TECHNICAL INFORMATION

BOLLARD PULL TRIAL CODE

For Tugs with Steerprop Propulsion

Steerprop

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A Skogman / 22 March 2001

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FOR TUGS WITH STEERPROP PROPULSORS

This Bollard Pull Trial Code is established to define the procedures of performing bollard pull trials in a manner that ensures repeatability as well as comparability for trials performed at different locations and/or with different vessels. The need for this code originates from the lack of an acceptable standard for bollard pull trials, as well as from the large variation in requirements for bollard pull trials in the rules of different classification societies. In the compiling of this code the rules and requirements of BSRA (1961), Lloyd's Register of Shipping (1992), Det norske Veritas (2000), American Bureau of Shipping (xxx), Germanischer Lloyd (xxxx) and Bureau Veritas (1985) have been used as a basis.

1 General

Bollard pull trials are conducted in order to determine the static pull that a tug is able to employ in operating conditions. To enable fair comparison, the trials are not performed in typical operation conditions (e.g. shallow and confined harbour basin), but in conditions as close to ideal as possible, i.e. in conditions where the environmental and external effects are minimised.

This code introduces the minimum requirements for trial site, vessel state and environmental conditions as well as the actual procedures for conducting the trials and definitions on bollard pull, to be used on tugs equipped with Steerprop Azimuth Propulsors.

2 Trial Site and Vessel Requirements

The trial site should be carefully chosen to minimise the effect of the environmental conditions. The following minimum requirements have to be fulfilled with regard to trial site and vessel state.

2.1 Trial Site

Recommendation

The location for the trials should be chosen with no piers, docks, jetties breakwaters or other obstructions close to the tug. The best place for the bollard is on a legged jetty with no wall, allowing the propeller wake to flow through/under the jetty. If a solid pier is chosen the bollard should be located as to give a clear run for the propeller wake, see fig. 1 and 2.

The water depth on the trial site should comply with the below requirements (see chapter 2.2 Water Depth).

