In Tank Pumping Requirements for Retrofit of LNG Import Terminal to LNG Export Terminal

EBARA

ABSTRACT:

The recent rush to monetize the increased US gas supply due to increased shale gas production has created an opportunity for existing LNG import terminals to export LNG. These import terminals have used their existing assets: loading berth, marine piers, and LNG storage tanks to create a good economic opportunity, while keeping costs lower than a typical greenfield LNG production plant.

Export pumps designed to load LNG tankers are larger in flow than the original low pressure feed pumps currently installed at import terminals. In order to obtain higher export pumping rates without the capital expense of installing new tanks, LNG export pumps must be retrofitted into the existing LNG storage tanks.

This paper will examine the challenges of using the existing pump and tank geometry (pump column) of the original supply to create the higher flow export pumps. Ebara International Corporation (EIC Cryo) USA has supplied new pumps for several of these retrofit projects. This paper will summarize the stages of a typical project: new design (and conditions), pump design challenges, successful testing, and ultimately installation and start up.

Table 1. Typical In-tank Pump Sizes from around the World

Parameter	LNG Plant Receiving Terminal (regasification)	LNG Plant Receiving Terminal (regasification)	LNG Plant Receiving Terminal (regasification)	LNG Plant LNG Production Middle East (liquefaction)
Location of Plant	USA	Europe	China	Middle East
Pump Column Diameter	38″	24″	24″	40″
Flow Rate	800 m^3/h	450 m^3/h	400 m^3/h	1500 m^3/h
Electrical Frequency	60hz	50hz	50hz	50hz
Motor type	4 pole	2 pole	2 pole	4 pole

