Performing the ro-ro

This, the 32nd in our regular Knowledge series of how-to articles, puts the theory of how to perform a ro-ro operation into practice. MARCO VAN DAAL explains

After three articles of nautical and marine information combined with vessel behaviour and stability it is now time to look at an actual ro-ro operation and apply the theory of the past three articles.

Ro-ro is short for "roll-on, roll-off" which covers operations from shore to barge and from barge to shore. There is a significant difference between the roll-on and the roll-off operation. So, to further clarify the type of ro-ro operation we talk about load-out (move from shore to barge) or load-in (move from barge to shore).

When preparing for a ro-ro operation it is important to know your environment (tides, depths, type of quay and jetty) as this has an impact on equipment selection, (in terms of the number of ballast pumps, the size of the barge) and type of ro-ro operation (with ramp, with steel plate, grounded barge, floating barge).

We differentiate between five basic types of ro-ro operation;

- Roll-on (roll-off) to free floating barge (tidal)
- roll-on (roll-off) to free floating barge (non-tidal)
- roll-on (roll-off) via steel plates (non-tidal)
- roll-on (roll-off) to barge fixed aground
- beach landing, barge fixed aground.

In nautical and marine operations, reference is often made to documents that have been drafted by classification societies. Complying with the contents of such documents, to a great extent, warrants a safe project performance or at least preparation, to satisfy insurance and-or insurance appointed surveyors. Reference is made to one such document here, the DNV document, *Guidelines for Load-outs* with document number 0013/ND of which the latest revision was issued last December 2015. In section 5 (table 5-1) DNV recognises five types of load-outs, see Figure 1.

NOTE: On 12 September 2013, DNV (Det Norske Veritas) and GL (Germanischer Lloyd) merged into DNV GL, forming the world's largest classification society, with headquarters in Oslo, Norway.

It is important to point out the difference between the two summations of these five ro-ro types as they may seem identical at first glance. There is a distinct difference which could cause confusion.

The DNV classes of load-out (Figure 1) are based on tidal limitations with reference to pumping capacity or pumping requirement whereas the basic five ro-ro operations has expanded that and includes the operational environment.

The two main differences being that DNV does not differentiate between using ro-ro ramps or using a steel plate as the transition between shore and barge. This is because in terms of a pumping requirement it makes no difference. It does, however, make an operational difference in the allowable vertical barge movement, which is much less when using steel plates.

DNV also does not differentiate between a grounded barge at a jetty and a beach landing where a jetty is absent and has to be constructed.

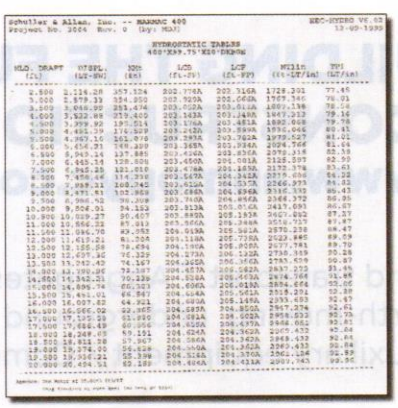
NOTE: Even though the list in Figure 1

FIGURE 1

Table 5-1 Load-out Classes

Class	Tidal Limitations
1	The tidal range is such that regardless of the pumping capacity provided, it is not possible to maintain the barge level with the quay throughout the full tidal cycle, and the load-out must be completed within a defined tidal window, generally on a rising tide.
2	The tidal range is such that whilst significant pumping capacity is required, it is possible to maintain the barge level with the quay during the full spring tidal cycle, and for at least 24 hours thereafter.
3	Tidal range is negligible or zero, and there are no tidal constraints on load-out. Pumping is required only to compensate for weight changes as the load-out proceeds.
4	Grounded load-out, with tidal range requiring pumping to maintain ground reaction and/or barge loading within acceptable limits.
5	Grounded load-out requiring no pumping to maintain ground reaction and/or barge loading within acceptable limits.

