The Specialist Committee on Performance of Ships in Service (PSS)

Final report and Recommendations to the 27th ITTC

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Membership and Meetings

- Dr. Anton Minchev (Chairman), Force Technology (FT), Denmark
- Dr. Uwe Hollenbach (Secretary), Hamburg Ship Model Basin (HSVA), Germany.
- Dr. Masaru Tsujimoto, NMRI, Japan
- Mr. Michio Takai, Sumitomo Heavy Industries Marine & Engineering, Japan
- Dr. Jinbao Wang, MARIC, China
- Mr. Heungwon Seo, Hyundai HI, Korea
- Dr. Angelo Olivieri, INSEAN, Italy
- Prof. G. Grigoropoulos, NTUA, Greece
- Mr. Henk van der Boom, MARIN, The Netherlands
- Dr. Sofia Werner, SSPA, Sweden
- Dr. W. Gorski, CTO, Poland

Five Committee meetings were held as follows:

- Force Technology, Denmark, 7-9 December 2011
- Vienna Model Basin, Austria, 8-9 March 2012
- MARIC, China, 10-12 October 2012,
- INSEAN, Italy, 6-7 June, 2013
- NTUA, Greece, 15-17 January 2014

The AC representative Prof. Gerhard Strasser attended all the meetings in order to follow closer the update of the speed/power trial procedure and provide feedback from IMO/MEPC meetings.

Terms of Reference (TORs)

1. Cooperate directly with the AC and ITTC representative in IMO with regard to EEDI (Energy Efficiency Design Index).
2. Liaise with the Resistance, Propulsion and Sea-keeping Committees as relevant, specifically with regard to estimating *fw*, in the EEDI.
3. Monitor and review the state of the art for EEDI and EEOI (Energy Efficiency Operational Index) prediction and determination methods, including CFD based ones.
4. Review the existing procedures for the ship model testing with regard to the requirements arising from the EEDI prediction process, including ITTC Recommended Procedure 7.5-02-07-02.2, Prediction of Power Increase in Irregular Waves from Model Tests, and liaise with the Sea-keeping Committee to decide whether an update of the procedure is required.
5. Identify and describe the practical aspects of the EEDI prediction process involving ship model testing, and develop a guideline for EEDI prediction.
6. Take into account minimum power requirements for safe and effective manoeuvring with respect to the EEDI formula (sea margin)
7. Describe the type of data (and the quality of that data) that should be recorded during full scale monitoring trials, including the issues of surface roughness.
8. Review the existing ITTC trial test procedures in this context. Review the existing speed correction methods for Full Scale Trial Measurements including ISO 15016, and come up with recommendation if the problems are identified, taking into account the MARIN report as contained in document MEPC 62/5/5.
9. Review the technologies (hydrodynamic issues) for enhancement of the powering performance, such as speed reduction, energy saving devices, hull form and propeller design, etc.
10. Investigate the experimental and numerical possibilities to estimate the effect of steering and wind to the added resistance.
11. Look for full scale data that will allow improving powering estimation taking into account the surface roughness (hull, appendages and propeller).
12. Examine the possibilities for numerical methods in the prediction of the influence of surface roughness on the shaft power prediction in full.

General Remark

- One of the major objectives for establishing the present Specialist Committee on Performance of Ships in Service was to assist/cooperate with IMO/MEPC on the practical implementation of the EEDI calculation and verification process. Therefore, the focus of the Committee work was the major revision of the Speed/Power trial procedures:

- *7.5-04-01-01.1: Speed and Power Trials, Part I Preparation and Conduct*

- *7.5-04-01-01.2: Speed and Power Trials, Part II Analysis of Speed/Power Trial Data*

Cooperation with AC/IMO

The Advisory Council (AC) to the 27th ITTC nominated Prof. Gerhard Strasser (AC Chair) to act as an ITTC (AC) representative to IMO/MEPC. Following closely the work of IMO/MEPC, Prof. Strasser participated in MEPC63, 64, 65 and 66 sessions with subsequent attendance in I – V PSS Committee technical meetings.

The MEPC 63rd session adopted four sets of guidelines intended to assist in the implementation of the mandatory Regulations on Energy Efficiency for Ships in MARPOL Annex VI, which are expected to enter into force on 1 January 2013:

- 2012 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships;
- 2012 Guidelines for the development of a Ship Energy Efficiency Management Plan (SEEMP);
- 2012 Guidelines on survey and certification of the Energy Efficiency Design Index (EEDI); and
- Guidelines for calculation of reference lines for use with the Energy Efficiency Design Index (EEDI).

Following the IMO recommendation, ITTC started a closer cooperation with the ISO with the objectives of updating ISO 15016 standard based on the developed ITTC recommended procedures 7.5-04-01-01.1 and 7.5-04-01-01.2

Introduction to EEDI

$$EEDI = CF_{ME}*(SFC_{ME}*P_{ME}+SFC_{AE}*P_{AE})/(Capacity*V_{REF})$$

Where:

CF_{ME} - Carbon emission factor

SFC_{ME} - Specific fuel consumption of main engine

SFC_{AE} - Specific fuel consumption of auxiliary engines

P_{ME} - 75% of the rated installed power (MCR) for each main engine without any deduction for shaft generators;

except for LNG carriers having diesel electric propulsion system and LNG carriers having steam turbine propulsion systems

P_{AE} - Installed auxiliary power

Capacity – For dry cargo carriers, tankers, gas tankers, ro-ro cargo and general cargo ships, deadweight should be used as *Capacity, (tons)*.

For containerships 70% of deadweight should be used as *Capacity, (tons)*.

For Passenger ships Gross tonnage should be used as *Capacity*.

Vref **– Is the ship speed, measured in knots, on deep water in the maximum design load condition (*capacity*) as defined above, at the main engine shaft power at 75%MCR and assuming the weather is calm with no wind and no waves.**

EEDI(details)

installed power for each main engine (j)

required auxiliary engine power

waste heat recovery system

the main engine power reduction due to innovative energy efficient technology

$$EEDI = \frac{\left(\prod_{j=1}^{M} f_j\right)\left(\sum_{i=1}^{nME} C_{FME(i)}\ SFC_{ME(i)}\ P_{ME(i)}\right) + P_{AE} C_{FAE} SFC^{*}_{AE} + \left\{\left(\prod_{j=1}^{M} f_j \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)} P_{AEeff(i)}\right) C_{FAE} SFC_{AE}\right\} - \left(\sum_{i=1}^{neff} f_{eff(i)} P_{eff(i)} C_{FME}\ SFC_{ME}\right)}{f_i \quad f_c \quad f_l \quad Capacity \quad V_{ref} \quad f_w}$$

Capacity:

- For cargo carriers, tankers, gas tankers, ro-ro cargo and passenger ships and general cargo ships,

 >**deadweight**

- For container ships

 >**70% of deadweight**

- For passenger ships,

 >**gross tonnage**

Vref (ship speed)

measured in nautical miles per hour (knot), on deep water in the maximum design load condition (Capacity) at the output of the engine(s) and assuming the weather is calm with no wind and no waves.

f_W is a non-dimensional coefficient indicating the decrease of speed in representative sea conditions of wave height, wave frequency and wind speed (e.g., Beaufort Scale 6),

(*fw*=1 at this moment)

EEDI Application

All new ships (according below table) of 400GT and above, build from 1st January 2013

* not apply to ships of diesel-electric propulsion, turbine propulsion and hybrid propulsion system

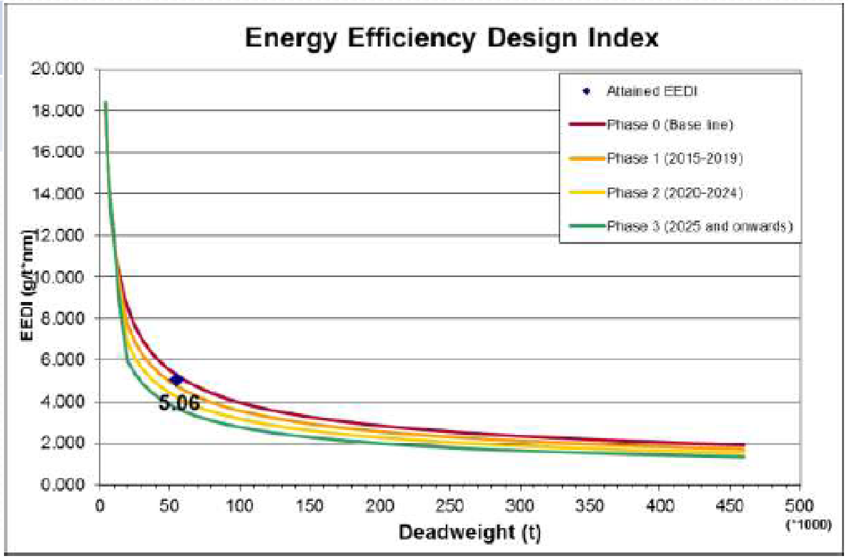
** separate to Gas carrier and LNG carrier

