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# LNG Marine Loading Arms and Manifold Draining, Purging and Disconnection Procedure

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## CONTENTS

**Introduction**

**Principal Objective**

**Overview**

**Conclusions**

**ANNEXES**

**Annex 1: Example Incidents**

**Annex 2: Example Procedure: Marine Loading Arm and  
Manifold; Draining and Purging Procedure**

## Introduction

This advice has been prepared following reports, from a number of members, that there appears to be confusion and misunderstanding among some ship and jetty operators over the safe conduct of this operation.

This advice specifically pertains to terminals employing rigid marine loading arms (MLAs). (The basic principles are applicable for hose systems that may be used for LNG ship-to-ship transfer, but there will be differences in the details.)

## Principal Objective

The principal objective is to disconnect the MLAs in a manner that eliminates any risk of liquid release and reduces the release of cargo vapour to the atmosphere to an absolute minimum. For this operation to be conducted safely and in a timely manner, it is essential that there is a carefully thought out procedure in place and that there is good communication between the ship's staff and the shore operational staff, both of whom bear responsibility for safe conduct of the operation.

The process has a number of logical steps:

1. Lining up to drain the system from the MLA, and/or manifold, to shore or ship tank.
2. Isolation of liquid and vapour valves on either side of the manifold connection.
3. Removal of liquid from the MLA, and/or manifolds, to shore or ship tank.
4. Purging of flammable vapours from the connection.
5. Verification that the target conditions (flammable gas concentration) have been achieved.
6. Disconnection of the manifold.

### 1. Drain System

On most LNG ships, the manifold is drained via the spray header to a cargo tank. Check that the spray valves are open on one tank and that all relevant line valves leading to the tank are open.

### 2. Isolation of Liquid and Vapour Valves Either Side of the Manifold Connection

For the shore side, this means closing the valve at the base of the MLA. For the ship, this means closing the first valve inboard from the manifold flange,

which in most cases is the ESD valve. The majority of LNG ships now have double shut-off valves at each liquid manifold and both of these should be closed. The valve to the manifold drain system described in 1 above should then be opened.

### 3. Removal of Liquid

This is usually carried out in a series of stages using nitrogen from ashore. First, nitrogen pressure is used to push the liquid from the shore side of the apex of the MLA back to shore. Secondly once the shore side drain is complete, the MLA will be drained from the apex back to a LNGC cargo tank. Completion is usually indicated by a sudden fall of pressure in the MLA/manifold and a change in sound as the flow in the drain system goes from liquid to gas. Drains and vents to the atmosphere should not be opened at this stage in the procedure.

**Note:** It has been reported that some have suggested cracking open a drain to the manifold to check that liquid has been removed. This is potentially dangerous, unnecessary and should not be done at this stage.

Draining the section between the ship's double shut-off valves (if fitted) and the manifold valves on the ship's manifold may also be accomplished using normal heat in-leak (vaporisation) to pressurise the space and force the liquid into the drain system.

### 4. Purging Flammable Vapours

The most common procedure is to pressurise the section, with nitrogen, up to 3 to 5 bar with all valves closed, and then open the valves to drain the piping into the ship and back to the cargo tank. This process may need to be repeated two or three times.

## 5. Verification

This is a key aspect of ensuring the safety of the disconnection procedure. The vent in way of the manifold is opened and the vapour is tested using a meter calibrated for measuring methane in nitrogen. A typical target level is 2% by volume in nitrogen to ensure a margin of safety when disconnection occurs and the vapour and nitrogen mixture is achieved. As a final check, briefly crack open the drain to the drip tray to ensure that no liquid is lying in the bottom of the line.

If both tests indicate safe conditions, fully depressurise the manifold connection by closing the valves to drain the piping to the cargo tank (preventing back flow), opening the drains to the drip tray and the vents for disconnection. It has been noted that leaving a pressure of about 0.5 bar in the space reduces or prevents an increase in

hydrocarbons in the space. If this is adopted all piping should be depressurised before disconnection is commenced.