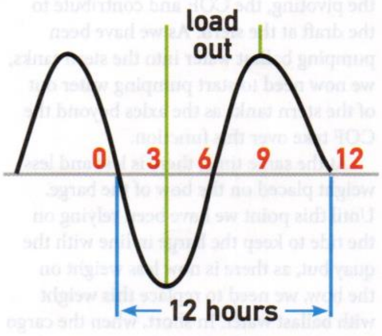
FIGURE 2



ABOUT THE AUTHOR

Marco van Daal has been in the heavy lift and transport industry since 1993. He started at Mammoet Transport from the Netherlands and later with Fagioli PSC from Italy, both leading companies in the industry. His 20-year plus experience extends to five continents and more than 55 countries. It resulted in a book *The Art of Heavy Transport*, available at: www.khl-infostore.com/books Van Daal has a real passion for sharing knowledge and experience and holds seminars around the world.

FIGURE 3



is titled "load-out classes" and the DNV 0013/ND document is called "Guidelines for load-outs", leaving the impression that only load-outs are covered (excluding load-ins), section 1.2 states that load-ins are also covered by this document.

By type

First is a load-out onto a free floating barge with tidal conditions. In every load-out (and load-in for that matter) the barge is pre-ballasted so that the barge deck is horizontally lined up with the quay. Figure 4. Load-outs performed in an area with tidal conditions often make use of buoyancy. While the load or cargo is inching forward onto the barge an increasingly higher load is transferred from shore to barge. The consequence is that the draft (the submerged part of the barge) increases and the freeboard (the part of the barge above the waterline) decreases. How much the draft increases can be determined from the hydrostatic particulars as shown in Figure 2. The first column shows the average draft (in decimal feet) and the second column shows at which displacement (barge weight plus all cargo, fuel, equipment, crew, etc) this occurs.

Ideally, when performing a load-out and the draft of the barge increases, the upcoming or rising tide will bring the barge deck back to the desired level, in line with the quay. This delicate balance has to be monitored throughout the entire load-out. If the cargo is rolled onto the barge too quickly and the tide cannot catch up, the barge deck will end up below the quay. Likewise, if the cargo is rolled onto the barge too slowly, the barge deck will end up above the quay, as the rising tide will not stop and wait.

From the above, we can draw the conclusion that a load-out is preferably performed on a rising tide. As we know that the time between two high tides (or two low tides) is 12 hours and 26 minutes (provided there is no disturbance by land mass and-or restricted water flows, etc.) we can state that the load-out should be completed well within six hours, starting from low tide, as after six hours the rising tide will turn into a falling tide and will work against you. Figure 3.

Does this mean that the load-out can be performed without any ballasting if the rising tide provides sufficient buoyancy? The answer to this question is a resounding "No". Let's assume that the load-out is performed on the bow of the barge. As the load is transferred from shore to barge, the bow of the barge submerses further into the water. At the same time the stern rises (draft at the stern reduces) and the barge will end up with a certain amount of trim. Trim being defined as a difference in draft between bow and stern. The length of the transporter determines the allowable trim, you cannot run out of stroke. DNV 0013/ND document section 14.2.5 recommends not to plan beyond 70 % of the transporter stroke. Generally during a load-out the barge is maintained at near zero trim.

We know from the previous article that the barge moves (pivots) about the centre of flotation (COF). If, for the sake of convenience, we assume that the barge in question is perfectly symmetrical at the bow and the stern, than the COF is exactly at the longitudinal centreline of the barge. This means that if the draft at the bow increases by 30 cm (1 foot), the draft at the stern decreases by 30 cm (1 foot).

NOTE: The actual centre of flotation can be found in the hydrostatic particulars and differs with the draft as the barge in reality is not symmetrical. Column 5 in Figure 2.

Every tonne of weight transferred to the barge at the bow needs to be compensated with water pumped into the ballast tanks at the stern to keep the barge at near zero trim. Figure 5. The principle of moment