*** only regulated for Passenger ship having non-conventional propulsion

Ship types for EEDI calculation*	Reduction of EEDI	
	After 1st January 2013	After 1st September 2015
Bulk carier	X	
Gas carrier	X	**
Tanker	X	
Container ship	X	
General cargo ship	X	
Reefer	X	
Combination carrier	X	
Passenger ship		X***
RO-RO cargo ship (vehicle carrier)		X
RO-RO cargo ship		X
RO-RO passenger ship		X

IMO Stipulated EEDI Reduction Rate

Phase #	Vessel built	EEDI below base line
Phase 0	Jan 2013–Dec 2014	0%
Phase 1	Jan 2015–Dec 2019	10%
Phase 2	Jan 2020–Dec 2024	20%
Phase 3	Jan 2025 –>	30%



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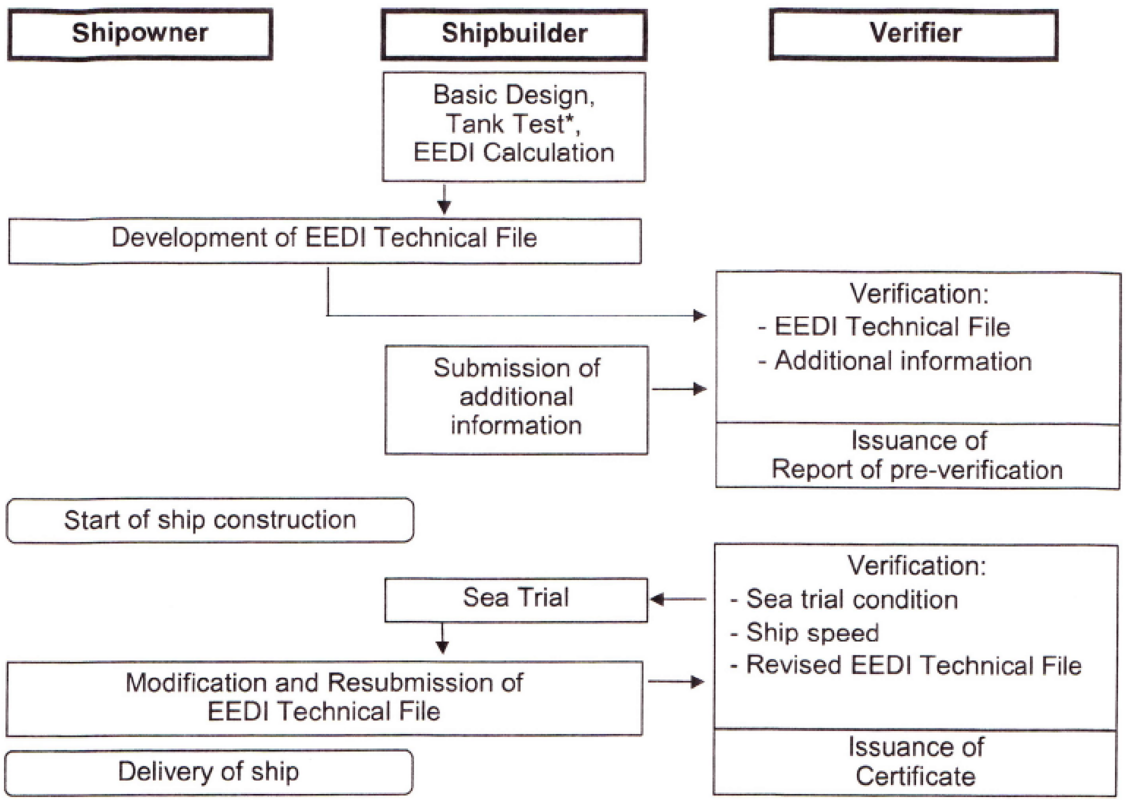
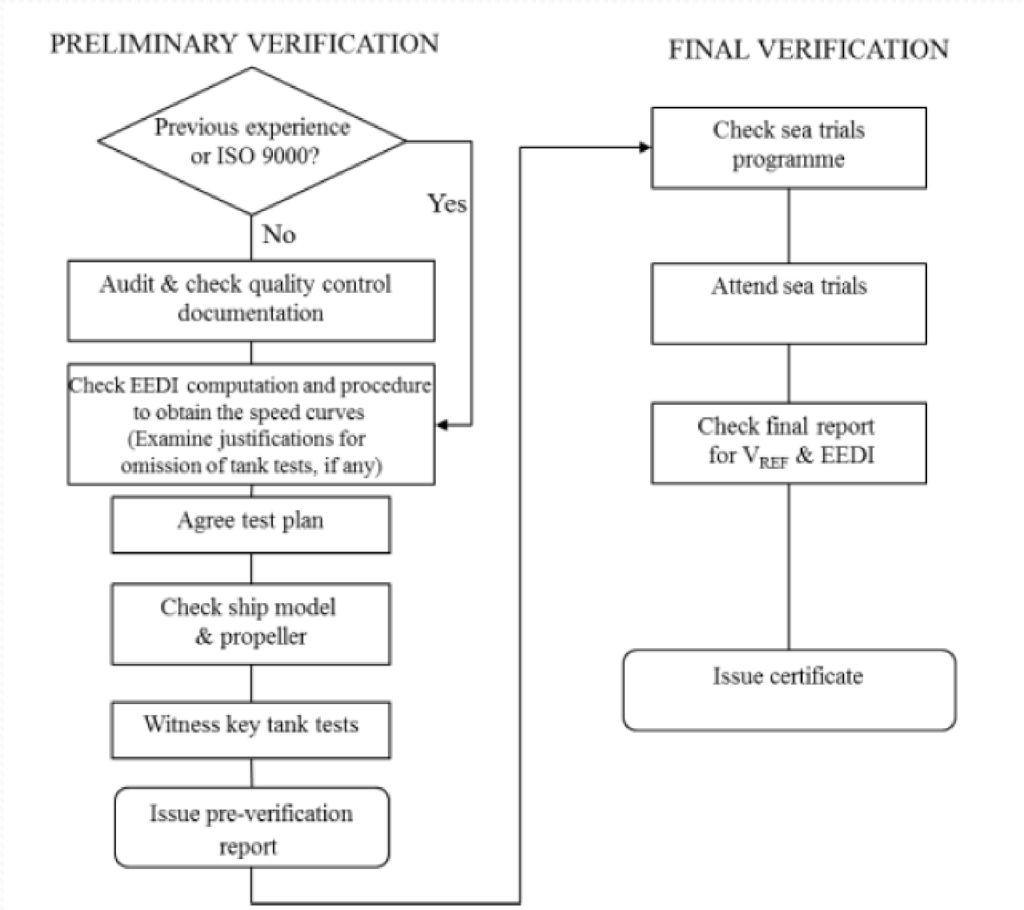
EEDI Survey and Certification



* To be conducted by a test organization or a shipbuilder itself.

Figure 1: Basic Flow of Survey and Certification Process

Practical Aspects of EEDI Prediction



POWER CURVES

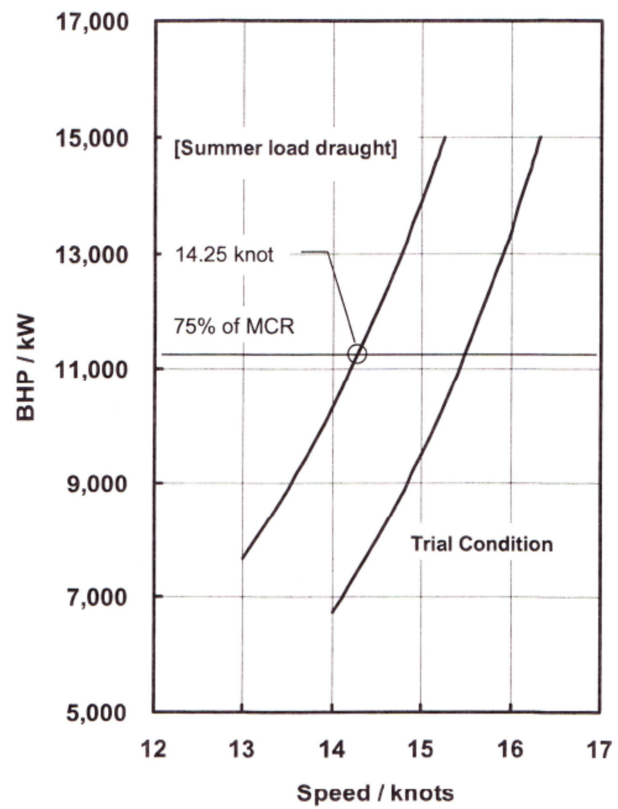


Figure 2.1: Power curves

POWER CURVES ESTIMATION

Power curves are estimated based on model test results. The flow of the estimation process is shown below.

