Current status on revision work of ISO15016 for EEDI verification
- Conduct and analysis procedure of speed trial –

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Background

- Norway requested to revise the existing ISO15016 analysis method referring STA method (2011.4 MEPC62).

- Japan and ITTC proposed to review the analysis method and special committee : PSS started their study (2011.12).

- IMO MEPC65 (May,2013) assigned two international methods.

  In the Guidelines on a survey and certification of the EEDI, the results of the sea trial analysis should be modified in accordance with ITTC method or ISO 15016:2002
  * ITTC method is considered as preferable

- Since July 2012, ISO has started the revision of ISO15016:2002 by experts including ITTC.

- IMO welcomed the collaborative efforts made by ISO and ITTC to harmonize their standards and urged ISO to submit the revised ISO15016 by early 2014.

- **Harmonized Standards,** in which problems of both ISO15016:2002 (e.g. too complicated, and ambiguous results) and ITTC method (e.g. containing black box, and inaccurate results) are solved, **are essential.**

Basic Concept of harmonized ISO15016

- ISO principle
  The WD gives a step-by-step description, which is vital to transparent verification for all concerned parties including non-experts.

- One document covers all
  The WD covers trial preparation, conduct and the assessment of speed and power performance of speed trial data.

- No room for arbitrary/ambiguous calculation
  The WD has been improved to eliminate room for arbitrary/ambiguous calculation, which procedure can be confirmed by the calculation program in the form of a transparent excel spread sheet.

- Direct power method in ITTC guideline
  The WD has been incorporated with the direct power method under the advises of ITTC and was accepted as a basis for the harmonization in the ITTC Advisory Council held on 5 and 6 September 2013.

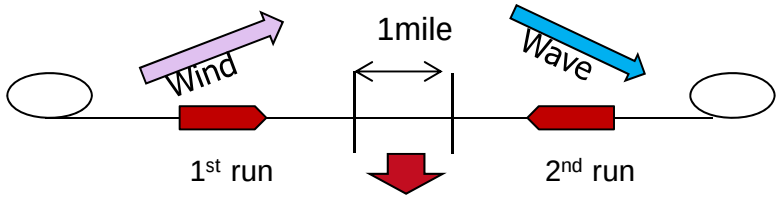
➢ Direct power method

- **Direct Power Method has been incorporated into the harmonized ISO 15016**

What is the difference between ISO15016:2002 and harmonized ISO ?

Basic Concept of ISO15016:2002 is ····

Measurement



Correction to No Wind, Wave, Current Condition

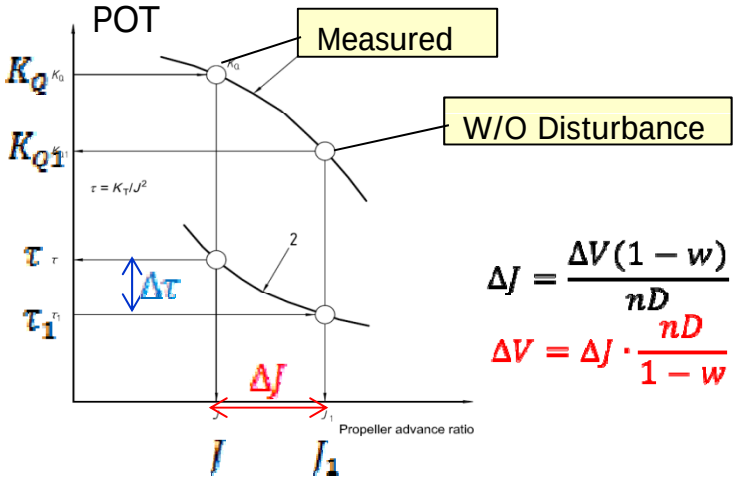
Basic concept : Propeller Load: τ

$$Q = \frac{P_D \eta_R}{2\pi n} \qquad K_Q = \frac{P_D \eta_R}{2\pi \rho n^3 D^5}$$

$$\tau = \frac{K_T}{J^2} = \frac{R_{Calm} + R_{Wind} + R_{Wave}}{\rho D^2 V^2 (1-w)^2 (1-t)}$$