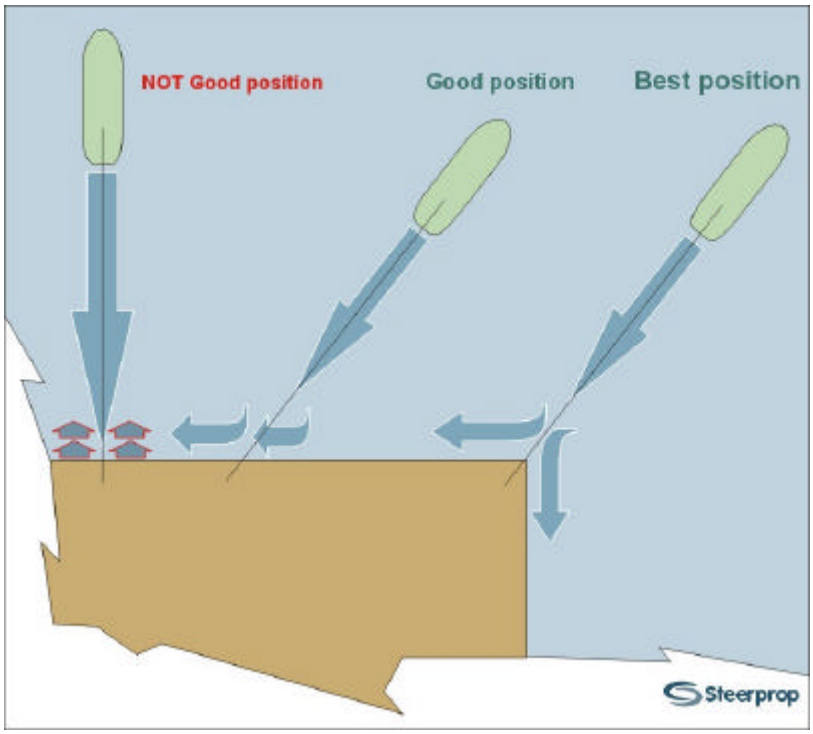

Fig. 1 Positioning the tug for bollard pull trials

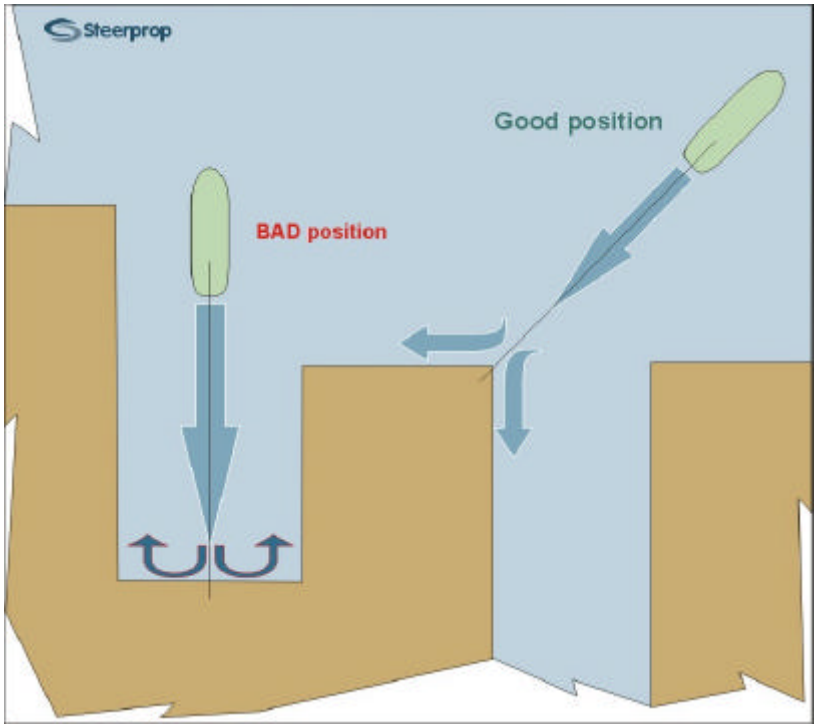

Fig. 2 Positioning the tug for bollard pull trials

2.2 Water Depth

In order to achieve a fair bollard pull the build-up of water circulation has to be avoided. Water circulation is generated by the propeller wash and available amount of water below and around the vessel – in very confined and shallow water there will certainly be circulation. Hence the water depth has to be as large as possible, not only below the tug but also around it.

Requirement

Minimum required water depth within a radius of 100 m from the tug is obtained as depth below the keel (see fig. 4) using equation (1), from the graph in fig. 3, or from table 1.

$$d_{min} = k_1 * (k_2 * P^a - k_3 * P^b) + 3 \ [m] \qquad (1)$$

where

d_{min}	=	minimum required depth under the tug
k_1	=	0.060
k_2	=	52.00
k_3	=	46.26
P	=	total propulsion power [kW]
a	=	0.60
b	=	0.61