## 6. Disconnection of Manifolds

Once the verification process is complete and the MLA fully depressurised, the drain valve should be left open in case of any small leakage past valve seats. A final check should be made to ensure that the methane content remains below 2% by volume before disconnection.

Disconnection should not commence until all MLAs have been satisfactorily purged in case (as has happened in the past) the wrong MLA is inadvertently selected and disconnected.

The manifold blanks should be installed immediately and the drain and vent valves then closed.

## Overview

The staff in the manifold region should be limited to essential staff only. All staff engaged in or working in the vicinity of the operations described in this paper must wear appropriate personal protective equipment (PPE). Gas detectors must be in good order and correctly calibrated. Any tools used, e.g. spanners, must be the right size for the job, clean and in good condition.

**Note:** Occasionally one still sees references to 'non-sparking' hand tools (e.g. spanners). These were typically made of non-ferrous metal alloys. ISGOTT discusses this in section 4.5.2 of the latest edition (5th edition published 2006) and does not recommend their use. SIGTTO supports this position.

Annex 1 briefly describes two incidents where the correct procedures were not followed.

Annex 2 provides an example of a detailed procedure prepared by a SIGTTO member. This is purely for illustrative purposes to show the level of detail that may be needed. Please note that not all ship and shore manifolds, and cargo piping systems are configured the same. We therefore strongly recommend that you develop procedures that are right for your ships/terminal, rather than copy someone else's, since they may not be appropriate.

It is an important principle that the procedure is clear and agreed by both ship and shore. We note that this particular member has, on their written procedure, included space for inserting agreed changes and signature by both parties specifically for this operation.

Verification using a gas detector is essential. While time or number of cycles of pressurisation/depressurisation may be a useful indicator, the principle of testing with a detector must be adhered to. If reliance is placed only on a time or cycle based system, a leaking valve in the cargo system, on ship or shore, may go undetected, leading to disconnection taking place in unsafe conditions.

Another issue with some gas detectors is that they automatically switch from % volume to % LFL at low concentrations. Be sure you know what your meter is reading when you use it!

The operation may be conducted sequentially, i.e. all steps completed for one MLA before moving to the next, or in parallel. The key factor in selecting which method usually rests on the ability of the shore system to maintain the necessary supply of nitrogen.

It is normal to leave the vapour MLA to last. The procedure is similar except that there is no liquid to remove.

## Conclusions

Mishandling or poor execution of the drain and purge procedure can lead to serious incidents. SIGTTO recommends that:

1. All members review their procedures for draining and purging manifold connections for adequacy. If a detailed written procedure is not available, one should be prepared following the principles described above, recognising that not all terminals and ships have identical arrangements.
2. The procedures are specifically discussed and agreed by both ship and shore prior to the operation.
3. The procedures should comply with SIGTTO LGHP and ERS publication recommendations.

## Annex 1: Example Incidents

### Incident 1

This incident occurred while draining and purging the manifolds at the end of loading. The weather conditions were dry and very still (nil wind). The purging was proceeding with the vents and manifold drains to atmosphere open. Progress of the operation was slower than normal as a result of problems with the nitrogen supply. (There may also have been some pressure to complete the operation to avoid delay to sailing.) A member of the ship's staff approached the vent to check with a gas detector when the gas cloud ignited. The fire was very short lasting, really only a flash fire, and had largely burnt out before the fixed shore monitor was brought into operation. However, the crew member involved suffered serious burns.

Despite thorough investigations, the source of ignition has never been definitively identified. It may have been some unexplained fault with the gas detector or it may have been static electricity. Another possibility was a spark generated by a dropped object. No evidence could be discovered to support any of these hypotheses.

### Incident 2

The Secretariat has recently become aware of another incident. During the draining and purging operation after cargo discharge a release of LNG and vapour occurred. The LNG came into contact with two persons and several persons were located inside the vapour release. Fortunately, no one was hurt and there was no ignition of the vapour.

