CLASS GUIDELINE

DNVGL-CG-0155  Edition February 2016

Full scale testing of escort vessels
FOREWORD

DNV GL class guidelines contain methods, technical requirements, principles and acceptance criteria related to classed objects as referred to from the rules.

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Any comments may be sent by e-mail to rules@dnvgl.com

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This is a new document.
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SECTION 1 INTRODUCTION

1 Preamble

The purpose of this class guideline is to guide and ensure a uniform way of executing full scale testing for the assignment of the Society’s class notation \( \text{Tug(Escort } (F_S,t,v)) \). The Society’s focus during the test will be to monitor and ensure safe execution of the test, that stability criteria are fulfilled, and that the design behaves in a safe manner in any operational position.

2 General

Escorting is different from conventional towing in many ways. Conventional towing takes place in smaller harbours at low speeds (2-3 knots). The tug provides a towing force to the assisted vessel that is mainly a function of the tug’s thruster capacity in terms of pure power. Escorting, on the other hand, takes place at higher speeds (6-10 knots). The towing force is not explicitly dependent on the thruster capacity, but more a function of the hydrodynamic flow field around the tug's hull. See Figure 1.

As the hydrodynamic forces acting on the tug’s hull increase approximately with the square of the speed, the steering ability increases more than proportionally with the speed. Escort service is therefore normally undertaken in the speed range of 8 to 10 knots.

The notation \( \text{Tug(Escort } (F_S,t,v)) \) means that the escort tug is capable of providing a continuous transverse steering force of \( F_S \) tonnes to the towing wire used to control the assisted vessel while proceeding at a forward speed of \( v \) knots. Furthermore, it can manoeuvre from a specific operational position in the aft of the assisted vessel to a corresponding position on the other side in \( t \) seconds. Several force-speed combinations are possible in the class notation. The force and time measurements have to be performed following the hereby prescribed test procedure, and the vessel shall show outstanding dynamic stability to meet the requirements of the class notation.

![Figure 1 Escort (left) vs. Conventional towing (right)](image-url)
3 Purpose

The purpose of the test is to determine the escort rating parameters ($F_S, t, v$) as defined in the DNV GL Rules for Classification of Ships RU SHIP Pt.5 Ch.10 Sec.11 [1.3.4].

In RU SHIP Pt.5 Ch.10 Sec.11 [6.5], the limiting criteria for escort operations are determined by applying a heeling moment to the tug and ensuring there is a certain amount of reserve stability beyond the equilibrium state. Furthermore, the strength and capacities of towing line components will also need to be taken into consideration.

The only reliable means of determining the escort rating number are approved full scale sea trials where the topline force $F_W$ is carefully selected from within certain time periods during which heeling angle does not exceed the critical heeling angle value from the approved stability booklet, and thus ensures that the vessel is operating constantly during that period in a safe manner. This value for $F_W$ combined with the respective $\theta$ - $\beta$ angles combinations should then be used to establish $F_S$ ($\theta$ and $\beta$ as defined in RU SHIP Pt.5 Ch.10 Sec.11 [1.3]). It is noted that any different loading condition than the one used for the sea trial will result in different $F_W$, i.e. different escort ratings, and it is the responsibility of the party requesting the test to load the tug in such a way as to achieve a maximum escort rating number without exceeding stability and winch criteria from the rules.
SECTION 2 FULL SCALE TESTING

1 Test description

The following tests shall be undertaken during the full scale sea trial:

Measurement of steering force $F_S$

The escort tug will connect its towing line wire to the assisted vessel’s stern and follow it with the wire slack, both ships travelling at the same speed. The tug will then position itself at an agreed angle of attack relative to the flow of water, thus generating a hydrodynamic force (lift and drag force) on the submerged hull of the tug which is used to steer the assisted vessel and the resulting towline tension $F_W$ shall be recorded. These readings combined with the respective $\theta$-$\beta$ angles combinations should then be used to establish $F_S$.