FIGURE 4

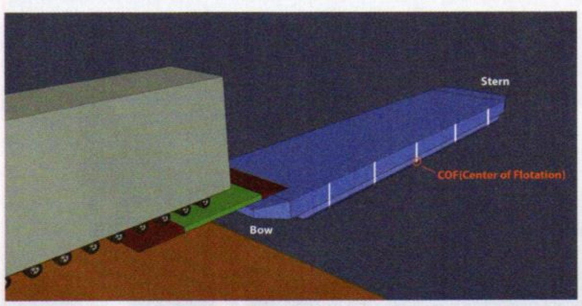


FIGURE 5

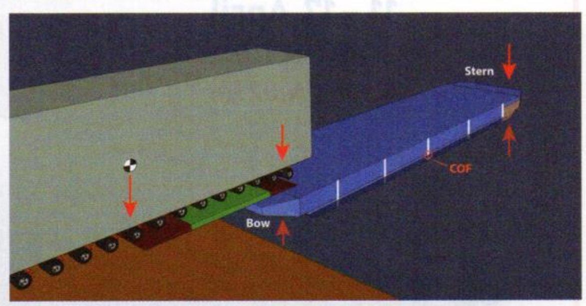


FIGURE 6

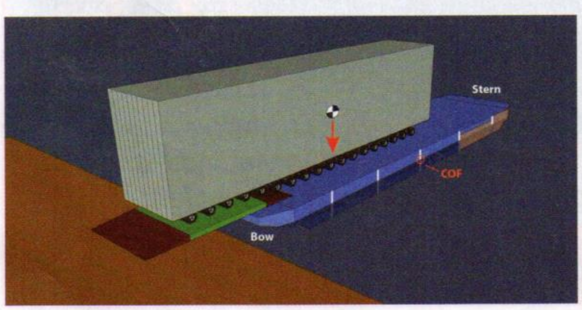
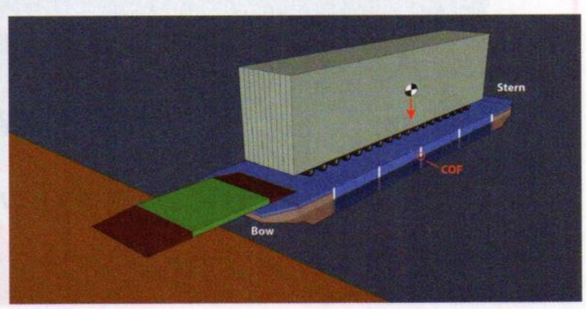


FIGURE 7



about the COF applies. Figure 6.

From the total weight of the barge (including ballast and cargo), the average draft can be read from the hydrostatic tables (column 1) in Figure 2.

The trim of the barge can be calculated with the following formula;

EQUATION 1

$$trim = \frac{displacement * (CoG\text{-}CoB)}{MT1}$$

where;

displacement is equal to the total weight of the barge, cargo, crew, equipment, etc (Archimedes law)

COG and COB are the centre of gravity and centre of buoyancy in longitudinal direction

MT1 is the moment to change trim 1 inch, column 7 in Figure 2.

Notes;
The trim is affected by the term (COG-COB), as the COG gets closer to the COB the barge will show less trim. We cannot influence the COB but we can influence the COG (the combined COG) by means of ballasting. If we manage to ballast the barge in such a way that the COG gets close (or even lines up with) the COB, the barge will remain at near zero trim.

Checking units

MT1 stands for Moment to Change trim by 1 unit (either 1 inch or 1 cm depending on other units in the hydrostatic tables). In Figure 2 the MT1 is Moment to Change Trim 1 inch.

It is important to check that the unit for the displacement (metric ton, long ton, etc) is the same unit as for the MT1 (metric tonne * metre / cm, long ton * foot / inch).

With the above information (average draft and trim) we can determine the draft at the bow and stern of the barge with the following two formulae;

EQUATION 2

$$draft\ bow = av.\ draft - \left(trim * \frac{CoF}{L}\right)$$

EQUATION 2

$$draft\ stern = av.\ draft + \left(trim * \frac{(L\text{-}CoF)}{L}\right)$$

As the axles move beyond the centre of flotation something changes. These axles now place load on the barge beyond the pivoting, the COF, and contribute to the draft at the stern. As we have been pumping ballast water into the stern tanks, we now need to start pumping water out of the stern tanks as the axles beyond the COF take over this function.

At the same time, there is less and less weight placed on the bow of the barge. Until this point we have been relying on the tide to keep the barge in line with the quay but, as there is now less weight on the bow, we need to replace this weight with ballast water. In short, when the cargo moves beyond the COF, the stern needs some de-ballasting while the bow requires the addition of ballast to keep the barge at near zero trim.

Once the cargo is in its final location (often required to be confirmed by a marine warranty surveyor) it is common that both bow and stern tanks contain a certain amount of water. The exact amount of water depends on the required or preferred draft. Figure 7.

When a barge is being prepared for its voyage it is often trimmed so that the bow sits slightly higher than the stern (some 1 to 2 degrees) as it aids its hydrostatic behaviour and reduces fuel consumption of the tug boats. ■