The immediate causes for the release were identified as:

- Failure to drain the piping between the ship's ESD valve and the double shut valve
- failure to close the MLA vent valve when the methane content was greater than the agreed percentage by volume
- opening an ESD valve with MLA vent open.

Root causes for the release were identified as:

- Failure to comply with established procedures
- failure to have adequate procedures
- competence of personnel undertaking the operation.

## Annex 2: Example Procedure MLA and Manifold; Draining and Purging Procedure

This procedure is the standard procedure for draining and purging and should be followed by all vessels as far as possible. It should be compared with the terminal procedure during the pre-transfer meeting. Any divergence has to be agreed between the ship and the shore and the revised procedure signed by both parties should be issued for use upon the completion of bulk cargo transfer. The procedure applies to liquid and vapor MLAs.

### Purpose of Draining and Purging

To disconnect the MLAs from the ship manifolds under safe conditions, always ensuring that, at no time, a flammable condition can be attained.

To achieve this all piping space between ship's ESD valve, ESD by-pass valve and liquid MLA isolating valve, prior to disconnection, must be measured by a suitable gas meter at less than 2% gas content in a nitrogen background.

### Source of Nitrogen Injection

Shore side.

### Alternative Source

Ship's side through manifold vent valve.

### Ship's Side Reception of Drained Cargo and Purged Gas

Designated cargo tank as described below.

### Nitrogen Pressure for Effective Draining/Purging

Upon reaching 3 to 5 bar, pressure should be released or nitrogen supply should be stopped. Piping should remain always pressurized at a minimum positive pressure of 0.5 bar until disconnection of the MLAs.

### Sequence

One MLA at a time, with the vapour MLA last.

### Pressure Monitoring

Manifold pressure gauge.

### Initial Line Up

Cool down (spray) valves from port or starboard manifold to the designated cargo tank (via liquid header) should be opened. These valves should remain open until the operation is complete.

### Attending Ship Personnel

Cargo engineer, deck officer, one able seaman.

### Attending Shore Personnel

Assigned shore representative(s) as agreed during pre-transfer meeting.

All personnel should wear proper PPE and carry portable Intrinsically Safe UHF radios for effective communications between CCRs and jetty personnel.

### Duties

Cargo engineer and shore representative are responsible for carrying out the operation.

Deck officer is responsible for the safety of the operation. He also monitors the pressure and measures the gas content. AB assists as directed.

### Standby Equipment

Gas meters, ship's nitrogen hose, necessary tools for the job.

### Before Draining and Purging

All persons involved, ship and shore, should have a clear understanding of method to be followed. To achieve this a meeting should be carried out before the job, the requirements of the agreed procedure fully followed and satisfied and relevant entry to be inserted in cargo operation book.

### Upon Completion of Draining/Purging and Before Start of the MLA Disconnection

Relevant Permit to Work forms to be completed and signed. LO/TO to be carried out in remote valve ESD (set to passive mode).

### Draining of Ship-Shore Piping Complex

Any gas flowing under pressure into liquid filled piping is always ascending in inclined and vertical pipes until reaching a **dead end**, (*double shut valve, top of MLA*) where it creates a 'gas piston', pushing the liquid downwards. In horizontal pipes of large and medium diameter the gas always lays on top forcing the liquid downwards. A gas piston is also created with LNG trapped between closed valves as it warms up. (*Gas means either nitrogen or cargo vapor*). Under a certain gas pressure the

liquid escapes from any opening at the lower part of piping. Pressure of 1 bar is enough to push LNG through a narrow pipe up to 22 m higher of the lower point that this pressure is exerted.

Pressure should not allowed to drop below 0.5 bar or nitrogen should not stopped flowing throughout the entire operation.