Manoeuvre test (measurement of $t$)

The escort tug will shift its position from a steering position minimum 30° from one side of the assisted vessel, i.e. $\theta$ angle is 60°, to the mirror position in the opposite side and $t$ will be the time required.

2 Information required prior to the test

A test programme should be prepared well in advance and submitted for acceptance to the Society by the company requesting the testing. The programme must contain all necessary information to ensure safe and efficient execution of the tests and is as a minimum to cover the requirements in the rules.

Together with the test programme a safety analysis report covering all relevant aspects during the test shall be submitted (to the Society) for information. International, national and local safety and environmental protection regulations shall be adhered to at all times.

It is the owner’s or the building yard’s responsibility to arrange for a full scale test to demonstrate compliance with the rules. It is also their responsibility to organise all practicalities with respect to escorted vessel, test site, supplying necessary test equipment, organising the test and documenting the results to the Society. The Society’s surveyor(s) will attend the test for the purpose of witnessing compliance with the agreed test programme.

3 General preparations for the test (procedures and checklist)

A suitable ship to be steered should be made available for a few hours to obtain the greatest towline force the tug can deliver at the speed $v$. A smaller ship will require a smaller steering force and hence result in a lower rating number.

The following items shall be documented in the test programme (obtained through tests, model measurements, estimates etc.):

- layout of towing arrangement (speed and heading of the vessels, towline path, wire length and breaking strength/capacities of towline components, approximate steering angle $\theta$ and oblique angle $\beta$ to be used during steering pull test)
- calculations of towline force $F_W$, steering force $F_S$ and braking force $F_B$ components at test speed including propulsion forces for balancing of oblique angular position of tug. It shall be noted that maximum values for $F_S$ and $F_B$ occur in different configurations, i.e. for different sets of $\theta$-$\beta$ angles
- stability calculations (both departure and arrival) proving that the vessel duly complies with the criteria by IMO (A749 Chapters 3.1 & 3.2) together with the two stability criteria described in the rules RU SHIP Pt.5 Ch.10 Sec.11 [6.5].
- information on towing winch (including brake capacity and pay-out/haul-in settings when in auto-tension mode). Towing winch shall be set to pay out automatically before the pull reaches 110% of the rated towline force $F_W$
- main engine and propulsion system, type and power
- documentation verifying assisted vessel’s strong point used during test. It shall be noted that towline may have a 90° angle to the transom of escorted ship, adding a sideways force to the fairlead used. If
a certificate with Safety Working Load (SWL) is not available, a written confirmation from the Master of the escorted vessel with the maximum acceptable wire pull and corresponding wire directions will be acceptable
— information about measuring equipment to be used during the test
— means of communication during test
— plan and preliminary time schedule of the test.

The steering angle θ and oblique angle β should be estimated before the test. They may be taken from model tests or other design data, or may be decided based on a separate test prior to the class-required sea trial. Markings for every 10° angle should be painted on the vessel’s bulwark for easier approximation of θ angle during execution of the test. However, for a towing staple where the towline can move within a large opening there should be two separate groups of angle markings painted on the bulwark, and, in addition, the 90° angle starting point for each group should be aligned with the towing staple boundary. See Figure 1 below.
The methods used for obtaining the above angles and forces shall be described in detail in the test programme. The equipment intended to be used shall be described and documented with respect to technical data, calibration, responding time etc., as relevant for each individual piece of equipment. The equipment may be the tug’s and the escorted vessel’s permanent equipment or it may be special equipment used during the test.

*Status of relevant measuring equipment (check-list):*

- load cell (type, capacity, measuring error and calibration certificate – to be calibrated at least once in the past year). The accuracy of the load cell should be ±2% within a temperature range and a load range
relevant for the test. If supplied by an external company, they should be informed about test procedure, hooking up, frequency to be used for measurements and results

- inclinometer (gyro type alternatively G-type accelerometer with filtering for removing horizontal and vertical accelerations due to towing line and weather influences, as these may otherwise influence the read-outs)
- global and internal positioning system, e.g. DGPS system connected with gyro compass
- synchronisation of all system clocks on separate measuring equipment (all automatic readings preferably to show real time)
- minimum 0.5-1 Hz to be used in general for continuous readings
- back-up recording system
- stop watches (minimum two) to be used for manoeuvre test
- system for relaying continuous readings from speed log.

