes

The main changes are:

— Requirements for fire detection in the regasification plant area have been included.
— Requirements for water spray/deluge system have been extended so that water monitors are no longer required.
— Requirements for emergency de-pressurization/blow-down of the regasification system have been clarified.
— Requirements for Process Shut Down have been defined.
— Interactions between the vessel’s emergency shut down system (ESD) required by the IGC Code and the emergency de-pressurization/blow down system and Process Shut Down System for the regasification plant have been clarified.
— Requirements for heating systems for regasification vaporisers have been detailed.
— Requirements for escape from the regasification area have been included.
— Requirements/guidance for necessary monitoring and control systems have been expanded and clarified.
— Requirements associated with ship-to-ship transfer of LNG in the case of permanently moored regasification vessels have been addressed.
— Requirements for testing and commissioning have been included.

The electronic pdf version of this document found through http://www.dnv.com is the officially binding version

© Det Norske Veritas

Any comments may be sent by e-mail to rules@dnv.com
For subscription orders or information about subscription terms, please use distribution@dnv.com
Computer Typesetting (Adobe Frame Maker) by Det Norske Veritas

If any person suffers loss or damage which is proved to have been caused by any negligent act or omission of Det Norske Veritas, then Det Norske Veritas shall pay compensation to such person for his proved direct loss or damage. However, the compensation shall not exceed an amount equal to ten times the fee charged for the service in question, provided that the maximum compensation shall never exceed USD 2 million.

In this provision “Det Norske Veritas” shall mean the Foundation Det Norske Veritas as well as all its subsidiaries, directors, officers, employees, agents and any other acting on behalf of Det Norske Veritas.
CONTENTS

1. General ......................................................................................................................... 4
   1.1 Introduction ............................................................................................................... 4
   1.2 Scope ....................................................................................................................... 4
   1.3 Definitions ............................................................................................................... 4

2. Application .................................................................................................................. 4
   2.1 Requirements ......................................................................................................... 4
   2.2 Class Notations ..................................................................................................... 4
   2.3 Documentation ...................................................................................................... 5

3. Piping design .............................................................................................................. 5

   4.1 Materials ............................................................................................................... 6
   4.2 Piping design and manufacture ............................................................................ 6
   4.3 Certification of components ................................................................................. 6
   4.4 Strength and tightness testing .............................................................................. 7

5. General Safety .......................................................................................................... 7
   5.1 Risk assessment .................................................................................................... 7
   5.2 Classification and extent of Hazardous area ....................................................... 7
   5.3 Cryogenic Releases ............................................................................................. 8
   5.4 Fire Safety ........................................................................................................... 8
   5.5 Physical protection of regasification units ........................................................... 8
   5.6 Gas detection ....................................................................................................... 9
   5.7 Heating system for LNG vaporisers ................................................................... 9
   5.8 Escape .................................................................................................................. 9

6. Process Safety ........................................................................................................... 9
   6.1 General .................................................................................................................. 9
   6.2 Process Shut-Down System (PSD) ..................................................................... 9
   6.3 ESD ....................................................................................................................... 10
   6.5 Pressure relief ..................................................................................................... 10
   6.6 Vent system ......................................................................................................... 10
   6.7 Monitoring systems ............................................................................................ 10

7. Functional requirements ........................................................................................... 11
   7.1 Start-up procedure ............................................................................................... 11
   7.2 Operational ......................................................................................................... 11
   7.3 Survey requirements for the in-service phase ..................................................... 12

8. Implications on Ship Design .................................................................................... 12
   8.1 Environmental conditions .................................................................................... 12
   8.2 Sloshing ................................................................................................................ 12
   8.3 Structural support of regasification equipment on deck ....................................... 12
   8.4 Gas detection in air inlets to the accommodation .............................................. 12
   8.5 Ship to ship transfer ........................................................................................... 12

9. Arrangement for submerged turret offloading ......................................................... 12

10. Testing and Commissioning ................................................................................... 13
    10.1 Alarms and safety functions ............................................................................. 13
    10.2 Fire alarms, fire extinction systems and water spray systems ....................... 13
    10.3 Equipment and automatic control systems ..................................................... 13