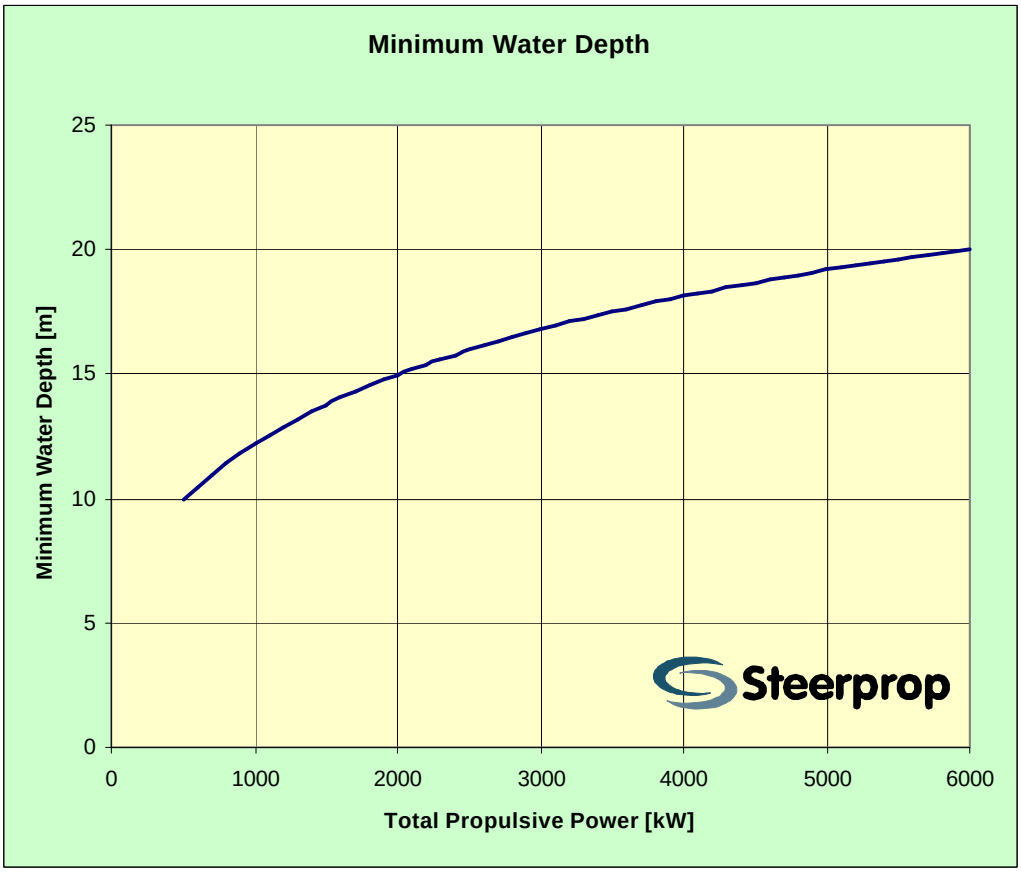

Fig. 3 Minimum required water depth below the keel of the tug

Table 1. Minimum required depth under the keel

Total propulsive power [kW]	Required depth under the keel [m]
1000	12.2
1500	13.8
2000	15.0
2500	16.0
3000	16.8
3500	17.5
4000	18.1
4500	18.7
5000	19.2

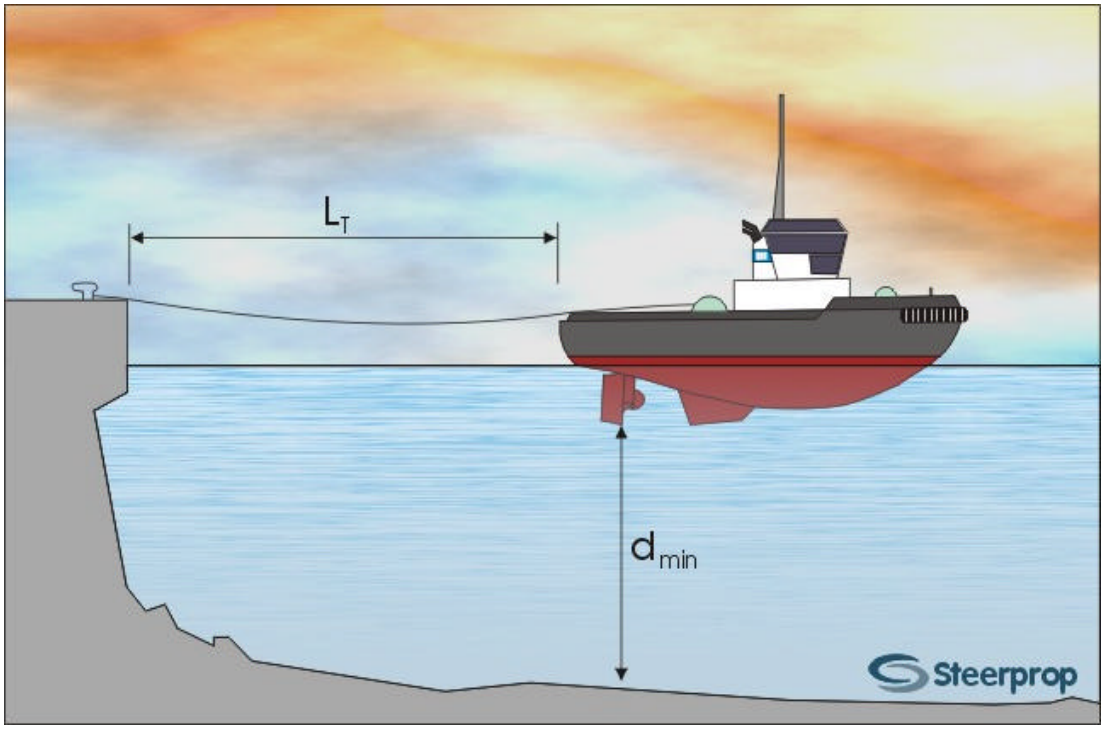

Fig. 4 Definition of towline length and depth below the keel

2.3 Towline Length

For practical reasons bollard pull trials are usually conducted in the confined waters of a harbour basin. In order to avoid the influence of a solid pier the towline should be as long as possible.