Recordings during each separate test from all measuring equipment shall be simultaneous. The duration of the “steady” readings part of each test shall be estimated in the test programme. It is obvious that real steady situations may be difficult to obtain, so whether the “steady period with recorded data” is sufficient or not and whether this data was obtained for a heeling angle below the critical heeling angle should be agreed immediately after each test. If not, the test shall be repeated.

Tank contents and general loading of the tug for the test shall be as close as possible to either escort departure or escort arrival loading conditions from the approved stability booklet, or a similar loading condition may be used that can be considered in between the two above.

From a stability point of view, failure to do so can result in the escort stability criteria not being satisfied, and the vessel reacting in unpredicted ways or even capsizing, while from a certification point of view, no critical heeling angle criteria are set and thus no indication regarding which load cell readings were within acceptable limits may be established.

When the vessel is still in harbour and before leaving quay-side to perform the test, the following parameters shall be recorded and verified in accordance with approved stability loading condition:

- draught forward/aft
- filling of tanks ballast water/fuel oil/fresh water (slack tanks to be kept to a minimum)
- height above waterline of the towline connection, i.e. the location where the towline leaves the tug crucifix or winch.

The following information for the assisted vessel shall be provided:

- name, DNV GL id (if relevant) and IMO No.
- main dimensions
- aft draft
- height of fairlead/chock above waterline and transverse position from centre line.

When on board the subject vessel on the test location, the following parameters to be recorded:

- weather (wind direction and strength, sea state, current)
- geographical information (test location).

*Pre-briefing*

All parties involved in the test, normally as a minimum:

- the Master and crew on board the tug vessel
- the Pilot, Master and officers on board the assisted vessel
- dedicated personnel with responsibilities for recordings, observations etc. on board the two vessels
- the attending DNV GL surveyor(s),

shall be briefed by the person responsible for the test (nominated non-Society person). The briefing shall be arranged before tests commence. The briefing should also cover the safety requirements to be adhered to during the test.
4 Operational parameters – test execution

Before commencement of the tests, it should be verified, as a minimum, that the following is in good working order and/or otherwise found acceptable by the attending surveyor (how this will be verified shall be reflected in detail in the test programme):

— winch mechanical brake shall be disconnected during the tests and winch to operate in auto-tension mode
— the towing winch pays out towing line automatically before the pull exceeds 110% of the rated towline force $F_W$
— the quick release of the towing winch works properly from all relevant positions and after an emergency release the winch brakes shall be in normal operation without delay
— same towline length to be used on both manoeuvre and pull test
— personnel involved should be familiar and comfortable with the tests planned (Master is qualified and trained, there is a watchman familiar with tug operations located near the quick release, etc.)
— no personnel allowed on neither tug nor assisted vessel’s deck while towline is under tension
— a system for communication is established between all parties involved in the tests
— the documentation for the fix point and the fairlead on the assisted vessel is acceptable for the expected loads
— a short test run has been performed verifying that reading/measuring of defined parameters in real time is recorded as planned with a satisfactory frequency
— backup readings to be recorded manually throughout test (see example “Escort test form”)
— assisted vessel to maintain course and speed during the test (auto-pilot can be used if size of vessel is sufficient to withstand steering forces from tug without using too large angles. If necessary, own rudder and engine to maintain course and speed to be used)
— try to achieve minimum 30 seconds interval of stable readings for each part of the pull test
— manoeuvre test to be measured as the interval between measured pull on one side and to the other (max pull not required and stable position required only at start position)
— no overload of tug with respect to cooling water, exhaust temperature and scavenging air should be observed for the duration of the whole test. All auxiliary equipment such as pumps, generators and other equipment which are driven from the main engines or propeller shafts in normal operation of the vessel to be connected during the test
— the prerequisites in the safety analysis are adhered to and safety measures considered acceptable.