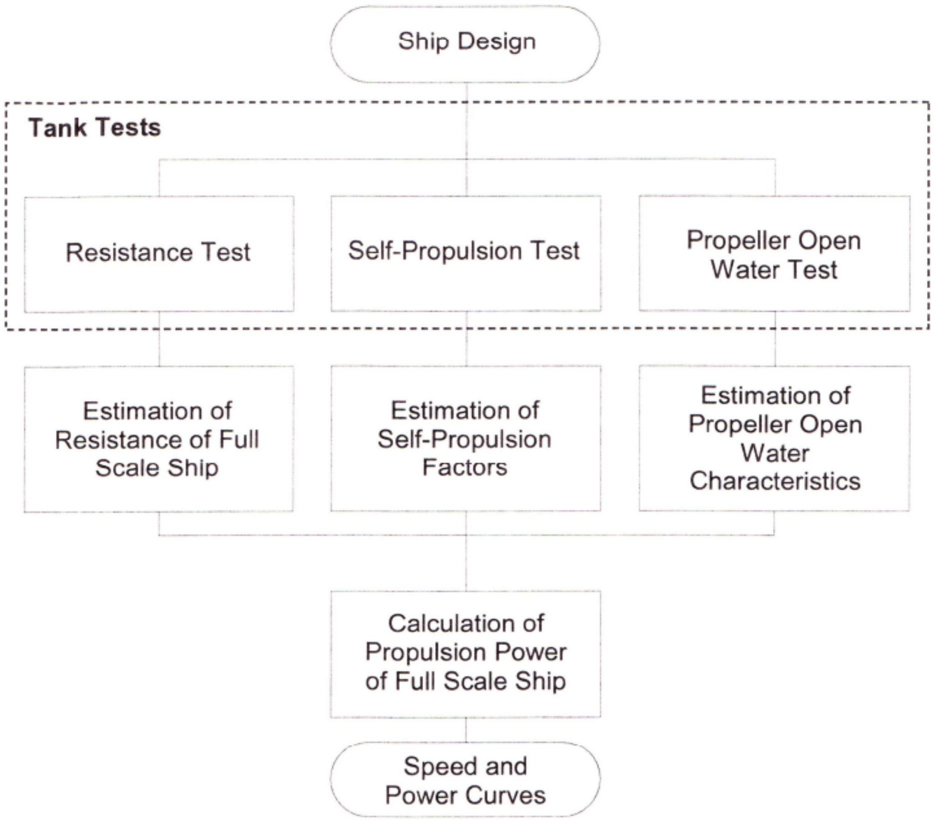


Figure 4.1: Flow-chart of process for estimating power curves

Conclusions on EEDI Verification Process

- EEDI prediction process shall follow the Industry guidelines
- Model tests shall be conducted according to ITTC Recommended Procedures
- In EEDI regulation, model basins are requested to build a quality control system, such as ISO-9000 or equivalent
- Further studies on $\delta CP/\delta \Delta CFC$ are necessary due to large scatter and lack of verification

Minimum Power Requirement

The IMO MEPC at its 65th session approved the Interim Guidelines for determining minimum propulsion power to maintain the manoeuvrability of ship in adverse conditions. The Interim guidelines are presented in detail in document MEPC.232(65) "Interim Guidelines for Determining Minimum Propulsion Power to Maintain the Manoeuvrability of Ships in Adverse Conditions".

Definition:

"Adverse conditions" mean sea conditions with the following parameters:

Ship Lpp (m)	Hs (m)	Tp (sec)	Vw (m/s)
Lpp<200	4.0	7.0-15.0	15.7
200<Lpp<250	Linear interpolation		
Lpp>250	5.5	7.0-15.0	19.0

Applicability:

The Guidelines should be applied in the case of all new ships in unrestricted navigation, required to comply with EEDI

Minimum Power Requirement

Assessment level 1 - Minimum power lines

- If the ship under consideration has installed power not less than the power defined by the minimum power line for the specific ship type, the ship should be considered to have sufficient power to maintain the manoeuvrability in adverse conditions. The minimum power line values, in kW, should be calculated as follows:

- Minimum power line value = *a* x *(DWT)+b*,

Where: *DWT* is the deadweight of the ship in metric tons; and *a* and *b* are the parameters given in below table:

Ship Type	a	b
Bulk carriers	0.0687	2924.4
Tankers	0.0689	3253.0
Combination Carriers	See tankers above	

Assessment level 2 – Simplified assessment

- The simplified assessment is applicable only to ships whose rudder area is not less than 0.9% of the submerged lateral area corrected for breadth effect.

- The simplified assessment procedure is based on the principle that, if the ship has sufficient installed power to move with a certain advance speed in head waves and wind, the ship will also be able to keep course in waves and wind from any other direction. The minimum advance speed in head waves and wind is thus selected depending on ship design in such a way, that the fulfilment of the advance speed requirements means fulfilment of course-keeping requirements.

Afw / Alw	Min Vck (kn)
<0.1	9.0
>0.4	4.0=Vnav
$0.1<Afw/Alw<0.4$	Linear interp.

Applicable for bulk carriers, tankers and combination carriers!

Minimum Power Requirement

A member of the PSS Specialist Committee, updated the original study for four typical bulk carriers of:

- DWT 30000 (Handy)
- 57000 (Supra-Handy-Max)
- 79000 (Kamsar-Max) and
- 176000 T (Cape-Size) and a VLCC 306000 T

to evaluate the most recent requirements.

Conclusion:

The Interim Guidelines seem to be premature and would need further refinement. Some recommendations for future ITTC work on this topic are formulated in the Conclusions of this report.

- All ships studied, very easily satisfy level 1 requirement, while some of them satisfy only marginally the requirements of level 2. This constitutes a major failure of rationalism, dictating that level 1 should be the strictest one. Since either level is sufficient to comply with the requirement, it follows that the simplest level 1 should not also be the easiest to fulfill.
- Since all oceangoing ships regardless of their length encounter the same weather and sea conditions, which affect more the smaller ones, the power margin must be increased in smaller ships.
- The regression line for the minimum power requirements (Level 1) seems to be satisfied by the 90% of the plotted sample, while only 10% of the plotted sample are below the curve, implying that the required minimum installed power is substantially lower than actual typical current designs for bulk carriers. The same holds true for the tankers.
- Thus, the Level 1, simplified method, which is included in the interim guidelines, adopted by resolution MEPC.232 (65) as the first level of a two or three-level assessment approach should be the most stringent and conservative, as a matter of principle.

Speed/Power Trial Procedure

- <u>Objectives</u>

  Speed/power trials are conducted to establish the performance of the vessel at design draught and trim under stipulated weather conditions

  The IMO asked for a transparent, un-ambiguous and practical method acceptable for all stakeholders as well as for the assessment of the IMO EEDI.

  This task was conducted by the ITTC Committee for the Performance of Ships in Service with the assistance of the STA-Group which has been working in this field since 2004.

- <u>History</u>

  BSRA, NSMB, SNAME and ITTC published methods for conducting and analysing speed/power trials. In 2002, the International Standard Organisation published ISO 15016, which included a complicated analysis method based on a wide choice of outdated correction methods and empirical data.

- <u>Approach</u>

  To derive the speed/power performance of the vessel from the measured speed over ground, shaft torque and rpm, <u>the Direct Power Method</u> is recommended

Preparation and Conduct

Purpose:

To determine ship performance in terms of speed, power and propeller revolutions under prescribed ship conditions, and subsequently:

- Verify the satisfactory attainment of the contractually stipulated Ship Speed

- Provide the Ship Speed for the calculation of the Energy Efficiency Design Index (EEDI) as required by IMO.

Preparation and Conduct

Part I is to define and specify:

- Responsibility of each party involved,
- Trial preparations,
- Vessel and propeller conditions,
- Limiting weather (wind) and sea conditions,
- Trial procedure,
- Execution of the trial,
- Measurements required,
- Data acquisition and recording
- Processing of the results.

