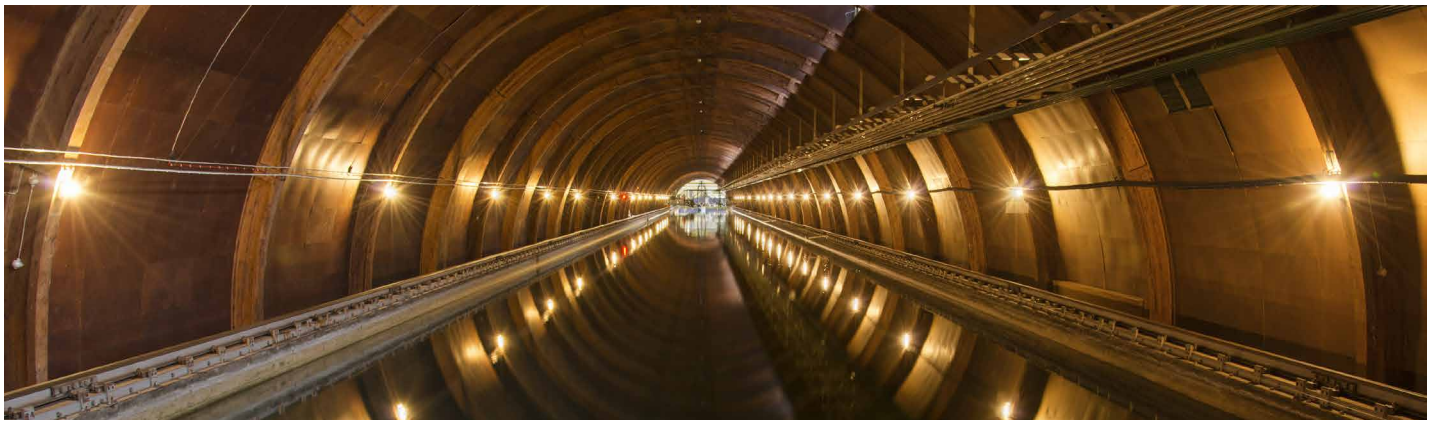
A fair trial – how to obtain the correct EEDI

In order to cap greenhouse gas emissions, the International Maritime Organization (IMO) recently passed a resolution on the Energy Efficiency Design Index (EEDI). This index is a measure of the amount of carbon dioxide a ship emits in relation to its cargo capacity and speed. A ship's EEDI value must not exceed the allowable limit set by IMO. SSPA, as an independent consultancy and an established model test basin, can help derive the hydrodynamic part of the EEDI value for new ships. We also act as part of the International Towing Tank Conference (ITTC) to develop the guidelines on establishing the EEDI values.



Achieving a fair and realistic EEDI value starts by selecting the right model test facility.

If a ship fails to comply with the required EEDI, it is not allowed to be taken into service! With such far-reaching consequences, the correct determination of the EEDI is of significant interest to shipyards and owners. Simplified, the EEDI is computed as:

$$EEDI = \frac{CO_2\text{- Emissions}}{\text{Capacity} \cdot f_w \cdot V_{ref}}$$

where f_w and V_{ref} reflect the hydrodynamic performance of the ship.

These factors can be improved through good design, an area where SSPA has a long experience (see for example "*Improving the EEDI of a ship – There's many ways to solve an equation*" RINA Conf. Influence of EEDI on Ship Design. 2014).

Finding f_w and V_{ref} requires physical tests, in model scale and full scale. Here, again, SSPA can play a role.

Pre-verification

The first step towards establishing the EEDI is the pre-verification during the design phase. Once the hull form and propeller design are complete, the calm water speed V_{ref} in the EEDI formula can be predicted by means of the towing tank test: the hull and propeller are built in model scale and tested in resistance and self-propulsion mode.

This step serves two purposes: firstly to catch a bad design before it goes into the building phase, and secondly to provide the necessary input for the final verification step: the sea trial. Model testing is therefore mandatory (unless it has been done for a sister ship).

Towing tank test as input for sea trials

EEDI is computed at scantling draught. Most cargo ships, however, go on sea trial at a light draught. Hence, to finally verify the EEDI at a sea trial, the speed V_{ref} for *scantling* draught has to be derived from the sea trial results at *trial* draught. This conversion is done using the *relation* between the trial draught and scantling draught obtained from the model test.

Deriving this relation from the model test sounds easy, but it conceals a challenging ongoing discussion in the shipbuilding community.

The key point is the empirical correlations factors used for the evaluations, and how they are set for various draughts. It is up to each towing tank institute to derive these empirical factors, and the end results can therefore differ from tank to tank.