The following data shall be continuously recorded, as a basis for determining the Escort rating and in order to verify that the escort vessel operates safely in all typical escort operations:

— towline tension during the steering pull and manoeuvre test
— towline length
— towline angle $\theta$ used during the steering pull and manoeuvre test
— oblique angle $\beta$ used during the steering pull test
— heeling angles on tug during the steering pull and manoeuvre test
— speed through the water of the escorted vessel during the steering pull and manoeuvre test
— time for the tug to shift its position from a steering position 30° from one side of the escorted vessel, i.e. $\theta$ is 60°, to the corresponding position opposite side (manoeuvre test)
— necessary samples of back-up readings
— weather condition and sea state
— tug’s actual loading condition and draught
— assisted vessel name, registry and particulars, including draughts and deadweight.

The speed should be taken relative to the sea. Estimates of current during the trials may be required. The current may be estimated by logging speed by GPS and relative log in separate runs while proceeding with and against the current.

Verification of test results/debriefing:
— critical heeling angle shall be verified. Sea test results exceeding critical heeling angle from approved escort stability calculations will not be accepted
— verify computer recordings with manual backup readings
— discussion of the execution of the test, verify no anomalies took place, and identification of possible sources of error in the automatic/manual readings.

5 Test report

After successful completion of the sea trial, a test report shall be forwarded to the Society. Representative periods of minimum 30 seconds may be selected and all recorded data from each period synchronised and presented in tabular form including arithmetic mean values. These load cell readings combined with the respective θ -β angles combinations should then be used to establish the steering force $F_S$.

Heeling angle of the vessel during these representative periods shall under no circumstances exceed critical heeling angle from approved escort stability loading condition.

The heeling angle together with the steering force from the sea trial can then be used as limiting parameters for the pilot of the tug to know during any actual operation what the vessel can safely deliver.

These results will also be reflected in the Escort Certificate and the re-issued Appendix to Classification Certificate, and a relevant memorandum to owner (MO) prepared.
SECTION 3 DESIGN CRITERIA

1 General

Due attention shall be paid, during the design phase of the escort vessel, to the balance between hydrodynamic forces, towline pull and propulsion forces. In order for the escort tug to be well balanced, the skeg and the towing line connection, i.e. the location where the towing line leaves the tug, should be located not too far from each other. This causes a well-balanced vessel and minimum requirements on the thruster pull to balance the turning moment. However, the towing line connection should at all times be located upstream relative to the pressure centre on the skeg, where the total hydrodynamic force is considered to be acting.

If the tug loses thruster supply, which may be experienced beyond certain angles of water inflow to propulsion units at higher speeds, the resulting turning moment set up by the hydrodynamic force on the skeg and the towing line force should turn the vessel into a reduced angle of attack relative to the inflow, with a subsequent reduction of the turning moment. This is a condition where the tug fails to a safe position, i.e. “fail safe”. On the other hand, if the towing line connection is located downstream relative to the skeg’s pressure centre, the tug will experience a constantly increasing turning moment in case of thruster failure. The tug will then not fail to a safe position and can, as a worst case, capsize. See Figure 1.

The Society reserves the right to request a test to verify that the vessel “fails to a safe” position, if deemed necessary.

Additional uncertainty that may arise for tug operations in an offshore environment with its related waves includes the following:

— the motions of the tug in waves can cause extreme line loads resulting in the towline breaking or even the tug capsizing when high loads are applied transverse to the tug
— green water on the deck and/or immersion of freeboard deck can severely affect the stability of the tug as well as the safety of the crew
— large tug motions and relative wave motions can result in thruster ventilation and reduced thruster efficiency.
**Figure 1 Balance between hydrodynamic forces and towline force**

Prediction of forces acting on the tug when escorting is necessary for scantling, manoeuvrability and preliminary stability calculations. Model testing is considered an indication of hydrodynamic forces for indirect towing.