Reference Document: ITTC 7.5-04-01-01.1

Trial Preparations

Hull surface roughness and fouling – Clean & smooth hull

Propeller roughness and fouling – clean & smooth (polished) propeller

Draughts - averaging the ship draft mark readings => by draft marks and/or draft gauging system

Trim < 1.0% Tm; Optimum trim do not considered (varies with speed)

Displacement - within +/-2% difference from the actual required displacement

Wind and Wave Measurements

Relative Wind – Speed and direction

- Correction for superstructure
- Correction for height > 10 m above sea level

Waves – Hs/Tp and direction

- Visual observation (min 3 observers)
- Wave buoy
- Wave radar

Current – speed and direction

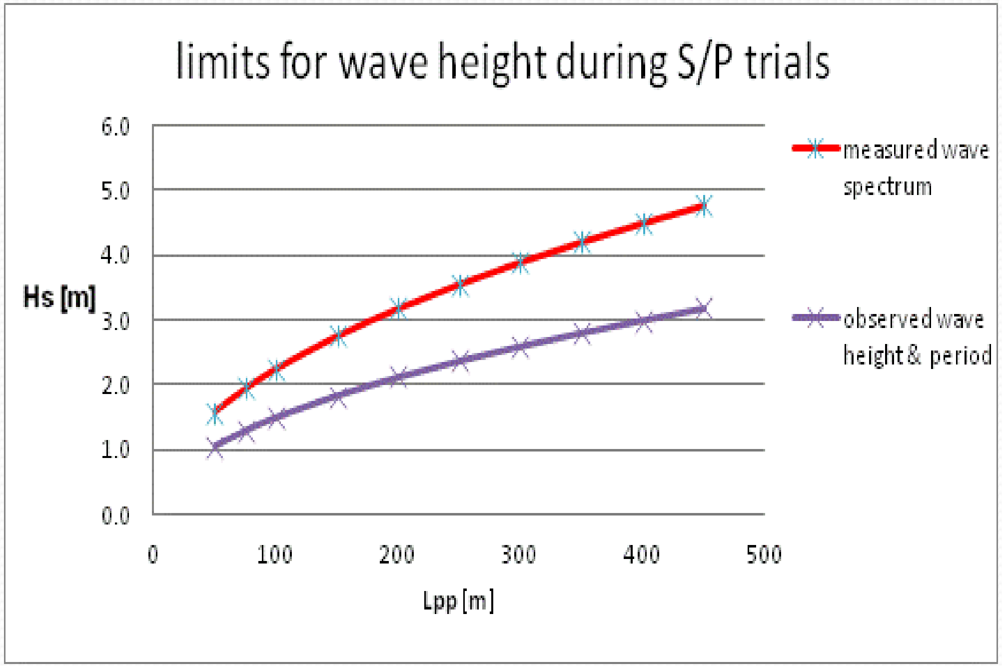
- ”Mean-of-means” of vessel speed during consecutive double runs

Wind/Wave Limits

Limiting weather (wind) and sea conditions:

Wind speed should not be higher than:

- Beaufort number 6, for vessels with L >100 m
- Beaufort number 5, for vessel with ≤100 m



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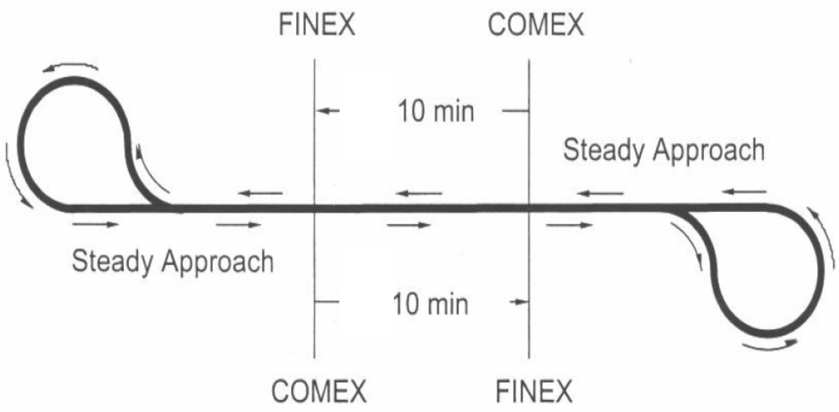
Preparation and Conduct

Ship track during double run:



These runs comprise:

- Two (2) Double runs (at the same power setting) around the Contract Power,
- Two (2) Double runs (at the same power setting) around EEDI Power (i.e. 75% MCR),
- Double Run for at least one other power setting between 65% and 100% MCR.
- Logging duration minimum 10 min for all runs

Preparation and Conduct

Data Acquisition and Recording:

- Time
- Propeller shaft torque
- Propeller shaft rpm
- Pitch of CPP
- Ship positional data
- Ship heading
- Ship's speed over ground
- Relative wind direction
- Relative wind speed
- Wave height, period and direction

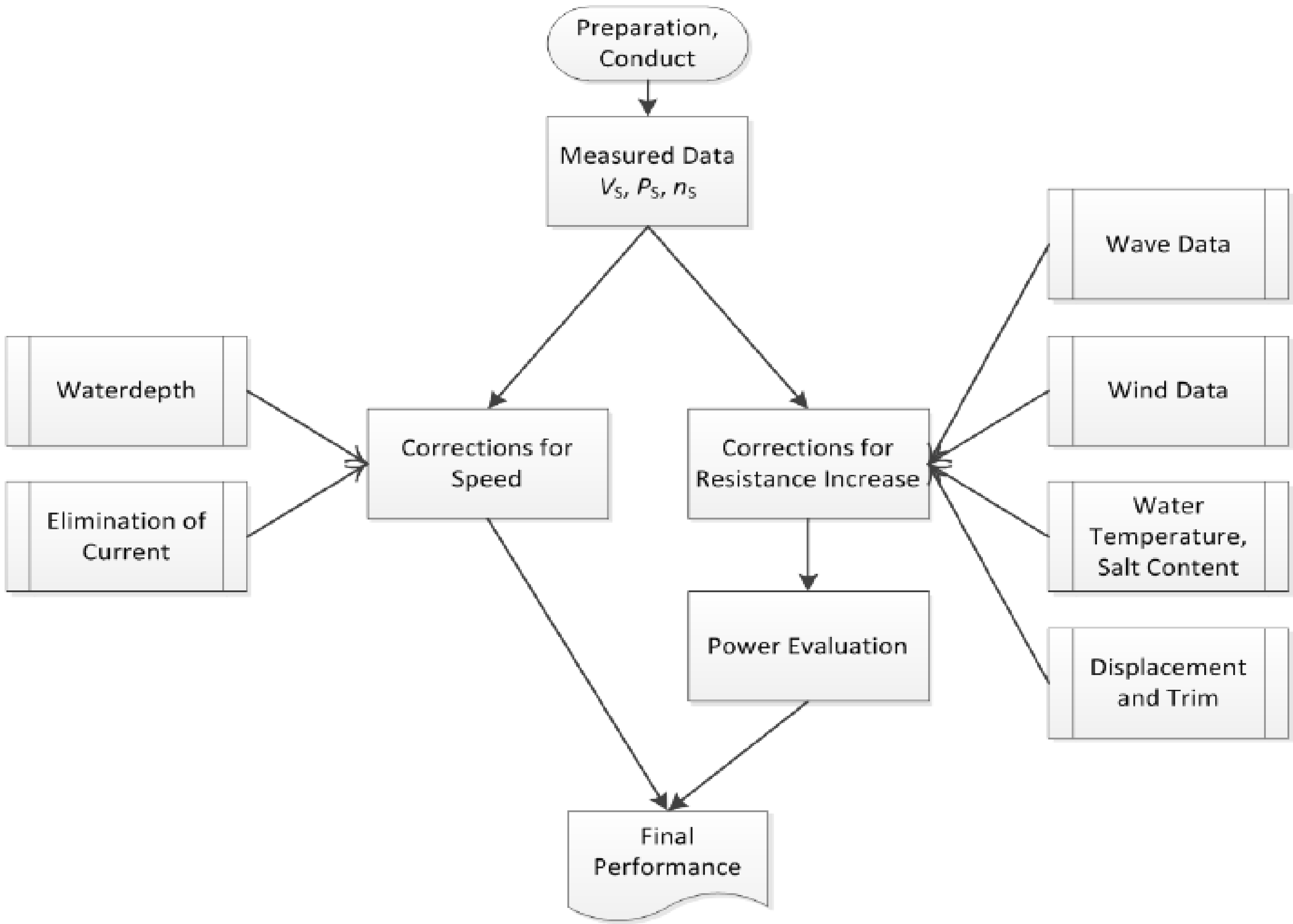
Analysis

Main Objectives of Part II:

- To define procedure for the evaluation and correction of speed/power trials covering:
  - Wind correction
  - Waves correction
  - Current correction
  - Temperature and salinity correction
  - Shallow water effect correction
  - Displacement correction

Reference Document: ITTC 7.5-04-01-01.2

Analysis


Preparation, Conduct
Measured Data
V_S, P_S, n_S
Waterdepth
Elimination of Current
Corrections for Speed
Corrections for Resistance Increase
Wave Data
Wind Data
Water Temperature, Salt Content
Displacement and Trim
Power Evaluation
Final Performance

Analysis

Direct Power Method:

Direct power method is applied, combined with test results from load variation tests.

$$P_{\mathrm{DC}} = P_{\mathrm{DM}} - \frac{\Delta R \cdot V_{\mathrm{SM}}}{\eta_{\mathrm{D0}}} \cdot \left(1 - \frac{P_{\mathrm{DM}}}{P_{\mathrm{DC}}} \cdot \xi_p\right)$$

with

P_{DC}:	corrected delivered power,
P_{SM}:	measured power,
V_{SM}:	ship speed measured,
ΔR:	resistance increase,
η_{D}:	propulsion efficiency coefficient,
ξ_{p}:	derived from load variation model test.