Requirement

The length of the towline – measured between the edge of the pier or shoreline and the stern of the tug (see fig. 4) – must not be less than given by equation (2), obtained from the graph in fig. 5 or from table 2.

$$L_T = k_1 * P^a - k_2 * P^b \quad [m] \qquad (2)$$

where

L_T	=	minimum required towline length
k_1	=	52.00
k_2	=	46.26
P	=	total propulsion power [kW]
a	=	0.60
b	=	0.61

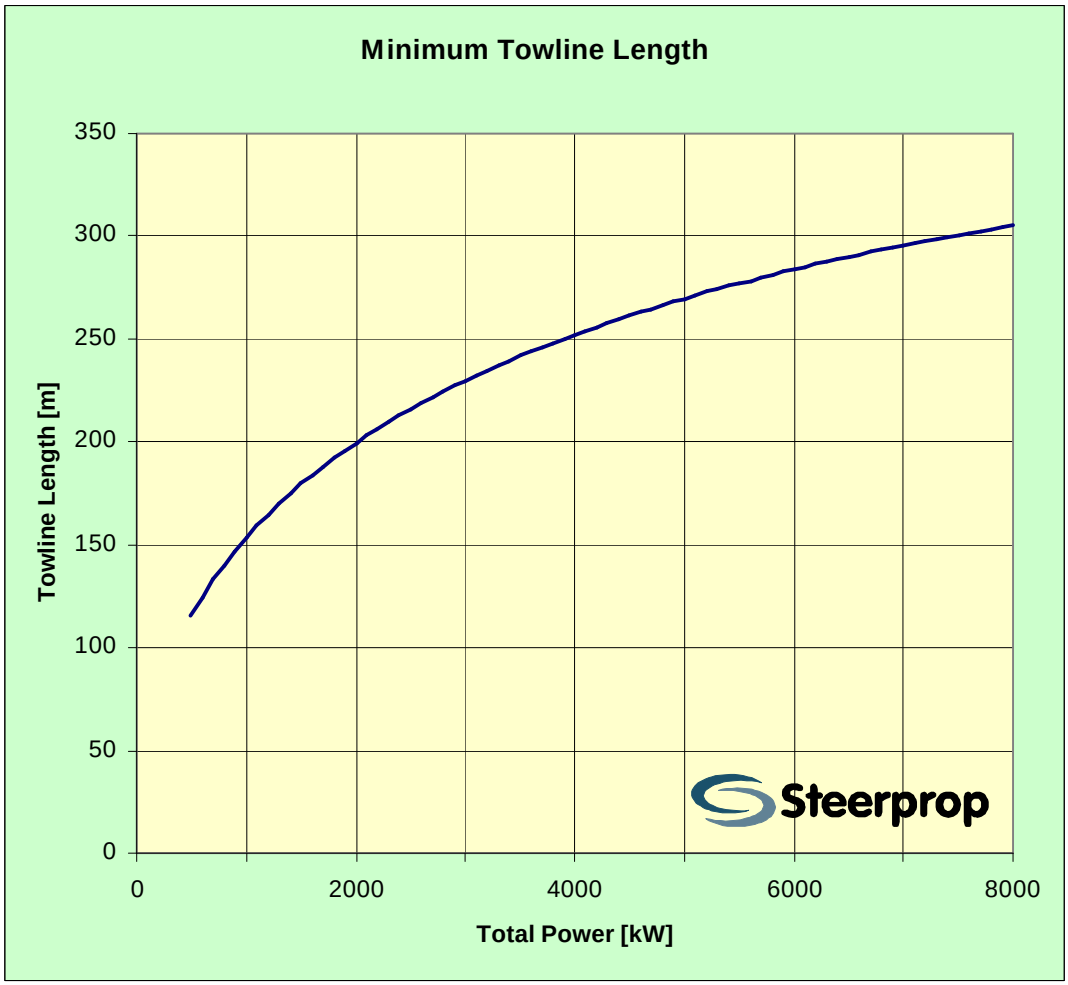

Fig. 5 Minimum required towline length for bollard pull trials

Recommendation

It is, however, recommended that a towline of at least 200 m be used, although the required towline length is less.