11. Examples of heating arrangements for LNG vaporisers ........................................ 13
    11.1 Closed loop with steam heating ..................................................................... 13
    11.2 Combined open/closed loop with seawater and steam heating ..................... 14
    11.3 Open loop with seawater heating and intermediate propane loop ................ 14
    11.4 Closed loop with steam heating and intermediate water/glycol loop ............. 15
1. General

1.1 Introduction
For LNG vessels intended to deliver natural gas directly to a pipeline gas grid, a regasification unit will be fitted onboard. After regasification the natural gas will be delivered through for instance a submerged turret buoy or through dedicated export manifolds. The regasification system should comply with requirements from applicable parts of the DNV’s Rules for Classification of Ships related to gas services.

The gas carrier design may be affected by continuous and even limited regasification operation and processing and export of high pressure gas. This might also affect areas and issues outside of the area of which the regasification system is located. Any such effects will need to be identified and associated hazards addressed.

For compliance with the regas notations, the approach outlined in this Classification Note should be followed. Regasification systems will be treated as novel technology with respect to the approval procedure. A risk based approach including HAZID/HAZOP techniques should be carried out, preferably involving DNV at an early phase of the design.

For demonstrated compliance with the procedures and recommendations given in Sec.1 through Sec.8, the notation REGAS can be granted. The notation gives basic requirements for regasification vessels

Submerged turret offloading arrangements shall be in compliance with DNV’s Rules for Classification of Ships Pt.5 Ch.3 Sec.14. Additional requirements to the turret compartment are given in Sec.9.

1.2 Scope
This Class Note explains requirements for classification of regasification systems and offloading systems for natural gas through a submerged turret buoy offshore or through dedicated gas unloading manifolds.

Since these installations may differ in arrangements and equipment, the requirements outlined may be subject to adjustments to suit the particular installations.

1.3 Definitions

<table>
<thead>
<tr>
<th>Regasification Plant</th>
<th>Regasification pumps, piping, suction drum and regas units from storage tank to export manifold/turret</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regasification Unit</td>
<td>Booster pump and vaporiser</td>
</tr>
<tr>
<td>Submerged turret offloading arrangement</td>
<td>Mooring- and offloading arrangement through ship’s bottom</td>
</tr>
<tr>
<td>STL</td>
<td>Submerged Turret Loading</td>
</tr>
<tr>
<td>ESD</td>
<td>Emergency shut-down</td>
</tr>
<tr>
<td>PSD</td>
<td>Process shut-down</td>
</tr>
</tbody>
</table>

2. Application

2.1 Requirements
The requirements in this section apply to vessels having regasification equipment used for gas export, and are additional to the requirements in DNV’s Rules for Classification of Ships Pt.5 Ch.5.

Vessels having submerged turret offloading arrangement shall comply with the requirements specified for class notation STL in the DNV’s Rules for Classification of Ships Pt.5 Ch.3 Sec.14. Additional expectations to such arrangements on gas carriers are given in Sec.9.

2.2 Class Notations
Ships built according to these guidelines may be assigned the class notations:

— REGAS
— STL (when the approach in Sec.9 is complied with, in addition to the requirements given in DNV’s Rules for Classification of Ships Pt.5 Ch.3 Sec.14).

For vessels where the propulsion machinery is not operational or installed while connected to a loading buoy or similar at an offshore location, the position keeping system shall comply with the requirements applicable for the DNV class notation POSMOOR, (DNV-OS-E301).

If the propulsion system is maintained in operational condition also while located at an offshore location, the position keeping system need not be considered as a part of the classification scope.

Loads on the vessel imposed by the mooring arrangement shall always be accounted for in the design of the vessel.
Guidance note:
Where it is desired to include the loading buoy or the position mooring system within the scope of classification these can be covered by the following Class Notations:

— OFFSHORE LOADING BUOY (in compliance with DNV OS E403)
— POSMOOR (ref. above).