**This Procedure has been agreed between Ship and Terminal representatives with the changes described in the last page.**

Vessel: \_\_\_\_\_

Representative: \_\_\_\_\_

Signature: \_\_\_\_\_

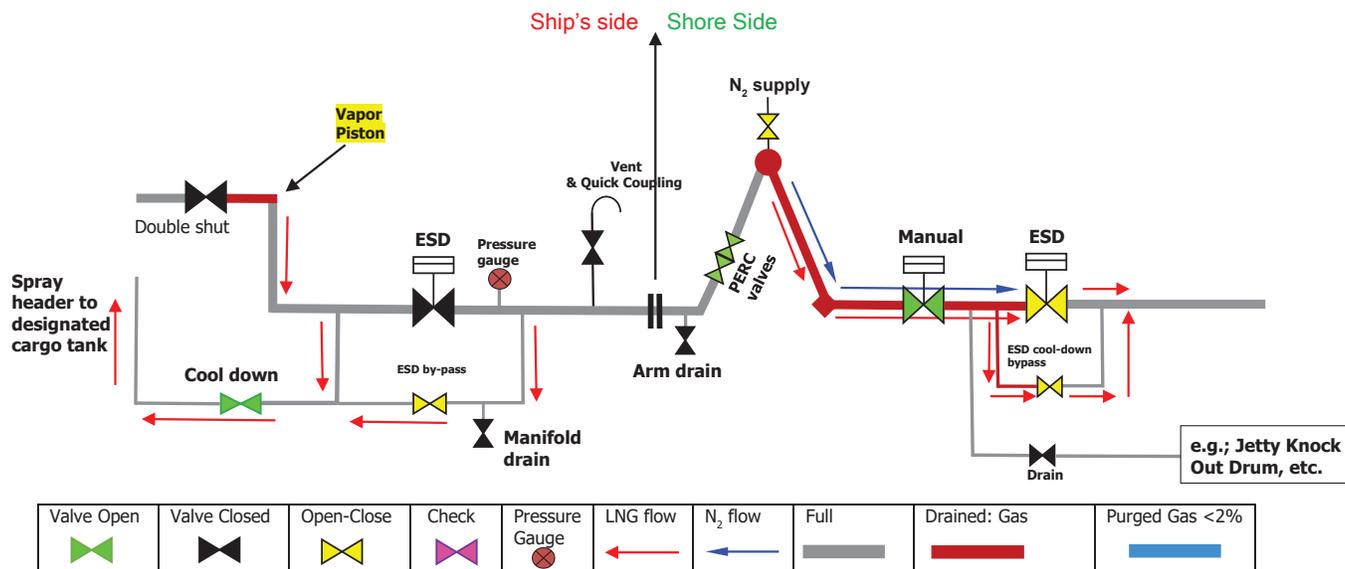
Terminal: \_\_\_\_\_

Representative: \_\_\_\_\_

Signature: \_\_\_\_\_

Date: \_\_\_\_\_ Time: \_\_\_\_\_

## 1<sup>st</sup> Stage: Draining Shore Side Liquid MLA (into shore tank)



### 1. Upon completion of cargo operation.

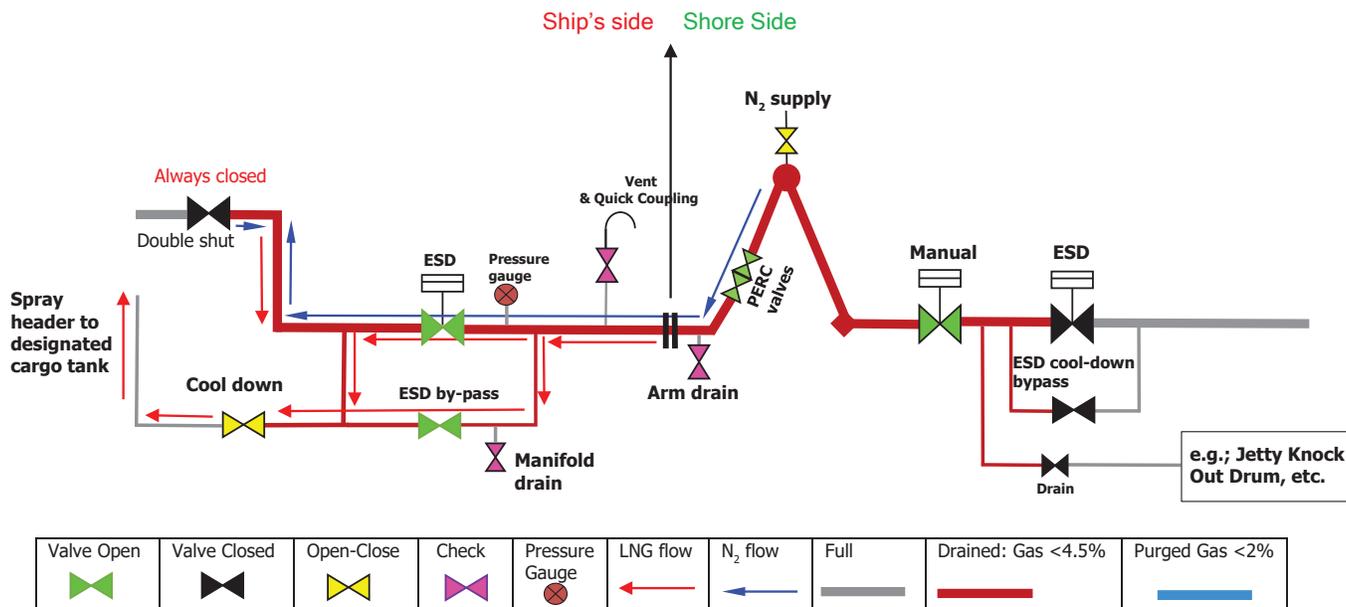
- Verify that trunk deck cargo liquid piping is drained as per cargo manual. Verify that double shut valves are 100% closed.
- Line up spray piping from connected manifolds to the designated cargo tank as described above.
- The ship's ESD valve and ESD bypass valve will remain **Closed** while the shore side part of MLA is blown back ashore by nitrogen\*.