Table 2. Minimum required towline length

Total propulsive power [kW]	Required towline length [m]
1000	153
1500	179
2000	200
2500	216
3000	230
3500	242
4000	252
4500	261
5000	270

2.4 Draft

Requirement The tug has to be loaded to its construction waterline in order to ensure an adequate immersion of the propellers.

2.5 Trim

Recommendation The tug should be trimmed on even keel or with a stern trim. If the propulsors are tilted (not vertically installed) an aft trim will be beneficial.

3 Environmental Conditions

The influence of wind and current can be significant on the trial results and thus the following requirements have to be followed.

3.1 Wind Speed

Requirement The wind speed during the trials shall not exceed 5 m/s.

If wind gusts causes the vessel to yaw significantly the test should be stopped and repeated.

3.2 Current

Requirement The trials should be conducted in waters with no current, wherever possible. The current must not exceed 1 knot (a current of 1 knot from the bow correspond to a drop in bollard pull of approx. 4 %).

In areas with tidal current special attention has to be taken in the timing of the trials. The trials should be started 1 …1.5 hours before high tide, when the current speed is less than 1 knot and the water level only slightly below maximum. This timing allows for a retrial if required. Trials after high tide should be avoided.

During the trials the direction of the current should be from the stern. Current from the bow or from the side are not acceptable, see fig. 6.

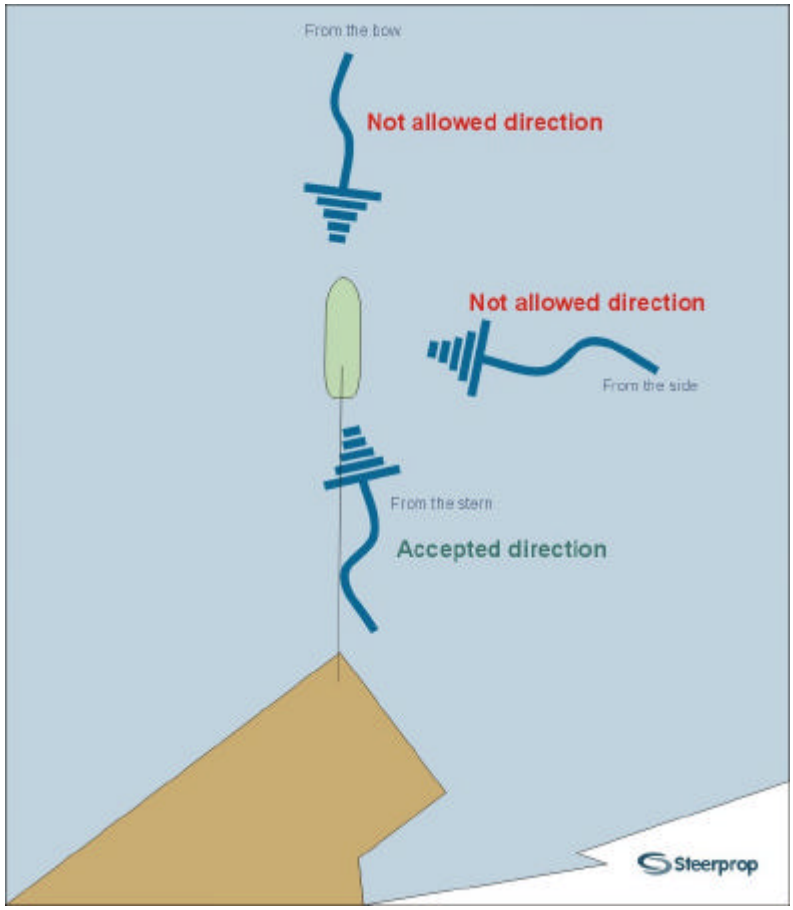

Fig. 6 Definitions of current directions and accepted direction

4 Trial Procedures

4.1 Preparations

The main engines have to be warmed up before starting a bollard pull trial. In order not to disturb the water on the trial site, the warming of the engine and preliminary engine adjustments need to be completed before bringing the tug into position for the trials.