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

2.3 Documentation
The following documentation should be submitted for approval:

<table>
<thead>
<tr>
<th>Table 2-1 Documentation requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Object</strong></td>
</tr>
<tr>
<td>Regasification system</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Regasification piping</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Electrical</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Structural</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Monitoring</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

3. Piping design
The regasification piping system shall as a minimum meet the requirements given in DNV’s Rules for Classification of Ships Pt.4 Ch.6 and Pt.5 Ch.5 Sec.6, or to a standard acceptable to DNV with the following additional requirements:

— A complete stress analysis for each branch of the high pressure piping system downstream the booster pumps should be submitted. This analysis must take into account all stresses due to weight of pipes with cargo, (including acceleration if significant), internal pressure and loads induced by movements of the ship.
— Stress analysis for piping with temperature below -110ºC taking into account thermal contraction should also be performed and submitted for information.
— The above calculations should be carried out according to a recognized code or practice (i.e. ASME B31.3).
— The effect of vibrations imposed on the piping system in the regasification plant should be evaluated when vibrations excited by thrusters or other relevant excitation sources may be expected. Suitable countermeasures shall be implemented.
— Expansion bellows should not be used in the high pressure piping system.

4. Materials, Manufacture, Inspection and Testing

4.1 Materials
Materials for the liquefied gas piping and cargo vapour piping shall be suitable for low temperature service. In general material should be selected for a temperature of −165°C.

Requirements for materials, documentation and testing, related to gas service see DNV’s Rules for Classification of Ships Pt.5 Ch.5 Sec.2 D (Table D4) and E (Table E1). For steam service see DNV’s Rules for Classification of Ships Pt.4 Ch.6 Sec.2 Table A2.

4.2 Piping design and manufacture
Cargo- and process piping shall be joined by butt welding. The number of flanges is to be kept to a minimum. Valves and expansion bellows should preferably be of weld-in type.

For requirements to design, welding and testing, reference is made to DNV’s Rules for Classification of Ships Pt.5 Ch.5 Sec.6 C500-C800.

4.3 Certification of components

A: For Gas Service

<table>
<thead>
<tr>
<th>Component</th>
<th>Certification</th>
<th>DNV Rules for Classification of Ships reference</th>
</tr>
</thead>
</table>
| Valves             | $D_N \geq 100\,\text{mm}, \text{DNV}^*$  
                   | $D_N < 100\,\text{mm}, \text{W}^*$       | Pt.5 Ch.5 Sec.6 H                             |
| Pressure relief valves | $D_N \geq 100\,\text{mm}, \text{DNV}^*$  
                             | $D_N < 100\,\text{mm}, \text{W}^*$       | Pt.5 Ch.5 Sec.9 C                             |
| Pressure vessels   | \text{DNV}^*                     | Pt.4 Ch.7                                    |
| Heat exchangers    | \text{DNV}^*                     | Pt.4 Ch.7                                    |
| Pumps              | \text{DNV}^*                     | Pt.5 Ch.5 Sec.6 G                            |
| Vaporizer          | \text{DNV}^*                     | Pt.4 Ch.7                                    |

B: For Steam Service

<table>
<thead>
<tr>
<th>Component</th>
<th>Certification</th>
<th>DNV Rules for Classification of Ships reference</th>
</tr>
</thead>
</table>
| Valves             | $D_N \geq 100\,\text{mm}, P > 7\,\text{bar}, \text{DNV}^*$  
                   | $D_N < 100\,\text{mm}, \text{W}^*$       | Pt.4 Ch.6 Sec.6 C                             |
| Pressure vessels   | \text{DNV}^*                     | Pt.4 Ch.7                                    |
| Heat exchangers    | \text{DNV}^*                     |                                             |
| Pumps              | \text{DNV}^*                     | Pt.4 Ch.6 Sec.6 B                            |