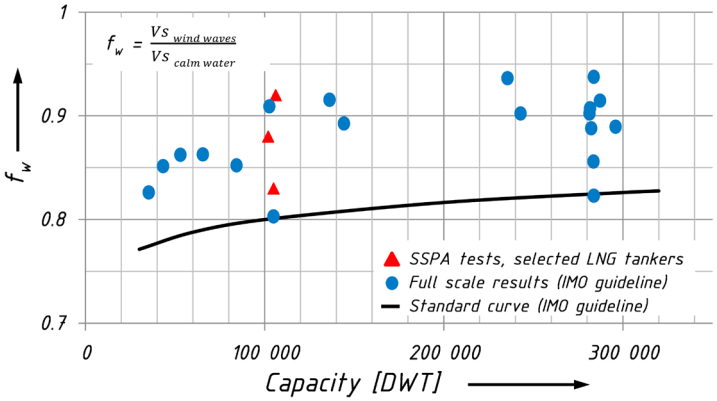
At SSPA we believe that realistic predictions require good relationships with yards and ship owners who can provide feedback on built ships.

Approval of pre-verification

The pre-verification tests and results have to be approved by an EEDI verifier. This tedious process includes checking that the model test facility complies with a number of international standards, and that the empirical correlation factors used for evaluation are reasonable.

Nomenclature

V_{ref}	speed at scantling draught at 75% MCR power
f_w	weather factor describing speed loss in Beaufort 6, Sea State 5
V_{ck}	minimum speed for safe manoeuvring in adverse weather conditions
IMO	International Maritime Organization
ITTC	International Towing Tank Conference
EEDI	Energy Efficiency Design Index, regulated by IMO
MEPC	Marine Environmental Protection Committee (IMO)



f_w factors for tankers. Ship-specific model test (red triangles) can give a much more favourable f_w-value than the simplified standard curve (black line).

Using a well reputable test facility which is trusted and known by the EEDI verifiers facilitates this process significantly.

Wind and waves

Because the sea is never calm, EEDI legislation also requires the determination of a 'weather' factor 'f_w'. This coefficient reflects what percentage of its calm water speed a ship loses in representative sea conditions (Beaufort 6, Sea State 5). A value of e.g. $f_w = 0.8$ means that the ship maintains 80% of its calm water speed in waves, i.e. the higher the value, the better the ship performs.

Guidelines regarding f_w and how it will eventually affect EEDI are currently being discussed at IMO and at the ITTC.

As the figure shows, the f_w curve given in the IMO interim guidelines is pessimistic (black line). More favourable ship-specific values can be obtained by seakeeping model tests (red triangles). Such tests require a large and fully equipped seakeeping facility like SSPA's Maritime Dynamics Laboratory.

Minimum installed power

To avoid ships becoming 'underpowered' and therefore unsafe, IMO also provides guidelines on a minimum speed V_{ck} to safely manoeuvre in adverse weather conditions. Seakeeping model tests are again the safest and most accurate way to determine the minimum installed engine power to sustain this course-keeping speed.

These tests need to be carried out at very low speeds, which can lead to unwanted wave reflection on the walls if the test tank is not wide enough. Therefore, it is crucial that the tests are carried out in a large wave basin.

Ultimately, a realistic determination of f_w and the minimum installed power will not only help with EEDI calculations, but it will also assist in assessing sea margin and bunker costs.

Sea trial analysis

Once the ship is built, the speed V_{ref} to be entered in the EEDI equation has to be verified in a sea trial.

IMO regulations stipulate two alternative standards for conducting and evaluating such sea trials: ITTC Recommended Procedure 7.5-04-01-01 (2014) and ISO 15016:2015 (from 1 June 2015). Both standards have recently been revised.

SSPA has been involved in this process and has a detailed insight into both of them. We provide support and advice related to sea trial analysis – anything from clarifying a small formulation to making a full second-opinion evaluation. SSPA can act on-board as an independent sea trial test team.

One of the largest differences of the two new sea trial standards compared to the previous one is the wave correction. There are now only four options, and the most accurate one is to use ship-specific model tests in regular waves. This is the only option that allows corrections for all wave directions, not only head seas. Including dedicated seakeeping tests in the model test scope will therefore give the best chances of a fair sea trial.

In summary

From design phase to ship delivery, there are many steps in the EEDI process where SSPA supports shipowners and yards to ensure that their ship gets a fair trial.

TOWING TANK

MARITIME DYNAMICS LABORATORY

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