Analysis

The resistance values of each run are corrected by estimating the resistance increase ΔR as,

$$\Delta R = R_{AA} + R_{AW} + R_{AS}$$

with

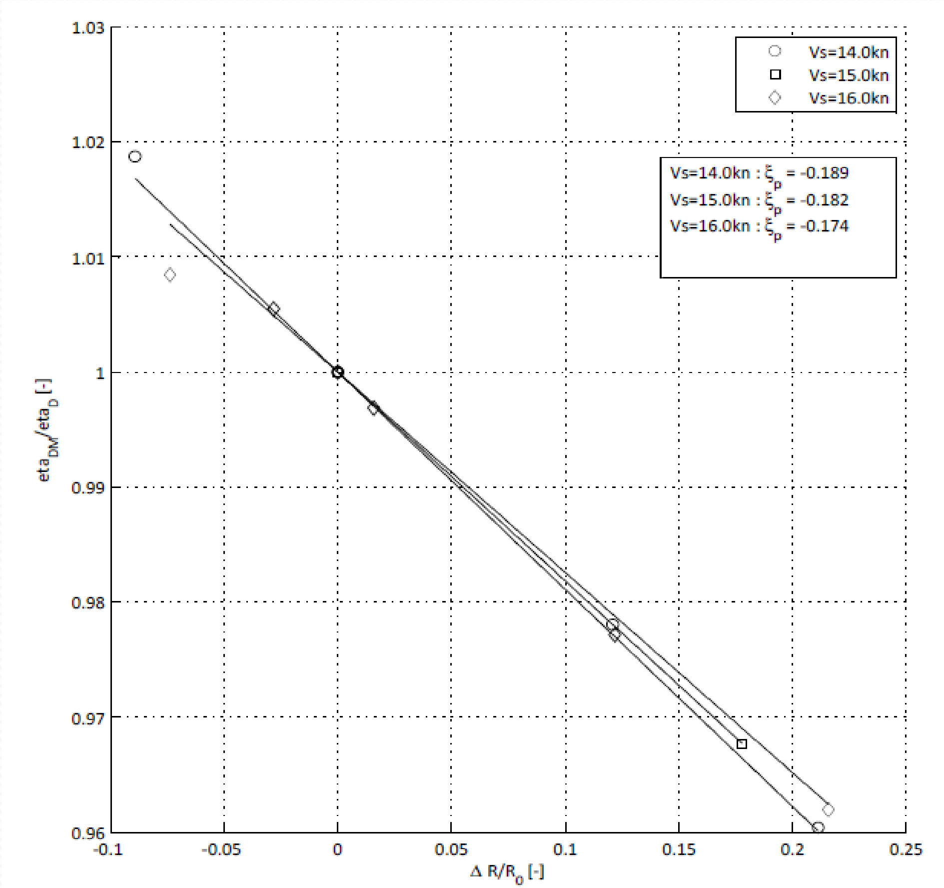
R_{AA} : resistance increase due to relative wind,

R_{AS} : resistance increase due to deviation of water temperature and water density,

R_{AW} : resistance increase due to waves,

Correction for Propeller Loading

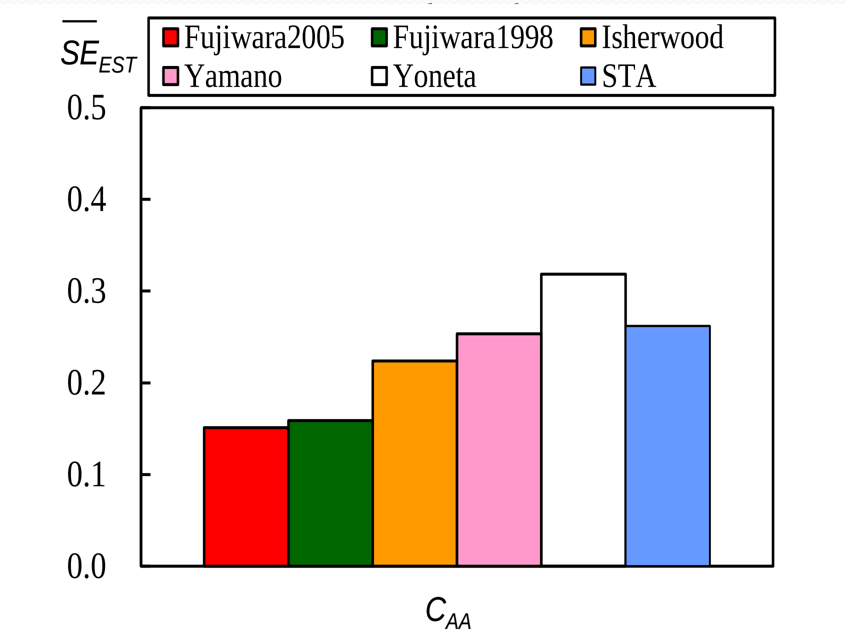
The load variation propulsion test has been selected to account for the influence of propeller loading on the propulsive efficiency



Correction - Wind

Validation summary, based on NMRI wind tunnel data-base

Validation indicated smallest error for Fujiwara 2005



As a result of the validation, the following three possible approaches were recommended:

- (1) Statistical regression formula for various ship types developed by Fujiwara
- (2) STA Dataset
- (3) Use of wind tunnel measurements for the specific ship

Analysis

Wave Added Resistance

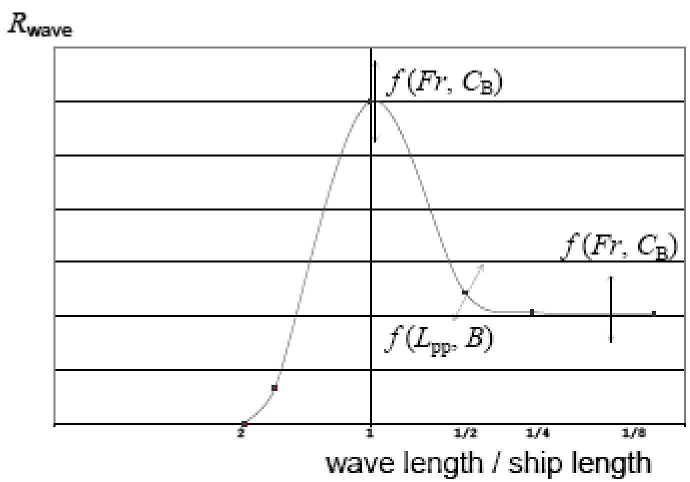


Fig.D-5 Parametric transfer function of mean resistance increase in regular waves.

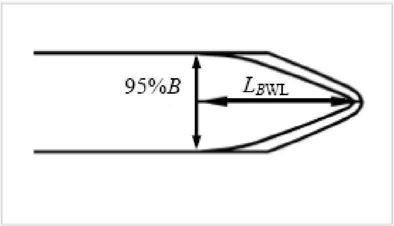
- Short waves ($\lambda/L < 0.5$):
  - No pitch/heave motions
  - Wave added resistance dominated by wave reflection only
- Long waves ($\lambda/L > 0.5$):
  - Pitch/heave motions
  - Wave added resistance governed by both wave reflection and wave radiation

Wave added resistance

Wave added resistance calculation approaches:

- Simplified approach for ships which do not heave and pitch (STA1)

$$R_{\mathrm{AWL}} = \frac{1}{16} \rho g H_{\mathrm{W1/3}}^{2} B \sqrt{\frac{B}{L_{BWL}}}$$



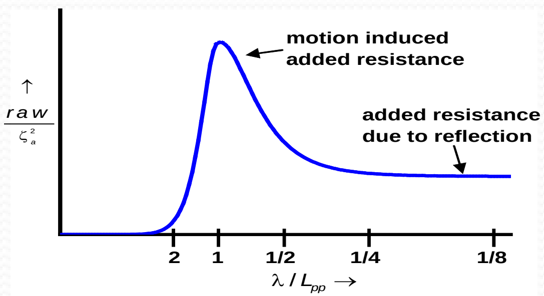
- Empirical approach with frequency response function for ships which heave and pitch (STA2 method); note requires measured wave spectrum!!!

$$R_{\mathrm{AWL}} = 2\int_{0}^{\infty} \frac{R_{\mathrm{wave}}(\omega; V_S)}{\zeta_{\mathrm{A}}^{2}} S_{\mathrm{f}}(\omega) d\omega$$