- Cool down valve should be **Open** to relieve pressure between the double shut valve and the ESD valve into the designated cargo tank.

(The trapped & under pressure cargo will drain into the designated cargo tank. This practice will speed up the ship side piping draining).

- When the terminal has confirmed the shore side section of the MLA is liquid free, close terminal ESD and ESD cool-down bypass valves and the ship staff will **Open** the ESD bypass valve.
- After terminal staff confirm that they have finished with draining the shore side MLA, proceed to 2<sup>nd</sup> Stage.

\* Terminal staff will drain and purge the shore side MLA into their piping or a vessel such as a knock-out drum, as shown above.

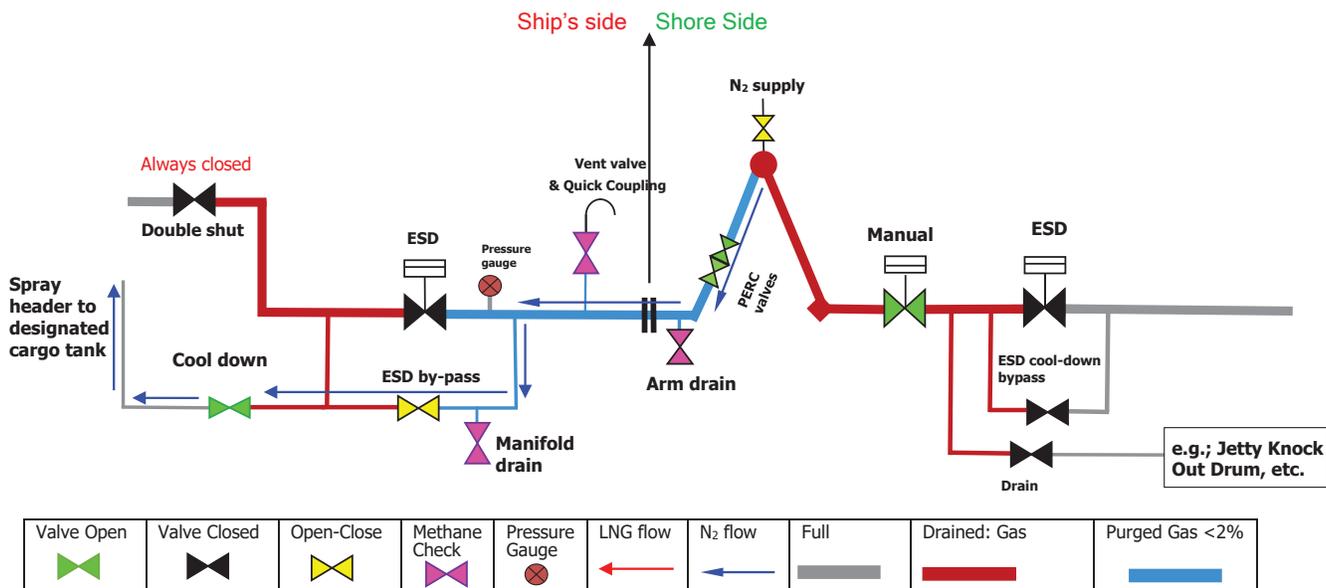
## 2<sup>nd</sup> Stage: Draining of Ship Side Liquid MLA & Manifold Piping



