HAZIRA ETHYLENE LIGHTER PROJECT

by P. M. S. Prasad and D. Murali (Reliance Industries), and
W.-D. Longrée and J. Berger (IMPaC Offshore Engineering GmbH)

When Reliance Industries built its Hazira petrochemical plant about 200 km north of Bombay and 18 km up the Tapi River from the Gulf of Khambhat in 1988-90, it was understood that its main raw material—ethylene gas—would have to be imported from overseas for a few years until a domestic cracker could be completed and the gas could be produced in the plant itself. The plant was scheduled to begin production early in 1991, which meant that the delivery of ethylene gas must begin then too.

Since the plant's tanks had a storage capacity of only 10,000 tons, the import rate for the ethylene gas had to be planned so that plant production would not be interrupted due to lack of feedstock and so that, on the other side, there would never be more ethylene on hand than could be stored.

IMPaC Offshore Engineering GmbH had been commissioned to study the options for importing ethylene gas and, during 1988-89, completed a comparison of alternatives from both technical and commercial points of view.

Conventionally, such gas is transported as a liquid at a temperature of -104°C in special ships which deliver the cargo by means of their own pumps into the storage tanks of the plant on shore—still in this supercooled condition. However, in this instance, gas carriers of the needed capacity (4,000-8,000 m^3) in fully loaded condition would have a draft of 5-8 meters. The Tapi was much too shallow to accommodate such vessels.

The options considered by IMPaC (and preferred by the owner) assumed that a tanker jetty would be constructed at the plant. The variant being considered was how to go about reaching the jetty. The options studied included dredging the Tapi to handle seagoing vessels with drafts of either 5 meters (about 4,000 m^3 cargo capacity) or 8 meters (8,000 m^3 cargo capacity), dredging the Suvali Harbor to handle one or the other of these types of vessels, use of a specially built seagoing tanker with a draft of 3.5 meters (3,500 m^3 cargo capacity) requiring minimal dredging of the Tapi, or construction of specially built lighter vessel(s) with extremely shallow draft which could lighter the liquid ethylene gas from the seagoing tanker outside the Tapi River. (Typical offshore unloading facilities—single point mooring, jetty or platform— and new-to-build harbor solutions had, of course, also been taken into consideration.)

All these options were planned to make a first delivery of ethylene at the beginning of 1991 and to increase the import rate to 80,000 tons per year after a few months.

As a result of IMPaC's study, Reliance decided in the summer of 1989 on the alternative of dredging the Tapi River to allow seagoing tankers with a five-meter draft to reach the jetty. Since correct sea charts of the river and estuary were not always available, Reliance engaged IMPaC to make an assessment of the existing data on the Tapi in respect to waterdepth, current, soil conditions, environmental conditions, etc. and to develop a specification for a shipping channel to be dredged in the river from the estuary up to the jetty at the plant including a turning basin and a waiting area with mooring buoys in front of the jetty.

After IMPaC and Reliance had invested more than a year's work in this direction and just as dredging was scheduled to begin, the political situation became such that the local authorities would not agree to dredging. The only option still open was lighterage.

The novelty of this option (and the source of some difficult development engineering) was the ship-to-ship transfer of such a hazardous cargo as liquid ethylene at -104°C. Criteria for the operation included: 1) failsafe operation even under moderate relative motions between the tanker and the lighter vessel due to waves, wind or current, 2) quick and easy connection and disconnection even under motions, 3) high pump-rate for cargo and vapor return line for gas, 4) possibility of quick release including self-closing valves for the case of an emergency, and 5) certification by Germanischer Lloyd.

IMPaC compared the two basic systems for making such a transfer: the conventional loading arm and a system of hoses under a crane. The result of this study was clearly in favor of a hose system with its higher degree of flexibility although no hoses and quick-closing valves with the required certification were available on the market. Corrugated steel hoses were considered to be limited by their bending radius and their susceptibility to internal corrosion and to torsional deformations. And multi-layer polymide hoses, although much more flexible and corrosion-resistant, had never been certified for temperatures below -50°C. No previous offshore transfer of ethylene gas from ship to ship had been documented so that meant prototype tests had to be executed.