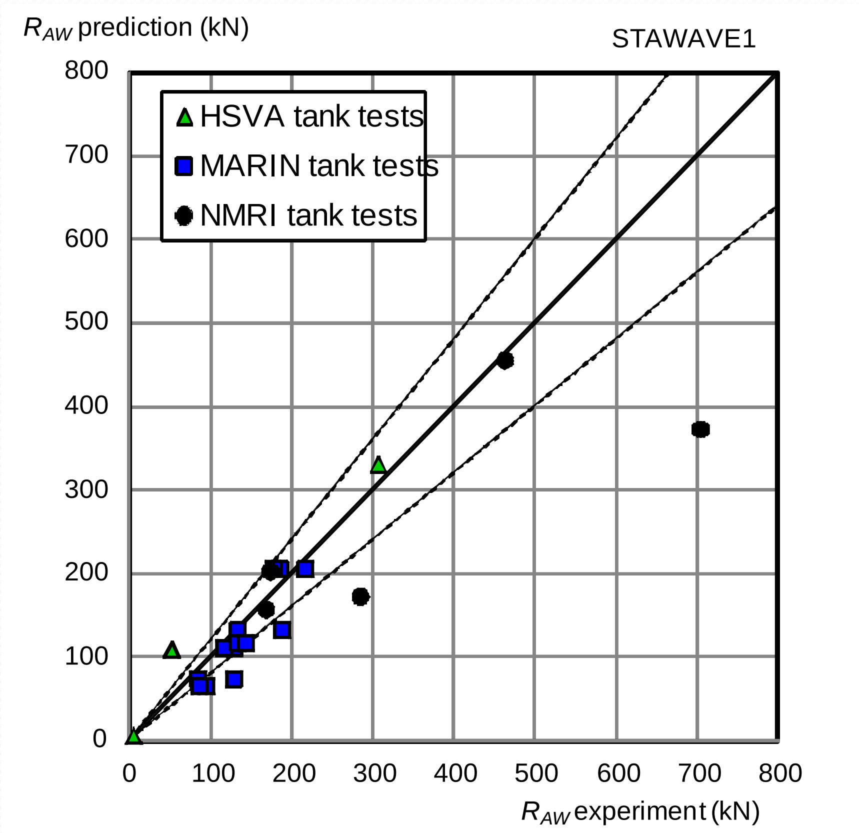
- Theoretical approach combined with simplified tank tests
  (*ΔR calculated based on Maruo's theory combined with practical correction validated by on board measurements*)

Correction - Waves

Three methods validated:

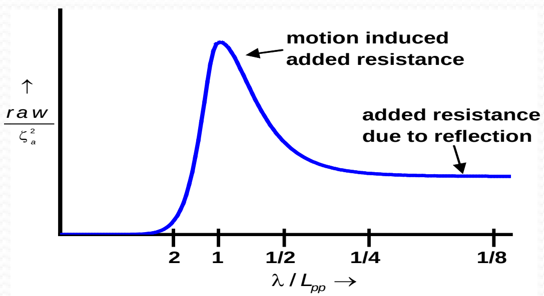


- STAWAVE1 – accounts only for wave reflection only



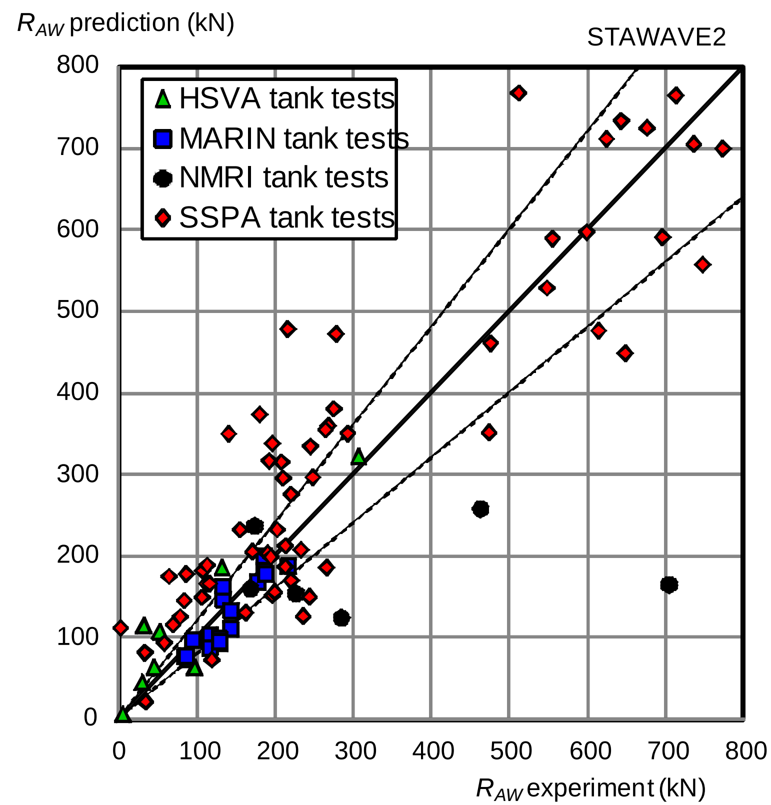
Correction - Waves

Three methods validated:



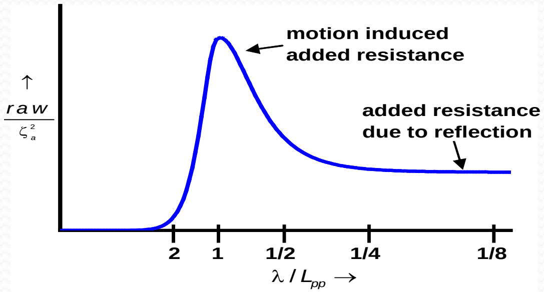
- STAWAVE1 – accounts only for wave reflection only

- STAWAVE2 – empirical correction method with frequency response function

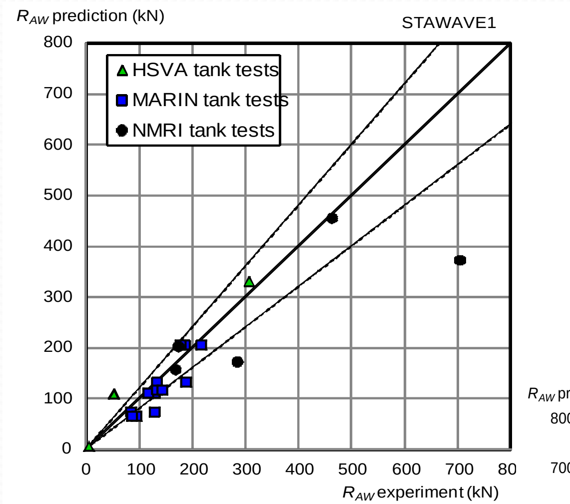


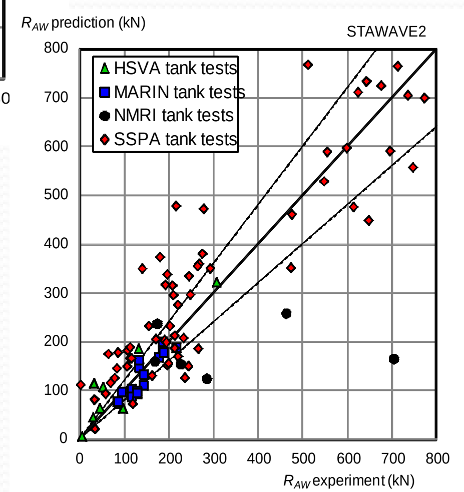
Correction - Waves

Three methods validated:



- STAWAVE1 – accounts only for wave reflection only
- STAWAVE2 – empirical correction method with frequency response function
- NMRI – theoretical method with empirical corrections. Provides the added resistance RAO



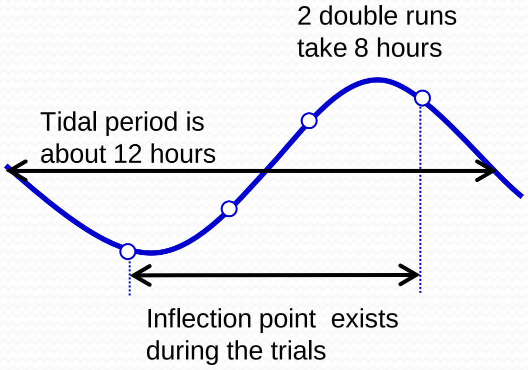


Current Correction

Specifics:

Typically current (tidal) varies periodically with time.

- Within the time frame of a double run, the current is assumed to vary parabolically with time.
  - ✓ In case of a single run, the current is assumed constant (time-independent).



