Offshore Ship-to-Ship Transfer of Liquefied Ethylene
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Die natürliche Zufahrt zu einem Terminal für verflüssigtes Äthylen weist nur gerin-
ge Wassertiefen auf. Seegehende Flüssiggastanker (LEGC) müssen daher auf Ree-
de 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 tech-
nisch 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. Conse-
quently, 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 sys-
tem, 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 di-
rections 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 op-
erational cases, such as
1. smallest LEGC fully loaded, with LV
being empty
2. biggest LEGC empty, with LV be-
ing 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.

Schematic diagram of cargo transfer system

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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
internal 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 deforma-
tions can be prevented.
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, LV and further details were ascertained by thorough investigations of the determinant parameters.

LEGCl'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 excessive 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 N2-supply for purging during cargo transfer.

LEGCl 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.

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