Requirement

Where the trails are to cover a range of different propeller revolutions / engine powers, the maximum bollard pull has to be conducted first, while the water on the site still is as undisturbed as possible. Subsequent bollard pull measurements as well as re-trials should not be carried out directly after last test, but a period of at least 10 minutes should be allowed for the water to settle.

The build-up of water circulation around the tug should be monitored and must not exceed 0.5 m/s.

4.2 Trial Set-up

4.2.1 Dynamometer

Recommendation The bollard pull should be measured using an electric / electronic dynamometer, with a measuring range suitable for the bollard pull in question. Alternatively a mechanical load gauge may be used.

The dynamometer should be calibrated, preferably both before and after the trials. Maximum acceptable deviation within the measuring range is less than ±2%.

4.2.2 Towline Set-up

Recommendation The bollard pull should be taken on the normal towing winch, hook or towing bit of the tug. The dynamometer should be connected between the bollard and the towline ashore. Where this is not feasible, the towline may be connected between the towline and the towing hook onboard the tug.

Special attention should be paid to the towline at the pier edge. The towline should not be allowed touch the pier between the dynamometer and the tug, as the friction in this contact is prone to reduce the dynamometer readings. If this cannot be avoided, a roller under the towline should be utilized.

4.2.3 Communication

Requirement With the load cell ashore, communication between the tug and the shore station has to be provided, either by mobile phones or be VHF. Before the test it should be ensured that the telecommunication does not disturb the data logging.

4.3 Steering During Trials

Recommendation A tug can normally not be maintained in position during bollard pull trials without steering. Steering action will, however, affect the bollard pull and should be kept to a minimum. If possible the vessel should be allowed to seek its natural position.

If any violent yaw or steering motions occur during the trials the test should be repeated.

4.4 Engine Power and Revolutions

The only way to accurately determine the actual engine power in bollard pull trials, is by measuring the torque on the intermediate shaft, using a torsion meter. Fuel consumption, fuel rack position, exhaust temperature readings may contain inaccuracies in power of up to 5%.

In many cases it is considered satisfactory to relate the bollard pull to the engine revolutions.

4.5 Bollard Pull Reading

Recommendation The bollard pull should during the tests be continuously recorded by a data logger / computer. Alternatively a graphic recorder may be used.

If this is not possible or if a mechanical load gauge is used, the gauge should be monitored continuously and the readings should be recorded at 30 seconds' intervals during the test.

4.6 Accuracy

4.6.1 Load Cell Accuracy

Requirement

Maximum acceptable deviation of the dynamometer used in the tests – within the measuring range – is less than ±2%.

4.6.2 Accuracy of the Result

"Whilst the accuracy of bollard pull measurement necessarily depends on the reliability and cumulative accuracy of all instruments utilized in the measurement process, it is anticipated that the accuracy of certified bollard pull at the stated machinery output will be contained within 5 % of the true value" (Lloyd's Register of Shipping)

5 Bollard Pull

5.1 Sustained Bollard Pull

Sustained bollard pull is the mean value of the pull during a 5 minutes' test. If the readings are recorded at 30 seconds' intervals, sustained bollard pull is the mean value of these readings during a 5 minutes' test.

5.2 Maximum Static Bollard Pull

Maximum static bollard pull is the mean value of the highest 30 seconds measured during the 5 minutes' test. If the readings are recorded at 30 seconds' intervals, maximum static bollard pull is the highest mean value of two subsequent readings.

5.3 Maximum Bollard Pull

Maximum bollard pull is the highest measured single value.