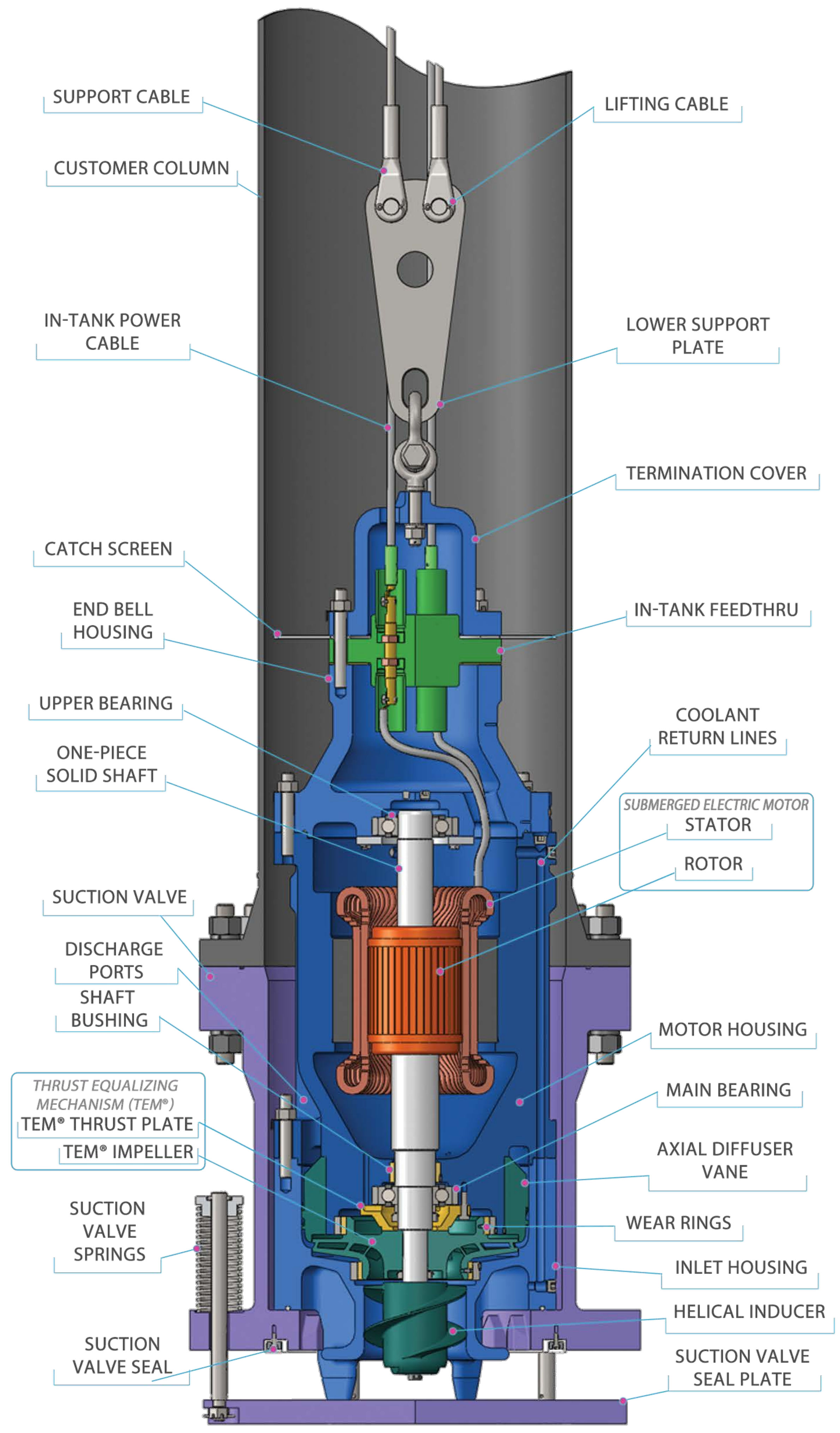

Figure 1 Typical Pump in Column showing pump, suction valve & accessories

INTRODUCTION:

In the early 2000s it was believed that there would be a gas shortage in the United States. In order to keep an adequate supply of natural gas, LNG importation projects were planned to meet demand. Consequently, several greenfield LNG import terminals (regasification plants) were built in the United States, Canada and Mexico to feed the United States' market and pre-existing US terminals expanded their capacity.

By the mid-2000s, shale gas production ramped up. As the production of shale gas deposits came online and LNG imports slowed, North American import terminals were of small utilization. Gas production continued to increase and LNG import terminal owners considered what could be done to make their assets more useful.

Some of the significant assets for LNG import terminals are: LNG tanks, marine ports, loading piers, loading arms, process areas, maintenance facilities, administrative facilities, utilities, etc. Many of these same assets are also needed for LNG production (liquefaction plants). Owners saw an opportunity to utilize a substantial amount of their assets to transfer their facilities over from LNG regasification for use in LNG liquefaction. LNG tanks are a substantial capital investment for any LNG plant whether it be regasification or liquefaction. Reusing the existing tanks would result in substantial savings over building a new LNG greenfield plant with new tanks.

The in-tank pumps used in LNG base load or LNG liquefaction facilities are used to load LNG ships. The goal is normally to load the ship as quickly as possible, so the pumps typically have higher flow capacity than the ones used for LNG regasification plants. [Table 1] describes a variety of in-tank pumps used throughout the world. Both regasification and liquefaction plants are shown in the table.

In-tank pumps used in LNG regasification plants are used to feed the high pressure vaporizer feed pumps. These pumps are designed to allow plant capacity to vary from small output to maximum send out. The plant design needs to be flexible to allow for one or multiple pumps to meet gas nomination requirements for the day.

LNG tanks are full containment style and the LNG must be removed from the top of the tank and not the side. The tanks use top entry pump columns utilizing a retractable style pump. In case of maintenance, pumps are removed through the top of the tank, which is kept in cold operation. It is very rare for a tank to be warmed up and decommissioned as this is a very costly and time consuming process.

The pump column is the pipe or conduit through which the liquid exits the tank. The pump in the column is similar to a downhole pump, but there is no separate discharge line. The pump manufacturer will also supply a suction valve at bottom of the pump column. The suction valve holds the pump and allows for the pump column to be sealed in case of pump maintenance/removal. [Figure 1] shows a typical pump column with pump and accessories. The pumps are removed from the top and also reinstalled the same way.

