Ship to Ship Transfers – Considerations Applicable to Reverse Lightering Operations

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1 **Summary**

The 4th (2005) edition of the ICS/OCIMF Ship to Ship Transfer Guide (Petroleum), referred to in this paper as the ‘STS Guide’, contains guidance on ship to ship transfers that includes recommendations that are relevant for ‘reverse lightering’ operations. ‘Reverse Lightering’, sometimes referred to as ‘topping-off’, is a ship to ship transfer operation in which a laden tanker, typically of Suezmax or Aframax size, is manoeuvred alongside a partially laden VLCC or ULCC in order to transfer cargo to the larger vessel. This differentiates the operation from conventional STS activities in which the manoeuvring vessel is typically in a ballast condition. With two nearly fully loaded vessels manoeuvring alongside under way, the issue of fender selection is critical and this paper aims to expand and build on the existing guidance by further discussing the factors to be taken into account regarding aspects that include berthing energy absorption requirements and recommended stand-off distances.

2 **Considerations**

Before committing to a reverse lightering operation, it is recommended that a risk assessment be carried out as outlined in Section 3.1.1 of the STS Guide.

2.1 **Fender Selection Procedures**

Table 9.1 in the STS Guide provides a quick reference guide to fender selection for STS operations. The number and size of fenders is determined based on the berthing coefficient (‘C’) and an assumed relative berthing velocity. The berthing coefficient is determined by calculation based on the displacement of the two vessels. When planning to undertake reverse lightering, consideration should be given to utilising fenders with higher energy absorption for the berthing phase than those recommended in Table 9.1 or by taking measures to reduce berthing velocities.

As stated in the STS Guide, the data presented in Table 9.1 is intended to be used with considerable discretion, based on knowledge and experience of the type of operation to be carried out. When considering ‘C’ values in excess of 200,000, the step changes for the ‘C’ value in the Table are large, namely to 330,000 and 500,000, and also coincide with recommendations for increased sized fenders, from 3.3 x 6.5 metres to 4.5 x 9.0 metres. The precise ‘break point’ prompting recommendations for the larger size fender is not indicated in the table but has been determined to be in the region of ‘C’ values in excess of 300,000.

For reverse lightering operations, in particular where ‘C’ values in excess of 200,000 will often be relevant, it is recommended that berthing energy is calculated using the procedure detailed in Appendix 2 (Fender Selection Calculation) of the STS Guide. This calculation will provide the berthing energy when landing on one fender during a quarter point berthing and is calculated based on the displacement of the two ships and an assumed berthing approach velocity. A constant of 1.8 is applied to account for the force of the surrounding seawater which acts to push the ships towards one another on berthing.

The berthing energy calculated using the Appendix 2 procedure should be used to ascertain the energy absorption requirements of the fenders and, following reference to manufacturer’s data, the type and size of fenders may be determined.
The following graphic summarises the two procedures for fender selection contained in the STS Guide:

### 2.2 Fender Energy Absorption Characteristics

The table in Appendix 2 of the STS Guide provides information on energy absorption values for fenders based on typical data from manufacturers. These values assume a maximum guaranteed energy absorption at 60% compression. While this value should be used for assessing fender requirements, it should be borne in mind that most manufacturers of pneumatic fenders ensure that a safety margin is built in to the design to protect against accidental over-deflection beyond the guaranteed value. This is illustrated in the following graphic:

In the diagram, the guaranteed energy absorption is shown at 60% deflection, equating to an energy absorption index of 1.0. The safety valve is shown to typically lift at a pressure equivalent to approximately 65% deflection, equating to an energy absorption index of 1.3. If subjected to continuing forces, the fender will continue to absorb the energy until the deflection reaches the largest diameter of the mouthpiece metal parts. At this stage, the fender will be subjected to an over-compression equivalent to some 2.3 times the fender’s designed energy absorption capability.
In order to obtain an understanding of the safety margins associated with fenders, operators should consult with manufacturers to determine the design energy absorption capabilities and compressibility limitations of their products.

### 2.3 Approach Velocities

The assessment of approach velocities is not a precise art and is often based on professional estimations from experienced mariners. However, as stated in the STS Guide, the approach velocity can have a dramatic effect on the berthing energy absorption requirements of the fender system. As an example, an increase of about 0.02 m/sec (0.04 kts) in approach velocity could result in approximately 28% increase in energy absorption requirements at berthing approach speeds in the range of 0.15 m/sec (0.3 kts) and a 20% increase at berthing speeds in the range of 0.20 m/sec (0.4 kts).

In reverse lightering operations, the manoeuvring vessel is often fully laden and will therefore be more difficult to manoeuvre alongside in anything other than calm weather conditions. In planning the operation, it is prudent to err on the safe side when selecting fenders and to take account of the potential for increased berthing velocities and higher angles of approach when compared with conventional STS operations. Should fenders of a larger size than required through calculation be available, consideration should be given to their employment.

If the size of available fenders poses limits on acceptable berthing velocities, arrangements should be employed to ensure that these berthing velocities are not exceeded. These would include, for example, imposing environmental limits on the operation or requiring the use of tugs to assist in berthing.

Simulation tools are available to support the assessment of berthing forces in varying environmental conditions and may be useful in determining limiting criteria for an operation.

### 2.4 Stand-off Distances

The avoidance of steel-to-steel contact between vessels during STS operations is addressed in the STS Guide by recommending that fenders are adequately sized to ensure that there can be no contact between ship’s structures through rolling. These principles apply equally to reverse lightering operations. However, the required stand-off distance may be a limiting factor for operations in anything other than calm weather conditions. Dynamic modeling tools can be used to identify optimum stand-off distances in specific conditions.

### 2.5 Equipment Availability

As mentioned above, in some locations, equipment availability may serve to restrict the size and displacements of vessels involved in reverse lightering or the allowable berthing approach velocities to ensure fender energy absorption limits are not breached. Furthermore, the limitations of available service craft to handle the larger sizes of fenders may also pose restrictions on fender availability. Each operation should be planned based on an assessment of available equipment and a joint discussion between vessel operators and STS service providers.

### 3 Summary of Recommendations

The following summarises the key recommendations contained in this paper:

- Before committing to a reverse lightering operation, the parties involved should carry out a risk assessment as outlined in Section 3.1.1 of the STS Guide
- when considering a reverse lightering operation, berthing energy should be calculated using the formulae in Appendix 2 of the STS Guide in order to determine the required fender absorption capability
- due account must be taken of the effect of approach velocities on the berthing energy absorption characteristics of the fender system. Weather, sea and swell conditions will influence the ability of the loaded vessel to manoeuvre during the berthing approach and should be considered as a limiting factor
- should fenders of a larger size than required through calculation be available, consideration should be given to their employment for reverse lightering operations
- if the size of available fenders poses limits on acceptable berthing velocities, arrangements should be employed to ensure that these berthing velocities are not exceeded. These would include, for example, imposing environmental limits on the operation or requiring the use of tugs to assist in
When planning a reverse lightering operation, due consideration needs to be given to the availability of fenders of a required type and size and of equipment, such as service vessels, capable of safely handling them.

Consideration may be given to using STS berthing simulation tools to calculate berthing forces and stand-off distances in varying environmental conditions to assist in the identification of weather windows for an operation.