C: Control and Electrical system

<table>
<thead>
<tr>
<th>Component</th>
<th>Certification</th>
<th>DNV Rules for Classification of Ships reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control system</td>
<td>\text{DNV}^*</td>
<td>Pt.4 Ch.9</td>
</tr>
<tr>
<td>Electrical system</td>
<td>\text{DNV}^*</td>
<td>Pt.4 Ch.8</td>
</tr>
</tbody>
</table>

$\text{W}^* = \text{Works (makers) certificate; DNV}^* = \text{DNV certificate}$

Recognized standards providing equivalent solutions may be considered. The use of recognized standards should be discussed and agreed with DNV in each case.
### 4.4 Strength and tightness testing

Cargo- and process piping shall be hydrostatically tested to 1.5 times the design pressure prior to installation. Heat exchangers are to be tested to 1.3 times the design pressure. Testing by using gas instead of liquid may be accepted on special considerations of safety implications.

Other piping may either be hydrostatically tested prior to- or after installation onboard.

After assembly onboard the complete cargo piping shall be subjected to a leak test using air, halides or other suitable medium according to an approved procedure.

### 5. General Safety

#### 5.1 Risk assessment

A risk assessment should be conducted, preferably in the early phase of the project, and should include at least assessment of the following:

- collision
- fire- and explosion
- dropped object
- cryogenic leakage.

The findings from the risk assessments carried out are to be considered in the design phase and addressed in the documentation submitted to class. The risk assessment should comply with the principles outlined in DNV-OS-A101 App. C.

Design loads and recommendations from the risk assessment are to be addressed in the final design.

#### 5.2 Classification and extent of Hazardous area

For deciding the extent of the hazardous area of a non-standard application on a gas carrier, the following should be considered:

- Regulations under the provisions of the IEC regime, with basis in IEC 60092-502, also referred to in IGC code through IMO resolution MSC.177(79): “Adoption of Amendments to the international code on the

---

**Table 4-1 Summary of standards/codes suitable for assessment of regasification equipment**

<table>
<thead>
<tr>
<th><strong>Process Equipment</strong></th>
<th><strong>Standards/ Codes</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>TEMA</td>
<td>Tubular Exchanger Manufacturers Association</td>
</tr>
<tr>
<td>NFPA 37</td>
<td>Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines</td>
</tr>
<tr>
<td>ASME VIII</td>
<td>Boiler and Pressure vessel Code</td>
</tr>
<tr>
<td>API RP 520</td>
<td>Sizing, Selection and Installation of Pressure Relieving Devices in Refineries</td>
</tr>
<tr>
<td>API RP 521</td>
<td>Guide for Pressure Relieving and Depressurising Systems</td>
</tr>
<tr>
<td>API Std 610</td>
<td>Centrifugal Pumps for Petroleum, Heavy Duty Chemical and Gas Industry Services</td>
</tr>
<tr>
<td>API Std 6D</td>
<td>Specification for Pipeline Valves</td>
</tr>
<tr>
<td>API Std 617</td>
<td>Axial and Centrifugal Compressors and Expander Compressors for Petroleum, Chemical and Gas Industry Services</td>
</tr>
<tr>
<td>API Std 618</td>
<td>Reciprocating Compressors for Petroleum, Chemical and Gas Industry Services</td>
</tr>
<tr>
<td>API Std 619</td>
<td>Rotary Type Positive Displacement Compressors for Petroleum, Chemical and Gas Industry Services</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Process Piping</strong></th>
<th><strong>Standards/ Codes</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>ASME B31.3</td>
<td>Process Piping</td>
</tr>
<tr>
<td>API 14E</td>
<td>Design and Installation of offshore production platform piping systems</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Fuel Gas System</strong></th>
<th><strong>Standards/ Codes</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>IGC Code</td>
<td>International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Metering System</strong></th>
<th><strong>Standards/ Codes</strong></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Process Safety</strong></th>
<th><strong>Standards/ Codes</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO 10418</td>
<td>Basic Surface Process Safety Systems</td>
</tr>
<tr>
<td>API RP 14C</td>
<td>Analysis, Design, Installation and Testing of Basic Surface Safety Systems for Offshore Production Platforms</td>
</tr>
</tbody>
</table>
— The IEC standard 60092-502 covering most typical arrangements on a gas carrier. The principles of the standard are implemented in DNV’s Rules for Classification of Ships.

