Offshore Ship-to-Ship Transfer of Liquefied Ethylene

Kurt Jungk*), P. M. S. Prasad

Die natürliche Zufahrt zu einem Terminal für verflüssigtes Äthylen weist nur geringe Wassertiefen auf. Seegehende Flüssiggastanker (LEGC) müssen daher auf Reede geleichtert und das verflüssigte Äthylen von flach gehenden Leichtern (LV) zum Terminal transportiert werden. IMPaC Offshore Engineering wurde beauftragt, die Durchführbarkeit des Leichterns auf See zu untersuchen. Das Übergabesystem für verflüssigtes Äthylen wurde optimiert und seine wesentlichen Bestandteile technisch entwickelt.

Due to limited water depth in the access waterway, sea-going Liquefied Ethylene Gas Carriers (LEGCs) cannot reach an upstream jetty for cargo discharge. Consequently, the liquefied ethylene will need to be lightered offshore and transported by shallow draft lighter vessel (LV) to jetty. IMPaC Offshore Engineering was entrusted to investigate the feasibility with ensuing optimization of the offshore transfer system, and subsequently undertook the basic engineering design work.

Basic Conditions

The investigation of the environmental conditions being prevalent at the offshore lighterage area during cargo transfer operation revealed that significant wave heights of up to 1.0 m had to be taken into account. In addition to wind effects, strong tidal currents reaching 6 kn influence the vessel's orientation. Therefore, wave attach from various directions had to be considered.

The flexibility of the cargo transfer system should allow to lighter LEGkCs of the most common types and sizes between approx. 1 000 and 11 000 m³ of cargo capacity.

The design also included special operational cases, such as

1. smallest LEGC fully loaded, with LV being empty
2. biggest LEGC empty, with LV being fully loaded.

The cargo transfer system has to comply with all regulations of relevance such as IMO requirements and OCIMF recommendations.

The temperature of liquefied ethylene under ambient pressure is minus 104 °C.

Investigated Systems

Two principal options for cargo transfer system were investigated:

- loading arm systems
- hose systems.

The loading arm systems consist of fixed pipe sections connected by swivel joints which take all movements induced to the system by relative motions between LEGC and LV when moored together. The most critical issues in design and construction of low temperature loading arms are the swivel joints and their sealings.

The investigations resulted in the following main conclusions:

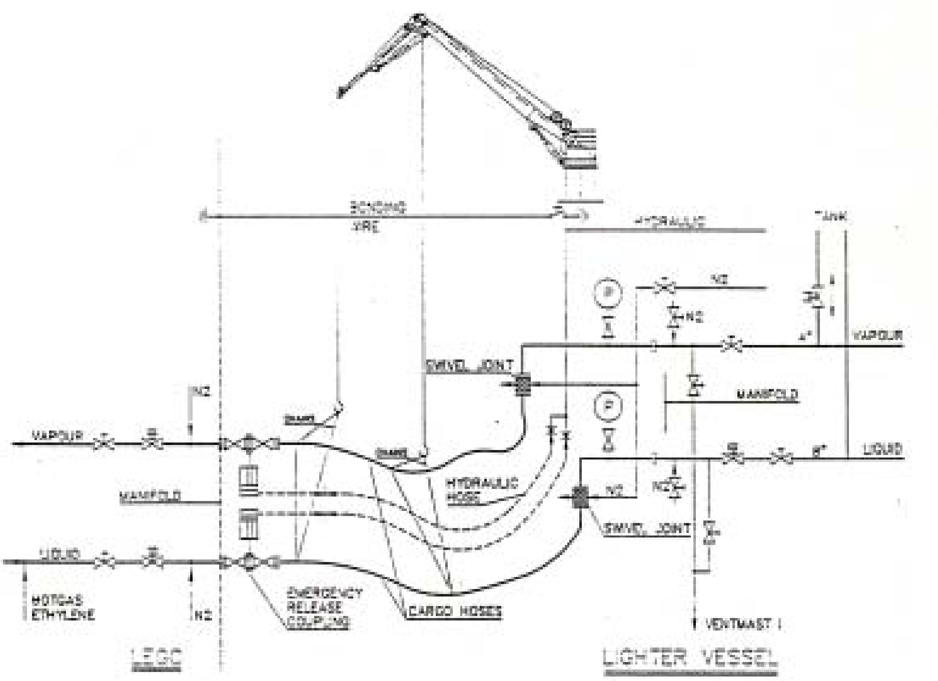
- The loading arm technology is well developed for cargo transfer at jetties in sheltered waters. No reference is available for actual offshore ship-to-ship-transfer.
- The swivel joints allow a high degree of flexibility of the loading arm system including motions to all directions. However, it is doubtful whether the presently available swivel joints are suitable to withstand the high frequency of movements and the high accelerations connected with offshore operations.
- The connection and disconnection between the loading arm on the LV and the manifold on the LEGC include a risk of damage to the tip of the loading arm.
- Repair of loading arm is time consuming.
- Costs for loading arms are high.