If the vessels’ arrangements, hull structure, machinery equipment, stability data, loading conditions and lightship weight are very similar, the Society may consider using the sea trial results of one ship as basis for designation of the **Tug(Escort)** notation, i.e. same escort rating number, to the sister vessels.
APPENDIX A ESCORT TEST RESULTS SCHEME

Place:
Attending surveyors:

Weather & Geographical information:
test location:
wind (strength/direction):
sea state:
current:

Vessel nominated for Tug(Escort) notation:
name:
DNV GL id:
IMO no:
draught aft:
draught forward:

Content of tanks (full/partially filled)
ballast water:
fuel oil:
fresh water:
height from Waterline (WL) to towing line connection, i.e. location where towline leaves crucifix or tug winch:

information above is in accordance with approved stability calculations (tick off):

Assisted vessel:
name:
DNV GL id (if relevant):
IMO no:
Main dimensions
L =
B =
D =
displacement:
draught aft:
draught forward:

height from WL to strongpoint (approximately mooring deck):
strongpoint transverse position from centre line (if relevant):

Towing line components & fixations:
— estimated max wire pull force during the test:
— breaking strength of towing wire:
— automatic pay-out of towing winch set at:
— strongpoint verified to have higher capacity than expected wire pull (ref. to drawing or Master’s confirmation):

If there are more than one possible towing attack points on tug, note which point was used during the test:
## Operational parameters (checklist)

<table>
<thead>
<tr>
<th>Pre-briefing carried out</th>
<th></th>
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<tbody>
<tr>
<td>Winch mechanical brake shall be disconnected during the tests and winch to operate in auto-tension mode</td>
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<td>The quick release of the towing winch works properly from all relevant positions and after an emergency release the winch brakes shall be in normal operation without delay</td>
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<td>Same towline length to be used on both maneouvre and pull test</td>
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<td>Personnel involved shall be familiar and comfortable with the tests planned (Master is qualified and trained, there is a watchman familiar with tug operations located near the quick release etc.)</td>
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<td>No personnel allowed on neither tug nor assisted vessel’s deck while towline is under tension</td>
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<td>A system for communication is established between all parties involved in the tests</td>
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<td>The documentation for the strong point and the fairlead on the assisted vessel is acceptable for the expected loads</td>
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<td>Backup readings to be recorded manually throughout test</td>
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<tr>
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<tr>
<td>Manoeuvre test to be measured as the interval between measured pull on one side and to the other (max pull not required and stable position required only at start position</td>
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<tr>
<td>No overload of tug with respect to cooling water, exhaust temperature and scavenging should be observed for the duration of the whole test. All auxiliary equipment such as pumps, generators and other equipment which are driven from the main engines or propeller shafts in normal operation of the vessel shall be connected during the test</td>
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<tr>
<td>The prerequisites in the safety analysis are adhered to and safety measures considered acceptable</td>
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</tbody>
</table>

### Steering force test

Load cell certificate in place (tick off):

#### Data to be recorded:
- towing wire force
- tug heeling angle
- wire angle ($\theta$)
- oblique angle ($\beta$)
- assisted vessel’s speed through water.

#### Tests:
10 knots / 8 knots

Cable length (from bollard to bollard):
<table>
<thead>
<tr>
<th>Time</th>
<th>Towing wire force</th>
<th>Tug heeling angle</th>
<th>Wire angle (θ)</th>
<th>Oblique angle (β)</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>
Manoeuvre test
Cable length (from bollard to bollard):

<table>
<thead>
<tr>
<th>Speed (knots)</th>
<th>Recorded time PS -&gt; SB</th>
<th>Recorded time SB -&gt; PS</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 knots</td>
<td></td>
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<tr>
<td>8 knots</td>
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</tr>
</tbody>
</table>

F<sub>w</sub> = Towline force
F<sub>s</sub> = Steering pull
F<sub>b</sub> = Braking Pull
β = Oblique angle
θ = Towline angle
CHANGES – HISTORIC

There are currently no historical changes for this document.
Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16,000 professionals are dedicated to helping our customers make the world safer, smarter and greener.