It is recommended that area classification is undertaken in such a way that the various steps which lead to the final area classification are properly documented.

All relevant information used should be referred to. Examples of such information or method used, would be:

a) Recommendations from relevant codes and standards.
b) Gas and vapour dispersion characteristics and calculations.
c) A study of ventilation characteristics in relation to flammable material release parameters so that the effectiveness of the ventilation can be evaluated.

It should be noted that the above approach refers to equipment and solutions/applications not considered covered directly by the prescriptive solutions found in the IGC Code or IEC 60092-502.

5.3 Cryogenic Releases

5.3.1 Protection of deck
It shall be documented that the deck is protected from cryogenic spill at the regasification unit and suction drum, alternatively that the deck is suitable for cryogenic temperatures.

5.3.2 Spray shields
For high pressure liquid lines downstream booster pumps, spray shields shall be provided for any flanged connections, to protect personnel and prevent deck and cargo tanks from being exposed to high pressure LNG.

5.4 Fire Safety

5.4.1 Water spray system
A water-spray system with an application rate of 10 l/m²/min. of the horizontally projected area of the regasification system shall be arranged to protect:
— the regasification units
— metering station
— suction drum
— export manifold
— internal surfaces of the turret compartment
— storage tanks for propane or other flammable fluids, if fitted.

The arrangements and capacities of the water spray pumps shall be such that with one spray pump system out of operation the remaining pump system shall have capacity to supply the spray system as well as the fire main if combined pumps are used.

Guidance note:
Firewater to the water spray system is to be available after any design accidental event. For example fire in one area should not result in complete loss of fire fighting capability. Fire fighting capability should also be maintained where an accidental event results in loss of main power.

5.4.2 Dry chemical powder
The regasification plant shall be covered by a dry chemical powder fire-extinguishing system complying with the requirements in DNV’s Rules for Classification of Ships Pt.5 Ch.5 Sec.11.

5.4.3 Fire detection
A suitable number of fire detectors including flame detectors, shall be fitted to cover the regasification units and export manifold.

5.5 Physical protection of regasification units
Depending on operational conditions the regasification units should be placed in a sheltered location protected from green seas.
5.6  Gas detection

5.6.1
The regasification plant is to be equipped with a sufficient number of gas detectors of the continuous monitoring type covering:
- regasification units
- ventilation inlets to accommodation and engine room
- condensate return to engine room (other systems not physically segregated from the gas system)
- export manifold
- turret compartment.

5.6.2
Audible and visual alarms from the gas detection equipment to be located on the navigating bridge, in the control position for cargo operation, and at the gas detector readout location.

5.7  Heating system for LNG vaporisers

5.7.1
Heating may be arranged as direct heating or indirect heating, i.e. an intermediate heating circuit. See chapter 11 for examples of heating arrangements.

5.7.2
Means shall be provided to detect leakage of high pressure LNG/NG into the heating fluid, to prevent overpressure in the heating system and to protect the vaporizers against freezing of heating medium.

5.8  Escape

5.8.1
Passages for safe escape from areas of the regasification unit, the export manifold and loading manifold (in case ship-to-ship transfer is intended) shall be arranged. Shielding from fire and heat radiation shall be provided for as necessary.

5.8.2
Two escape ways from normally manned areas shall be arranged.

6.  Process Safety

6.1  General
The regasification plant is to be designed so that a single accidental event shall not result in a critical situation.

Guidance note:
The safety system is to provide two levels of protection to prevent or minimise the effects of an equipment failure within the regasification plant. These means of protection are to be independent of each other and in addition to the control devices used in normal operation. Reference is made to the safety design philosophy in API RP 14C.