1. Verify that terminal has **closed** the MLA purge valve. Verify that Shore N<sub>2</sub> supply valve is **open**.
2. **Open** ship's ESD valve\*. Confirm MLA's valve is **open**. Monitor the pressure. Listen to the cargo flowing. When pressure suddenly drops and liquid flow stops, **close** the cool down valve.
3. Allow pressure to rise to 3 to 5 bar and **Open** the cool down valve until pressure drops to 0.5 bar. **Close** cool down valve.
4. Repeat step 3 one more time. N<sub>2</sub> pressure can be lower but not less than 2 bar. (Empty cargo piping needs much more nitrogen)
5. **Open** Vent valve **slowly**. Check methane % by volume through vent valve and if it is less than 4.5%, **crack open** manifold drain valve to verify that piping is dry. A few droplets may initially be observed. If you observe free liquid flow **close**, the manifold drain valve and **repeat steps 4 and 5**. If the piping is dry, check the gas content at the MLA's drain valve.
6. Upon verifying that piping is liquid free and that the methane % by volume is less than 4.5% at the manifold drain valve, **close** the drain valve. Verify that the MLA drain valve is **closed**. Proceed to Stage 3.

\* ESD valve may remain closed during this process on the terminal's request. This will increase the number of cycles required to achieve the 2<sup>nd</sup> stage draining objective.

## 3<sup>rd</sup> Stage: Gas Freeing of Ship Side Liquid/Vapor MLA & Manifold Piping



- Close** the ship's ESD valve. **Close** the ship's ESD bypass valve. Let pressure rise to 3 to 5 bar.
- Open** ship's ESD by-pass valve until pressure drops to **0.5** bar. Close the ship's ESD bypass valve.
- Open** Vent valve slowly. Check the methane % by volume through vent valve. If reading is less than 2% methane % by volume, **Open** Manifold Drain valve and measure Methane % by volume to read less than **2%** Methane % by volume. Shore side may check Methane % by volume through the MLA drain valve.  
If any reading is above 2%, **Repeat steps 1 to 3** until all check points are less than **2%** Methane % by volume.
- Close **ALL** valves except the MLA's PERC valves, with the piping pressurized at 0.5 bar\*. Set ESD valve to 'passive'. Proceed with draining and purging of remaining liquid MLAs following above 3 Stages.

### Disconnecting a MLA:

- Check pressure to be equal or above **0.5** bar.
- Check methane % by volume at manifold drain valve to be less than **2%**.
- Depressurize through check points.
- Disconnect MLA (by terminal's staff).
- Fit blind flange & tighten the bolts.

\* Piping (blue section) should remain pressurized until MLA disconnection to prevent leaks and ensure valves tightness.