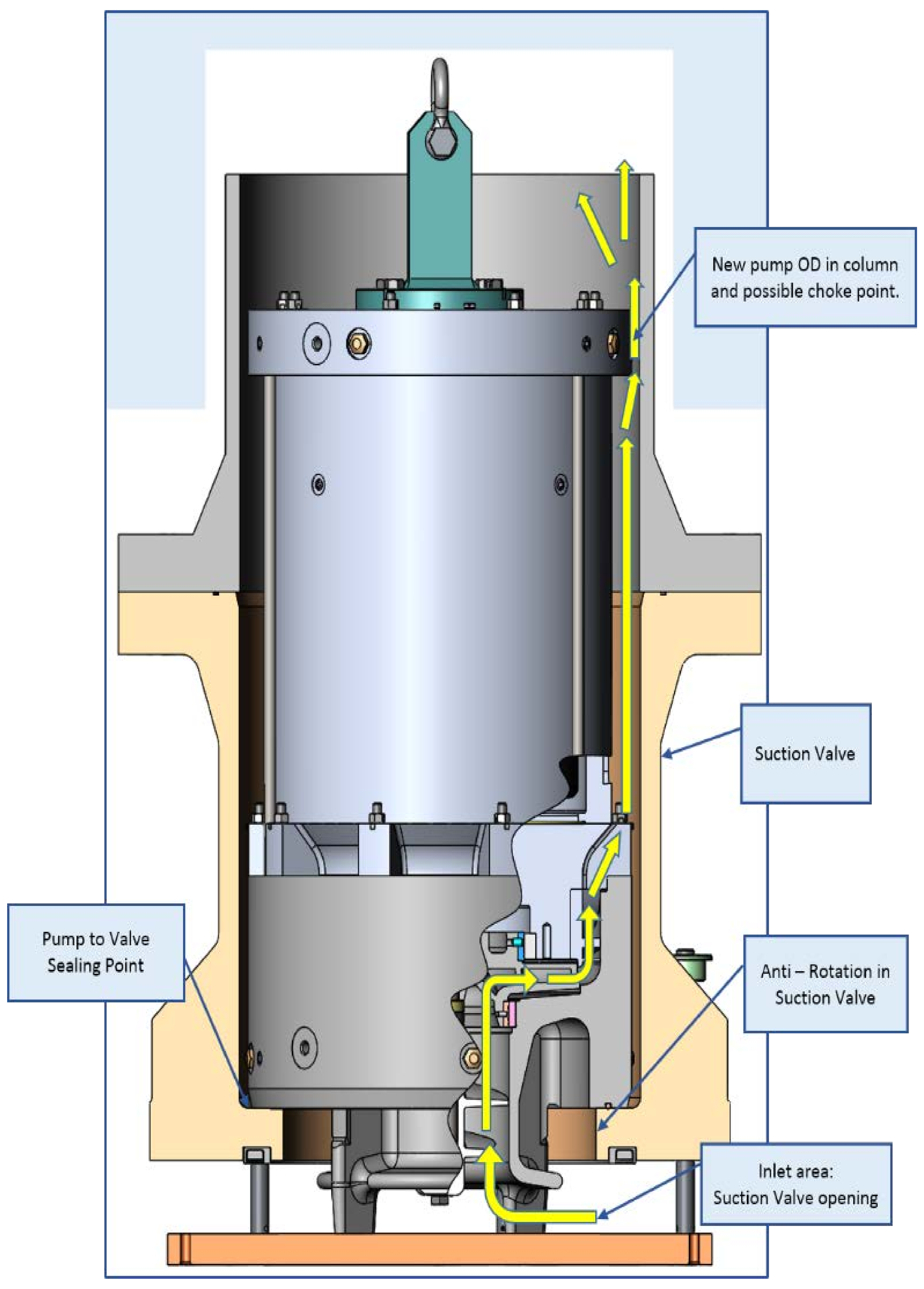

Figure 2 Typical Pump in Column and Suction valve showing areas of detailed design study.

REFIT OF PUMPS:

There are three US plants where in-tank pumps were changed from feed pumps (for LNG regasification) over to LNG ship loading pumps. Specifically for these instances, see [Table 2] which shows the original vs. new pump configurations. Note that the goal was to reuse as many components as possible of the original design to keep costs at a minimum, while still meeting new flow requirements.