6.2  Process Shut-Down System (PSD)

6.2.1
A Process Shut-Down System (PSD) for the regasification system shall be arranged. Initiation of PSD shall be from the monitoring system as indicated in Table 6-1, from manual call points and from fire detectors in the regasification area.

6.2.2
Activation of the PSD shall stop the LNG booster pump for the relevant regasification unit.

6.3  ESD
In context of this Classification Note the ESD system is the emergency shut down facility for the cargo handling system required by the IGC Code.
Activation of the ESD will:
- stop cargo pumps, spray pumps and booster pumps
— close all valves on the tank dome, in the case of cargo tanks with pressure relief valves set at a pressure above 0.7 barg
— close the cargo manifold/turret valves.

The ESD system is activated by manual call points and by fusible elements / fire detectors located in way of the cargo manifold, cargo tank domes and regasification units.

6.4 Blow down system

6.4.1
A blow down system shall be provided for the regasification plant.

Guidance note:
The blow down system shall be arranged to vent all parts of the regasification system containing more than 400 kg of flammable inventory to the vent system.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

6.4.2
Activation of the blow down system shall be by:

— manual call points located in the cargo control room, in the area of the regasification units and export manifold and the navigation bridge
— automatic by the fire detectors in the regasification area based on voting.

6.5 Pressure relief

6.5.1
If a suction drum in the inlet to the high pressure booster pump is fitted, it shall be provided with a relief valve sized for relevant cases i.e. fire exposure and blocked booster pump outlet.

6.5.2
Pressure relief valves shall be fitted in sections of the piping system where liquid can be trapped. Reference is also made to DNV’s Rules for Classification of Ships Pt.5 Ch.5 Sec.6.

The relief valves should discharge into the cargo tanks or to vent mast if means are provided to detect and dispose of any liquid cargo which may flow into the vent system.

In case of relief to cargo tanks, the effect of routing high pressure LNG/NG to the cargo tank must be documented.

6.6 Vent system

6.6.1
Special consideration needs to be given with respect to release rate and the potential for liquid flow through the vent mast. Part of the regasification plant will contain high pressure LNG and part will contain high pressure gas. Relief arrangements for both phases will need to be considered.

6.6.2
In general, the fitting of a knock-out drum to be considered between the relief valves and the vent mast. The knock out drum shall be provided with high level alarm.

As an alternative, a calculation showing sufficient capacity of the vent mast to avoid any liquid release through the mast is to be carried out.

For permanently moored vessels it may be considered disposing of gas via a flare rather than a vent. In such cases the capacity should be assessed per API RP 521 and it should be ensured that radiation levels are within acceptable limits.

6.7 Monitoring systems

Monitoring systems should in general comply with the requirements of the DNV’s Rules for Classification of Ships Pt.4 Ch.9.

Furthermore, it is assumed that the regasification process is under constant surveillance and control by qualified personnel.

The table below gives an overview of a typical extent of monitoring and control of regasification systems. This should be considered guidance and the requirements to monitoring and control will be subject to special
consideration on a case by case basis.