For hose systems, there are basically two types of hoses available on the market suitable for transfer of liquefied ethylene:

- corrugated stainless steel hoses
- multi-layer reinforced polyamide hoses.

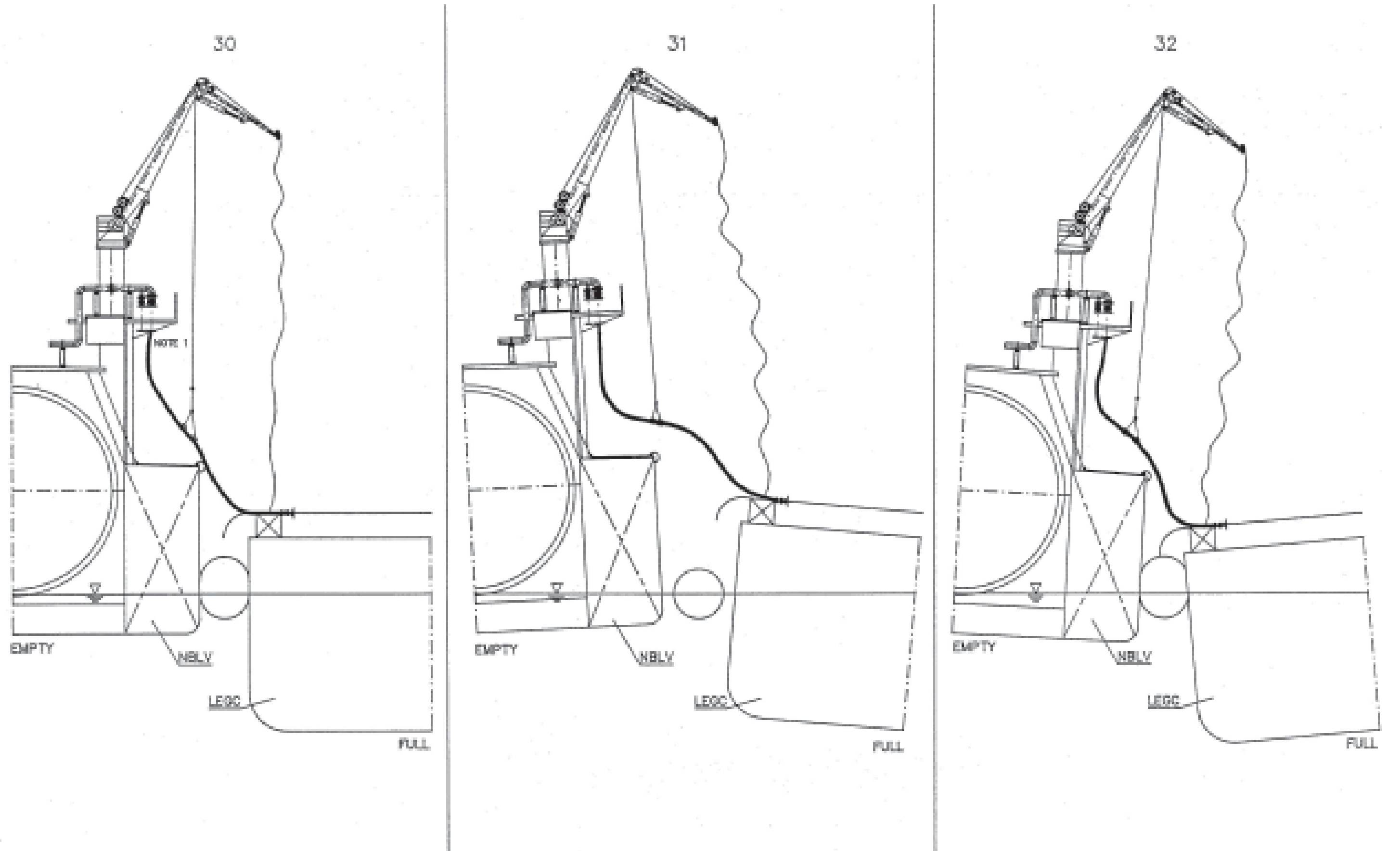
The investigations of the suitability of both hose types resulted in the following main conclusions:

- Hose systems seem to be more flexible than loading arms regarding the connection and disconnection as well as the relative motions and accelerations between LEGC and LV.
- Experience exists for non-comparable applications only. No reference is available for offshore operations of vessels with the high frequency and large amplitudes of motions expected.
- Corrugated steel hose are limited with respect to minimum bending radius and torsional deformations. In addition, they are susceptible to intemal corrosion.
- Multi-layer polyamide hoses are very flexible regarding various kinds of deformation, and are corrosion-resistant.
- Corrugated steel hoses are certified as cargo hoses for the transfer of liquid ethylene from ship to shore, provided that torsional deformations can be prevented.



Schematic diagram of cargo transfer system

*) IMPaC Offshore Engineering, Hamburg



Determination of optimal length of cargo hoses, cross section showing vessels moored together and moving under wave attack

- Multi-layer polyamide hoses were certified for temperatures of liquid chemicals to minus 50 °C, i.e. liquefied ethylene of minus 104 °C did not have official approval in the past.
- Costs of hose systems are moderate.

Selected Cargo Transfer System

The investigations revealed that the multilayer reinforced polyamide hoses can be considered to represent the optimum system for ship-to-ship ethylene transfer offshore.

IMPaC arranged for low temperature testing of polyamide hoses in accordance with the international standards and for approval by a certifying society for a temperature range of 60 to minus 104 °C.

Ship motion model tests were performed to investigate the movements of LEGC and LV moored alongside, and to determine the limiting environmental conditions, mainly the maximum wave height the vessels can withstand prior to shutdown of cargo transfer due to excessive relative motions of vessels.

The required lengths of cargo hoses, the optimum positions of manifolds of LV and further details were ascertained by thorough investigations of the determinant parameters.

LEGC's and LV's manifolds are connected by a 8" liquid transfer hose and a 4" vapor return hose. The hoses are permanently connected to the LV and securely stored on a stowage bed in longitudinal direction during transit. A hydraulic crane, equipped with articulated jib and two hooks, handles the hoses for connection to LEGC's manifolds. The crane supports the middle hose area in addition to free hose ends as far as necessary by means of lifting gears adjustable to the distance between LEGC's liquid and vapor manifolds.

The emergency release couplings including quick closing valves are fitted for each of the hoses and can be activated from the LV as soon as required. Supports temporarily fixed on board of the LEGC and adjustable in height are designed to ease the connection and disconnection of the hoses to and from the manifold as well as to avoid axcessive bending of the hoses. Swivel joints fitted at the LV's side of the hoses avoid unnecessary torsion in the liquid and vapor lines when moving them between storage and working positions by about 90° around vertical axes. The swivel joints are provided with N_2-supply for purging during cargo transfer.

LEGC and LV are connected by a bonding wire to guarantee the balancing of electrical potentials prior to hose connections. A switch is installed in line with the wire for electrical disconnection. Spool pieces can be installed between LV's manifolds and swivel joints to increase the length of connections if desirable.

Conclusions

Based on extensive investigations and tests, IMPaC developed an optimized system for offshore ship-to-ship transfer of liquefied ethylene. The aspects of safe operations were duly taken into account. Main advantages are the great flexibility of the designed cargo transfer system with multy-layer reinforced polyamide hoses, and its competitive costs.

Published by
Schiff & Hafen/SEEWIRTSCHAFT,
Heft 2/1991