Table 2. Original and New Pump Configurations

Parameter	LNG Plant 1	LNG Plant 2	LNG Plant 3
Pump Column Diameter (mm)	36″-150LB 877mm ID	36″-150LB 877mm ID	30″-300LB 737mm ID
Original Flow	978 m3/h	841 m3/h	1150m/3
Original Head	171m	173m	204m
New Flow	1600 m3/h	1800 m3/h	2000 m3/h
New Head	178m	200m	173m
Original Motor size	328 Kw	351 Kw	400Kw
New Motor size	507 Kw	825 Kw	665 Kw
Suction valve opening before (mm)	152	152	160
Suction Valve opening after (mm)	152	152	160
Pump Column/Tube	Reuse	Reuse	Reuse
Pump	New	New	New
Suction Valve	Re Use	Re Use	Re Use
Power Cables	Reuse or Modify	New	New
Lifting / Support Cables	New Support, Reuse Lifting	New	New
Headplate	Reuse	Reuse	New
Electrical System/Junction Box	Reuse	Reuse	New

CHALLENGES:

The design and manufacture of any new in-tank pump is complex and comes with many constraints. The design has to meet performance requirements (flow/head/power/NPSH) as well as fitting in the pump column. In a new construction project, the pump, column, and suction valve must be sized for the particular flow and application, but there is some flexibility as the design progresses. In addition, when installed for the first time, the pump can be inspected to verify good fit as personnel can still physically enter the tank for visual inspection.

In a retrofit scenario, the suction valve and column are reused. The pump must be installed and be of higher flow than the previous design. It is a very complex engineering evaluation and design process to ensure the required performance of the pump is satisfied as well as fitting pump into the space provided. Detailed engineering is done at each stage to ensure the new pump will work properly. To complicate matters further, the pump is then installed into a tank containing LNG, providing no access for visual inspection that a new tank would allow. A typical pump seated in its suction valve is shown in [Figure 2].

DESIGN CONSIDERATIONS:

- Fitting pump in column
  - Pump diameter must be less than column diameter and also allow flow to up pump column.
  - Pump can fit in column with some irregularities of pump column (straightness, ovality, etc.).
- Integrity of new design
  - Design pressure
  - Flange ratings
- Fitting pump in suction valve
  - Opening of suction valve is sufficient
  - Pump fits in anti-rotation devices of existing suction valve
- Pump seals in suction valve. This allows no pressure/flow loss while pump is running.
- No loss of Hydraulic performance
  - No issue with NPSH due to higher flows at suction area
  - No choke points where fluid goes past pump inside column as new pump is larger diameter than previous pump
- Accessories
  - Lifting and support cables are adequate length and strengths.
  - Power cables, electrical feedthrus designed for any electrical changes/amperage.
  - Refit of any condition monitoring equipment on the pump.

After the design and manufacture of the pumps, validation must be performed to ensure the new pump performs per the requirements. This includes the following:

- Validation of pump diameter
  - Pump fits in pump column.
  - Use of bumpers, etc. to ensure pump can be installed and removed from column when column is in cold condition.
- Fit up of pump in suction valve
  - Use of similar valves to ensure pump opens valve properly.
  - Pump locks in to anti-rotation devices properly.
  - Pump seals properly to valve.
- Pump performance test
  - Pump is operated in LNG and simulated column to ensure performance.
  - Pump is tested for NPSH to ensure no issues with higher flow.
- Site performance check
  - Pump is installed into pump column and existing valve.
  - Pump is operated to verify performance.

CONCLUSION:

Changing of in-tank pumps to higher flow has been done at three separate LNG terminals in the United States. The challenges of installing a larger flow pump into an existing cryogenic LNG tank are numerous. Columns and suction valves are constant, and new pumps must be designed to fit into the pre-existing equipment and still meet new performance requirements.

The design is then verified with fit up checks and performance tests to prove they will work once in the field. The final test is in the field, with the pump installed.

The USA plants were lucky, the original design of the tanks allowed for an easier transition to higher capacity loading pumps since the pump columns were designed with larger diameter pump columns. If this retrofit plan was attempted in Europe or elsewhere, the smaller diameter pump columns would have made fitting larger flow pumps much more difficult.

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