Table 6-1  Typical required monitoring and control of regasification systems

<table>
<thead>
<tr>
<th>Item/Parameter</th>
<th>Alarm</th>
<th>Shutdown</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suction Drum pressure</td>
<td>H/L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suction Drum level</td>
<td>L</td>
<td>LL</td>
<td>PSD</td>
</tr>
<tr>
<td>Vaporizer, heating medium inlet temp</td>
<td>L</td>
<td>LL</td>
<td>PSD</td>
</tr>
<tr>
<td>Vaporizer, heating medium inlet pressure</td>
<td>L</td>
<td>LL</td>
<td>PSD</td>
</tr>
<tr>
<td>Vaporizer, heating medium outlet temp</td>
<td>L</td>
<td>LL</td>
<td>PSD</td>
</tr>
<tr>
<td>Vaporizer, LNG inlet pressure</td>
<td>H/L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vaporizer, NG outlet temperature</td>
<td>L</td>
<td>LL</td>
<td>PSD</td>
</tr>
<tr>
<td>Vaporizer, NG outlet pressure</td>
<td>H/L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat exchanger, steam supply pressure</td>
<td>H/L</td>
<td>If steam is not direct heating medium</td>
<td></td>
</tr>
<tr>
<td>Heat exchanger, steam condensate return temperature</td>
<td>H/L</td>
<td>If steam is not direct heating medium</td>
<td></td>
</tr>
<tr>
<td>Overflow/Expansion tank in glycol loop</td>
<td>H</td>
<td>HH</td>
<td>If a glycol heating circuit is arranged</td>
</tr>
<tr>
<td>Liquid collector</td>
<td>H/L</td>
<td></td>
<td>If propane heating circuit is arranged</td>
</tr>
<tr>
<td>Gas metering for export, monitor NG flow</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss of power supply to control and monitoring system</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Instrument air, pressure</td>
<td>L</td>
<td>LL</td>
<td>PSD</td>
</tr>
<tr>
<td>Natural Gas to shore, pressure</td>
<td>H/L</td>
<td>LL</td>
<td>PSD</td>
</tr>
<tr>
<td>Natural Gas to shore, temperature</td>
<td>L</td>
<td>LL</td>
<td>PSD</td>
</tr>
<tr>
<td>Green line signal in STL lost</td>
<td>X</td>
<td>PSD</td>
<td>'Green line' means all conditions for transfer are confirmed</td>
</tr>
<tr>
<td>Vapour leakage into heating system detected</td>
<td>X</td>
<td>Gas detection in case of steam or glycol heating, pressure in case of propane heating</td>
<td></td>
</tr>
<tr>
<td>Activation of ship’s ESD system</td>
<td>X</td>
<td>PSD</td>
<td></td>
</tr>
<tr>
<td>Before disconnection; ensure depressurize and purge cycle completed</td>
<td>X</td>
<td>No disconnection before depressurize/purge</td>
<td></td>
</tr>
</tbody>
</table>

Separate transmitters to be provided for control and shutdown functions.

The control and safety system must be designed to ensure that no single failure leads to a dangerous situation. If a PSD (Process shutdown) input signal is lost, the corresponding shutdown must be activated immediately. However, if instrument redundancy is provided, with two or more dedicated shut down transmitters (for the input), it is acceptable to continue with one healthy transmitter. In that case any failure state on the remaining transmitter/signal must activate a shutdown. Also note that if two transmitters are used, shutdown is to be activated if signal from one of the transmitters reaches the limit for activation.

7. Functional requirements

7.1 Start-up procedure

The system must be designed with planned operational procedures to prevent excessive temperature differential. In case a suction drum is installed, it should be verified that the procedure for filling the suction drum for temporary containment of LNG from the cargo tanks is acceptable with respect to temperature differential. A pressure relief valve (PSV) on suction drum and a pressure control system to vapour main to be provided, preventing excess vapour generation if LNG enters a warm suction drum.

It must be ensured that valves and instrumentation allow appropriate pump cool down procedure in order to avoid excess temperature differential and possible pump damage with subsequent release of LNG.

Position indication should be provided on pump suction manual valve(s), interlocked to prevent pump operation if closed.

7.2 Operational

An operations manual should be provided, including start and stop procedures, safety precautions, and emergency procedures.
7.3 Survey requirements for the in-service phase
The installations and equipment related to the regasification system is subject to survey in service according to
the requirements for cargo handling equipment for gas carriers. Reference is made to DNV’s Rules for
Classification of Ships Pt.7 Ch.1 Sec.2 C.
For permanently moored regasification vessels special tailor-made survey programmes may be agreed upon.

8. Implications on Ship Design
The gas carrier design may be affected by continuous and even limited regasification operation and processing
and export of high pressure gas. This might also affect areas and issues outside of the area of which the
regasification unit is located.

8.1 Environmental conditions
A vessel intended to operate in all sea areas should be designed, with regard to structural strength, for the
environmental loading in the North Atlantic conditions with a return period of 20 years.
For vessels located continuously at one location design should consider environmental conditions for a 100
years return period at the specific site.
For fatigue the basic requirement is 20 years design life based on a scatter diagram for world wide operation
or at designated operation site as applicable.