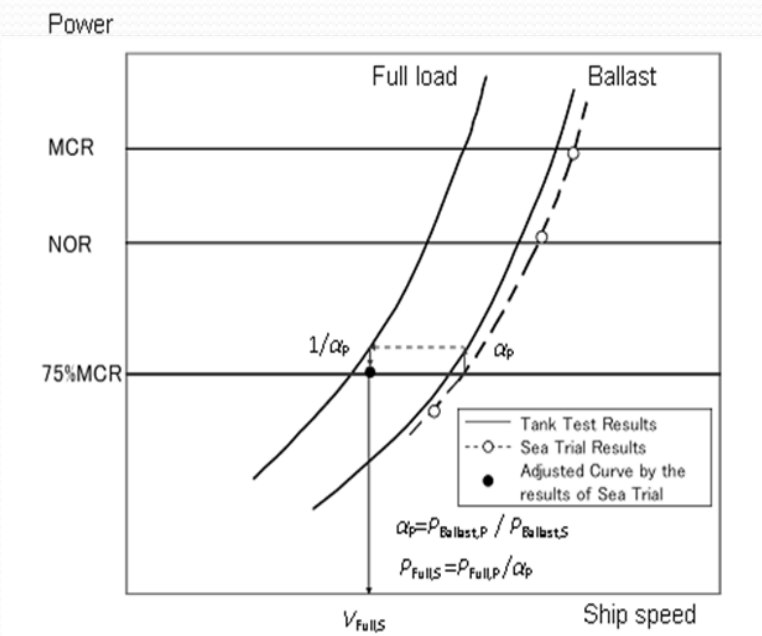
Special case => large low speed ships (VLCC), one run up to 2 hrs. Quadratic current speed assumption may not hold

Current Correction

- The current elimination is carried out by the "means-of-means" method, requiring minimum two double runs in case of quadratic current variation.

- An alternative method for current correction, the so called *iterative method*, has been introduced in the coming updated ISO15016 procedure.
  - This seems very promising, according to recent studies within PSS committee.
  - It is suggested for next TOR to consider introducing this method in future revisions of ITTC ***7.5-04-01-01.2***

Trial to EEDI Condition Correlation



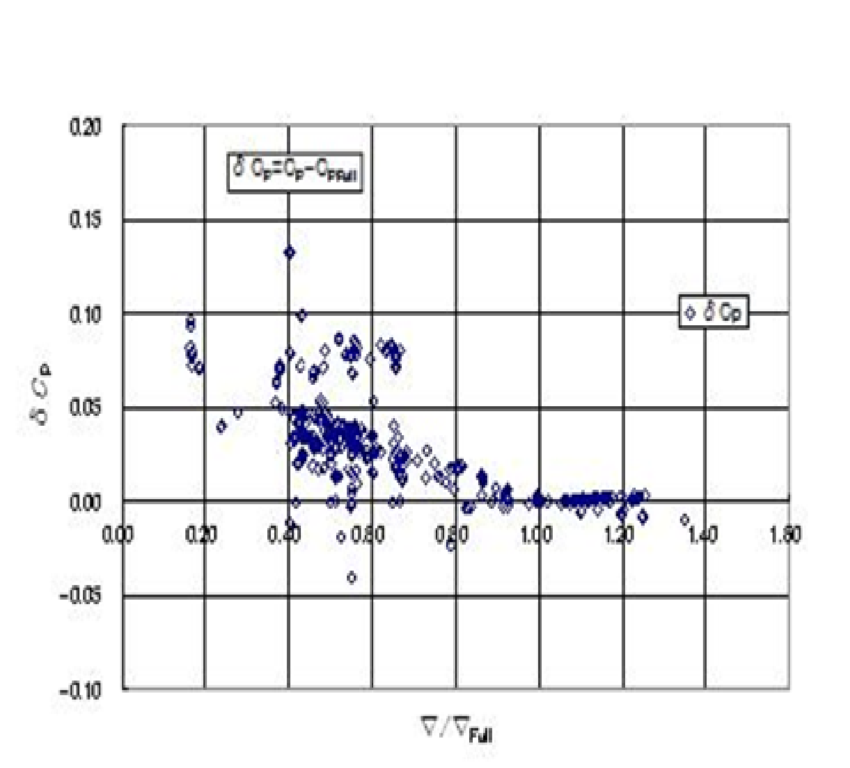
Requirements and Technical challenges:

- Difference of the model-ship correlation between fully loaded (EEDI) condition and trial (ballast) condition
- 1978ITTC Performance Prediction Method (PPM) shall be used
- Correlation based on thrust identity and correlation factors to be according method 1 (Cp-Cn) or method 2 (ΔCFC-ΔwC) of the ITTC PPM

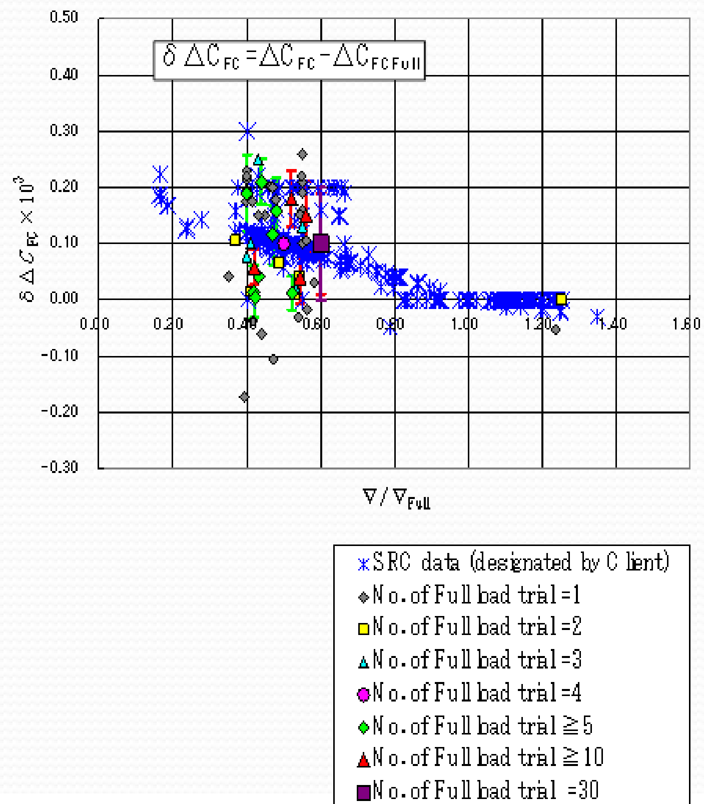
PSS Study on CP and ΔCFC, source:

Shipbuilding Research Center of Japan (SRC)

Variation of δCP as a function of the displacement ratio



Variation of ΔCFC as a function of the displacement ratio



Impact on Model Tests and Speed Trials

- Load variation tests should be part of the calm water propulsion model test program and the analysis of these tests should be according to the described procedure.

- For extrapolation to full scale the same procedure and empirical coefficients should be used for all draughts unless these procedures and coefficients are justified and documented with results of full scale trials for the specific ship type, size and loading condition.

- Speed trial shall consist of 5 double runs with minimum 10 minutes for the first ship, though for sister ships the programme can be reduced to 3 double runs.

Ship Propulsive Performance Improvement

- Hull form design and optimisation (new design)

1. Optimizing ship main particulars (L, B, T, S)
2. Optimizing hull lines (fore, mid, aft-ship)
3. Reducing added resistance in a seaway
4. Reducing windage resistance

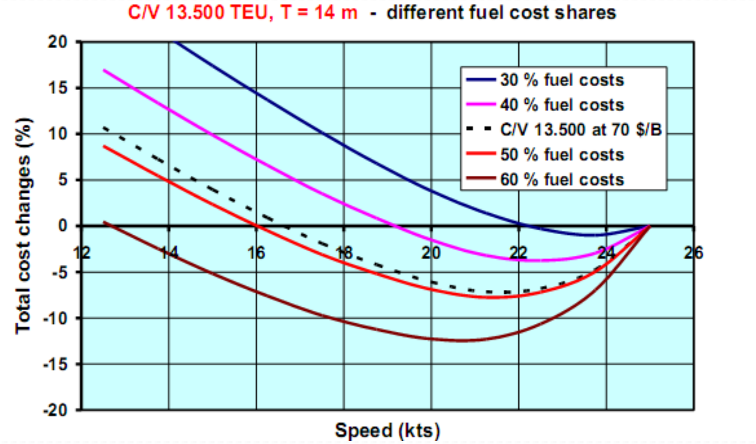
- Propulsor/appendages optimisation

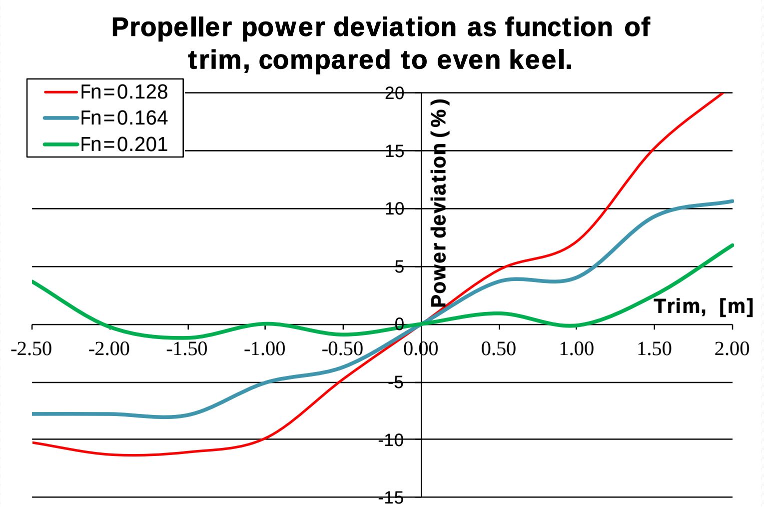
1. Propeller design (ducted, podded, CRP, CLT, Kappel, etc.)
2. Rudder and appendages (rudder bulb, twisted rudder)