6 Corrections

6.1 Correction for Shallow Water and Short Towline

If it is not possible to fulfil the requirements of minimum towline length according to chapter 2.3 in this code or the requirement of minimum depth below the keel according to chapter 2.2 in this code, the measured bollard pull shall be corrected using equation (3) and a correction factor obtained from fig. 7.

$$BP = k_1 * BP_m \qquad (3)$$

where

BP = Sustained bollard pull
k_1 = correction factor from fig. 7
BP_m = Measured sustained bollard pull

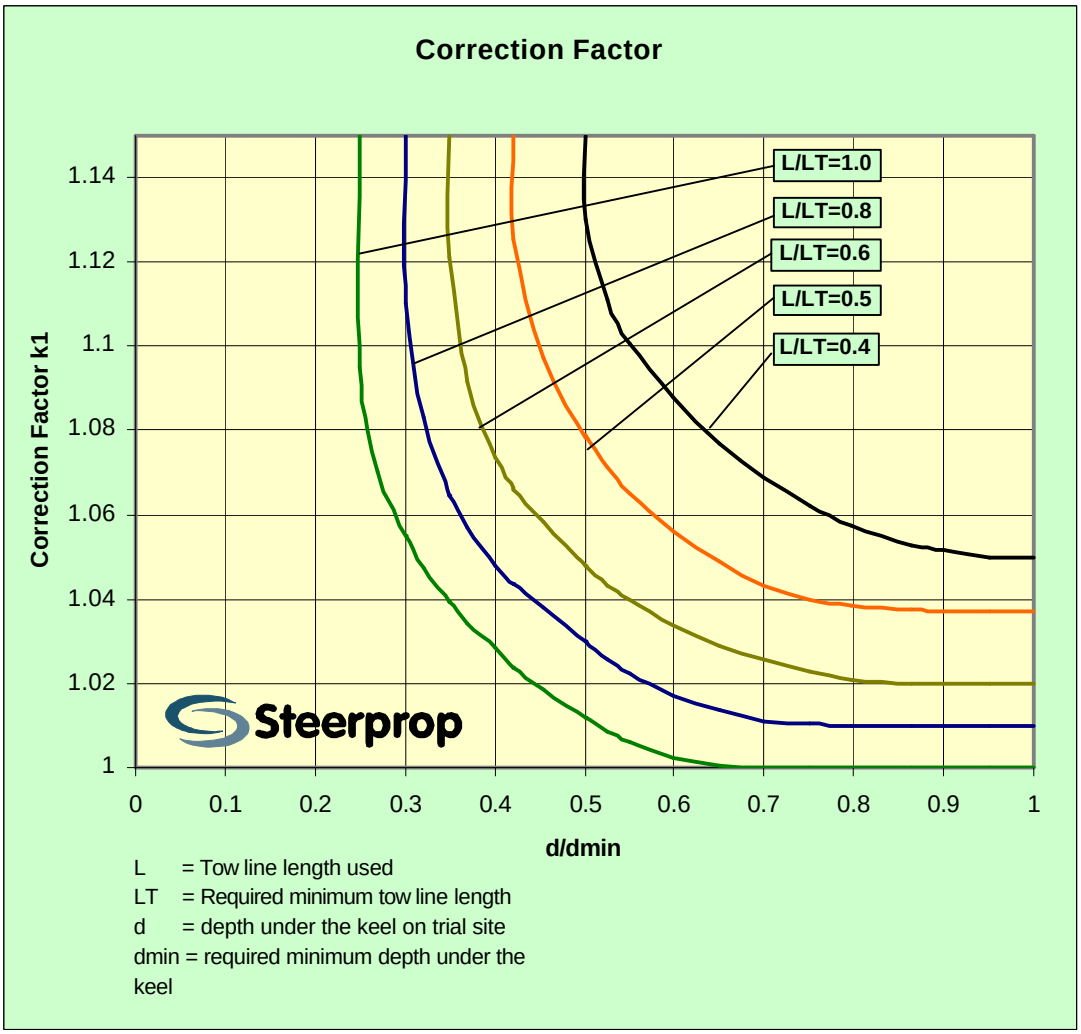

Fig. 7 Correction factor for shallow water and short towline

Steerprop Ltd.
P.O. Box 217
FIN-26101 RAUMA
Finland

e-mail: steerprop@steerprop.com
phone: +358 2 8387 7900
fax: +358 2 8387 7910