8.2 Sloshing
Operating a vessel as a regasification vessel will involve load cases where the cargo tanks will have
intermediate filling levels during the period of unloading. An assessment of the sloshing capabilities of the
cargo containment system must therefore be carried out and documented as relevant. Also the capacity of the
hull is to be evaluated for these increased loads. The degree of documentation required will depend on the cargo
containment system. For assessment on membrane cargo tanks reference is made to DNV Classification Note
No.30.9.
For a ship with a membrane or spherical cargo containment system the sloshing assessment should include:
— pump tower
— pump tower supports.
at all filling levels during operation.
For a ship with membrane tanks the sloshing assessment is also to include:
— cargo tank.
For a ship with prismatic cargo tanks the sloshing assessment is to include:
— cargo tank
— pump and piping connections to the internal tank structure.

8.3 Structural support of regasification equipment on deck
Interaction between the equipment for regasification and the hull to be considered in the design.

8.4 Gas detection in air inlets to the accommodation
It should be considered what the likelihood of gas reaching the accommodation will be, and what measures
should be in place to protect against gas ingress. This might involve location of detectors in the ventilation inlet
system to the accommodation with subsequent manual or automatic action on detection of gas.

8.5 Ship to ship transfer
For regasification vessels receiving LNG via ship-to-ship transfer, arrangements for emergency disconnection
of loading arms or loading hoses and quick release of moorings should be considered taking into account
location and weather conditions

9. Arrangement for submerged turret offloading
The design of submerged turret offloading system is to be in compliance with DNV’s Rules for Classification
of Ships Pt.5 Ch.3 Sec.14. In addition, the following apply for Submerged Turret Loading system (STL)
intended for export of high pressure natural gas:
— Explosion design loads due to explosion overpressure to be quantified and specifically designed for with respect to STL trunk and explosion relief arrangement.
— The STL room to be fitted with two independent means of escape.
— It must be ensured that positive isolation of regasification from STL can be provided, as well as positive isolation of regasification from the pump in the cargo tank. The isolation valves to STL to be remotely operable and fitted with position monitoring, which interfaces with STL depressurization and purging cycle monitoring.
— It must be ensured that PSD is immediately activated if green line signal in STL is lost.
— In case of differential pressure between sub-sea pipeline and regasification export pipe, it should be ensured that pipeline and buoy valves cannot be opened until the pressure difference is equalized.
— It must be ensured that the pipeline and regasification system will shutdown upon positive confirmation of gas detected in the turret compartment.
— Prior to disconnecting the STL piping must be depressurized and purged. Depressurization and purge cycle to be completed and confirmed, as part of the STL logic before next step can be initiated.
— Buoy and subsea valves should be fitted with proximity switches or similar for positive confirmation of connection/disconnection.

10. Testing and Commissioning

10.1 Alarms and safety functions
All alarms and safety functions are to be tested, including gas detection system.

10.2 Fire alarms, fire extinction systems and water spray systems
Fire alarms, fire extinction systems and water spray systems are to be tested.

10.3 Equipment and automatic control systems
At the first cargo regasification offloading operation, a surveyor shall witness the operations for verification of satisfactory function of equipment and automatic control systems.

11. Examples of heating arrangements for LNG vaporisers

11.1 Closed loop with steam heating

![Diagram of Closed Loop with Steam Heating](image)

**Figure 11-1**
LNG is directly heated by steam
11.2 Combined open/closed loop with seawater and steam heating

Figure 11-2
LNG is directly heated by seawater. At low sea water temperatures the seawater is preheated in a steam heater.

11.3 Open loop with seawater heating and intermediate propane loop

Figure 11-3
LNG is heated against an intermediate loop with propane and against seawater
11.4 Closed loop with steam heating and intermediate water/glycol loop

Figure 11-4
LNG is heated against an intermediate loop with water/glycol