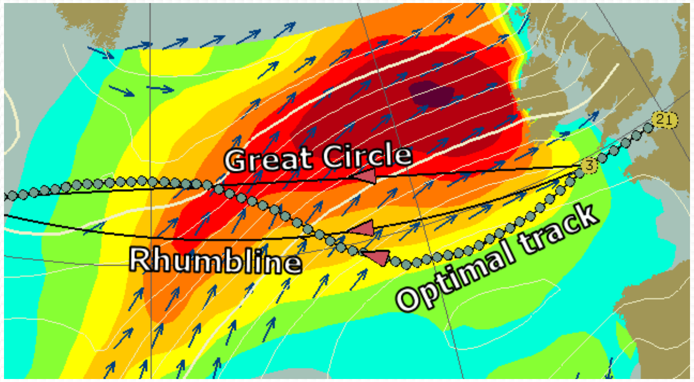
Ship Propulsive Performance Improvement

- In service performance optimisation

1. Speed optimisation
2. Optimum trim
3. Improved voyage planning







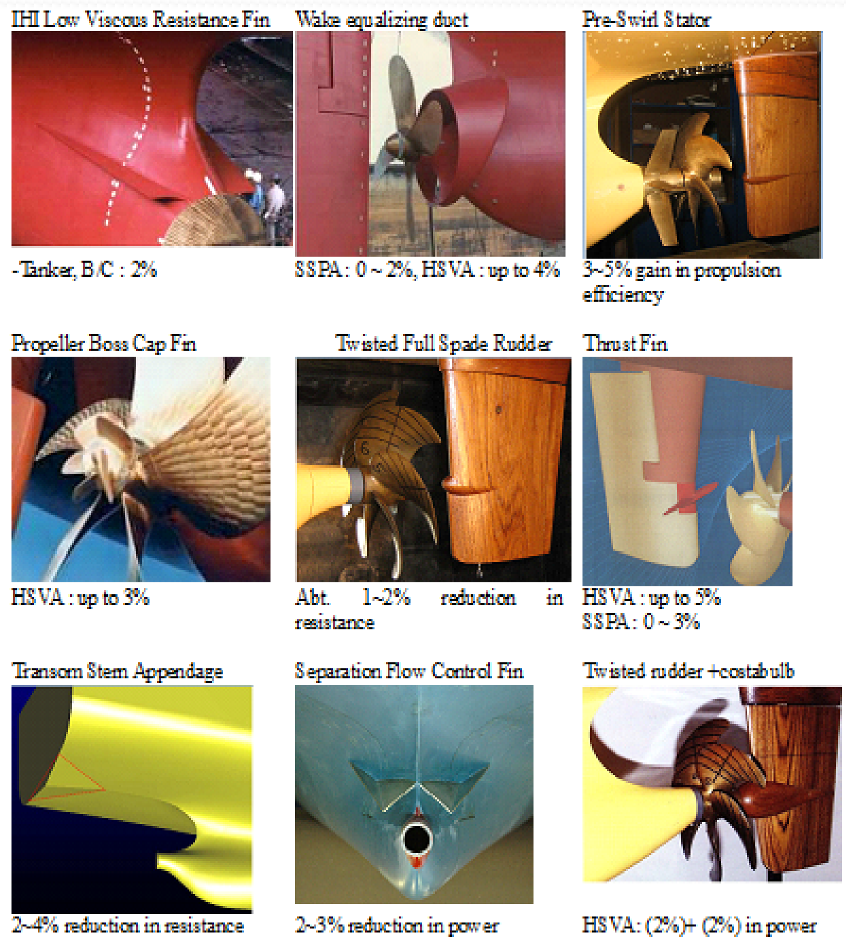
Ship Propulsive Performance Improvement

- Energy Saving Devices (ESDs)

1. Reducing propeller loading (axial losses) – ducts, semi ducts
2. Reducing rotational losses - pre and post swirl stators and fins
3. Reducing induction (vortex) losses - PBCF, rudder bulb
4. Better propeller inflow – vortex generators, pre-ducts

Challenges:

➢ ESDs scale effects (correlation to full scale)



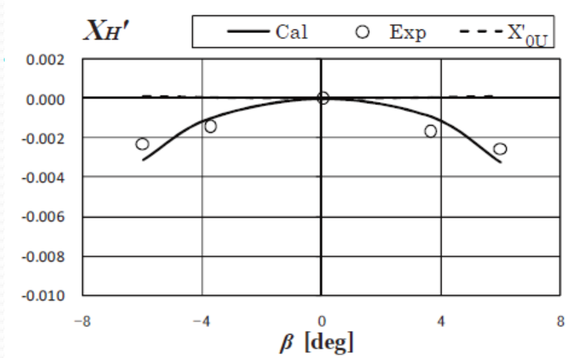
Effect of Steering and Wind

- **Wind effect (resistance)**

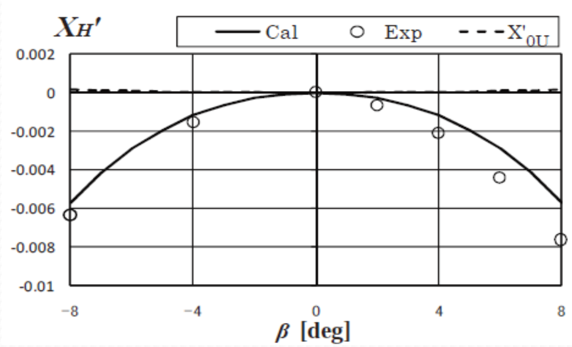
1. Wind tunnel test results
2. Wind CFD simulations
3. Empirical wind drag formulae

- **Steering effect**

1. Experimental approach (free running tests)
2. CFD numerical simulations – time domain is the preferable approach
3. Improved automated heading and steering control systems



Longitudinal force due to ship drift (bulk carrier, F_r=0.15)



Longitudinal force due to ship drift (containership, F_r=0.25)

Surface Roughness by Numerical Simulations

Approach:

1. Translate real roughness into simplified parameters (like ”equivalent sand roughness)
2. Introduce the simplified parameters into the equations describing the near-wall flow

Conclusions:

- Introducing homogeneous sand-grain roughness into numerical methods for speed/power prediction in trial conditions seems to be possible
- The possibility to study the effect of non-homogeneous roughness such as bio-fouling in operational condition is still limited

CONCLUSIONS

Recommendation to the Full Conference:

- Adopt the revised procedure 7.5-04-01-01.1
  Speed and Power Trials, Part I Preparation and Conduct

- Adopt the revised procedure 7.5-04-01-01.2
  Speed and Power Trials, Part II Analysis of Speed/Power Trial Data

CONCLUSIONS

Recommendation for Future Work:

- Refinement of the recommended procedures:

  - Temperature and density correction to take into account temp/density gradient
  - Investigate ISO proposed 'iterative method' as an alternative for load variation method and current elimination
  - Investigate statistical results from load variation tests
  - Investigate new shallow water method to replace Lackenby
  - Investigate wave limits for the wave correction methods
  - Investigate application of CFD methods for wind loads
  - Expand the wind coefficient database for more ship types
  - More extensive validation of the wave correction methods (STA1, STA2, NMRI)
  - Investigate feedback of speed/power data for correlation purpose especially for the design and EEDI draft

CONCLUSIONS

Recommendation for Future Work:

- Explore "Ship in Service" issues:

  - f_w application of tools investigated by the sea-keeping committee
  - Investigate feedback of speed/power data for f_w
  - Investigate the monitoring and analysis of speed/power performance of ships in service
  - Investigate EEOI issues originating from IMO requirements
  - Investigate the influence of ship hull surface degradation due to fouling and aging on the speed/power performance

- Develop new roughness correction methods for both hull and propeller; this suggestion could be more applicable for the Resistance/Propulsion committees

- Develop procedures how model tests with Energy Saving Devices such as ducts, pre-swirl fins, hub vanes, hull vanes, rudder fins and unconventional propellers should be conducted and how the measured results should be extrapolated to full scale; this suggestion is more applicable for the Propulsion committee

- ITTC to develop guidelines for the model testing community how to deal with the EEDI verifiers: what are they allowed to see; what documents to deliver to them; how to secure data confidentiality of our direct customers, etc.

QA session

- Thank you for your attention!