Model motion-tests were carried out in the tank of Marintek, Trondheim, Norway, in order to verify the relative motions between the liquid ethylene gas carrier and the lighter vessels during lighterage operation under different conditions of waves, currents and wind in order to find the limiting conditions. In addition, a HAZOP (Hazard of Operations) study was carried out by IMPaC in cooperation with other specialized companies and the classification societies Germanischer Lloyd and Lloyd's Register. A risk analysis covering such occurances as fire, power-failure, grounding, etc. was also conducted to detect unreasonable risks to people and environment due to design, construction or operation of the lighter vessels.

In addition to and at the same time as the various studies performed by IMPaC in preparation for executing the lighterage option, the company began to develop a strategy for acquiring the needed vessels. First they defined the design criteria for the three lighter vessels: 1) draft not to exceed 2.3 meters fully loaded due to water depth, 2) length not to exceed 85 meters due to bends in the river, 3) minimum speed of 7 knots due to current conditions, 4) loading capacity as great as possible to minimize the number of shipments and thus waiting cost of the seagoing tanker, 5) classification for local trade down to the lighterage area outside the river estuary and outside the monsoon period, and 6) ability to load alongside different sizes of seagoing tankers with very different relative positions of manifolds.

As IMPaC investigated qualified shipyards on behalf of the owners, it became obvious that 12-14 months would be the minimum time for delivery of such a vessel. At that point it was already March 1990. The plant's commissioning was scheduled for early the next year.

In order to prevent a delay, it was decided that the first of the three ships would use an existing pontoon-shaped hull on the main deck of which would be built cargo tanks, accommodations, and a propulsion plant. Although this was not the optimal design for a ship, it reduced construction time drastically.

Also, the reliquifaction plant which most ships have on board for reliquifaction of the cargo vapor was eliminated from this first vessel since it had a very long delivery time. Instead, the cargo tank was designed so that the fully loaded ship is able to withstand the local environmental conditions for 15 days without vaporization of the cargo which would lead to a pressure increase beyond the 7-bar level for which the tank was designed. (After 15 days, release of internal pressure through controlled ventilation is necessary.)

IMPaC collected and evaluated bids for barges and conversion into an ethylene lighter vessel and Reliance concluded a contract at the end of May 1990 with the shipyard Rauma Repola Offshore, Pori, Finland for the delivery of the converted lighter vessel on December 21, 1990. In addition to the fact that it was possible to meet the schedule for the plant's opening with this ship, another big advantage of the purchase was that the hull to be converted was also owned by the shipyard, making different contracts for purchase and conversion unnecessary. This eliminated the risk of a gap in the responsibility for damages to the hull which could be detected during the conversion. The single-point responsibility for delivery of a complete and fully classed ship remained with the shipyard.

At the same time, parallel to this process, IMPaC began the design and definition of the other two lighter vessels which were to be built from scratch and which were planned to be operational autumn 1991 and spring 1992. Only two additional criteria were added to those already developed for the converted lighter vessel. The new vessels should:
1) have a reliquifaction plant on board, and
2) be classed for all year's coastal trade around the coast of India. (This second criteria was achieved with additional ballast tanks which allow the vessels a maximum draft of 3.5 meters in loaded condition for better seaworthiness. These ballast tanks can be emptied to achieve a fully loaded draft of only 2.5 meters for traveling on the Tapi River.)

These two new vessels for which IMPaC supervised the construction were built in the Bodewes Shipyard, Foxhol, Holland and delivered late summer 1991 and spring 1992.

Even as the first lighter vessel was under construction, IMPaC began to prepare for lighterage operations by producing: 1) operator's manuals for the ship-to-ship lighterage and the jetty operations, 2) safety and emergency procedures for all operations, 3) training programs for the ships' crews and procedures for safety drills, and 4) programs for the prediction of the astronomical tide and the influences of environmental factors on the water levels.

Although this project was plagued by more than the usual number of setbacks and by more time pressure than the average project, Reliance was able to meet its target date for opening the plant and a potentally dangerous operation has been handled on a routine basis with a high level of safety.