$$\Delta\tau = \frac{R_{Wind} + R_{Wave}}{\rho D^2 V^2 (1-w)^2 (1-t)}$$

$$\tau_1 = \tau - \Delta\tau$$



$$\Delta J = \frac{\Delta V (1-w)}{nD}$$

$$\Delta V = \Delta J \cdot \frac{nD}{1-w}$$

Propeller torque changes from K_Q to K_{Q1}

Basic Concept of harmonized ISO15016 is ····

$$P_{DC} = P_{DM} - \Delta P$$

where

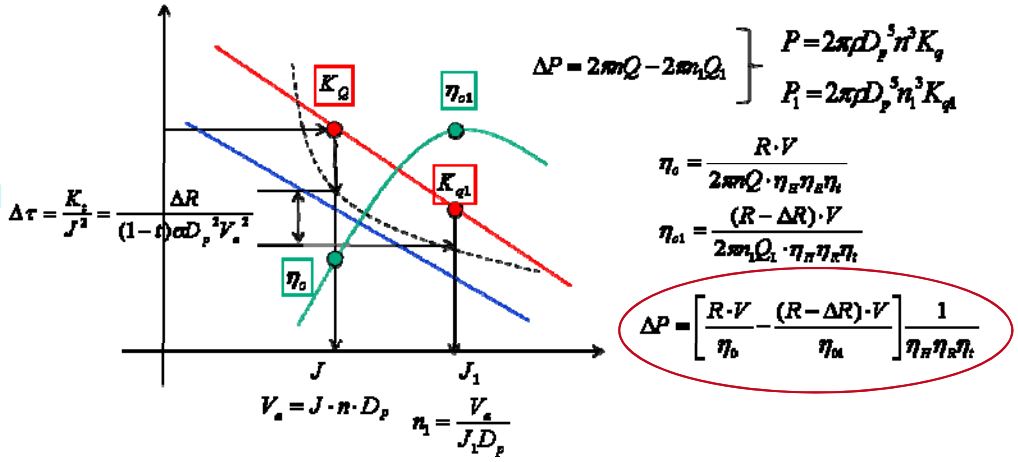
P_{DC}: delivered power in ideal condition,

ΔP: required correction for power.

The required correction for power ΔP is calculated

$$\Delta P = \frac{\Delta R V_S}{\eta_{Do}} + P_{DM}\left(1 - \frac{\eta_{DM}}{\eta_{Do}}\right)$$

V_S: ship speed through the water
η_{DM}: propulsive efficiency coefficient in trial condition
η_{D0}: propulsive efficiency coefficient in ideal condition



Based on the propeller open characteristics, power increase by environmental forces:ΔP is directory corrected using the additional resistance:ΔR and change of propeller efficiency.

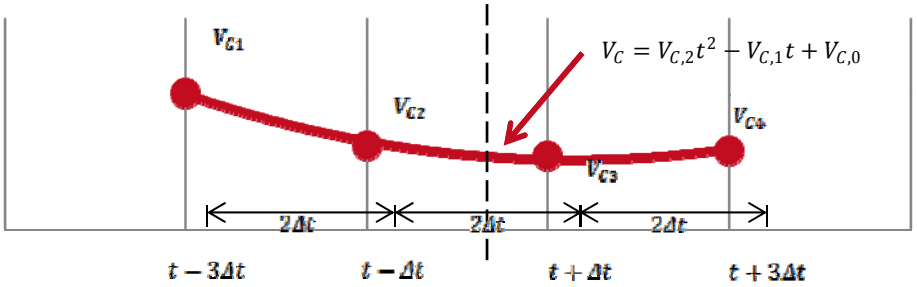
Basic concept for power correction is identical between existing ISO(ISO15016:2002) and harmonized ISO.

➢ Correction method for current

Two options are selected for the correction method

- Iterative Method
- Mean of means method

Ship speeds over the ground are expressed as follows, considering the relation of $V_G = V_S + V_C$ and each V_{Ci} obtained by substituting the time at each run for the quadratic function representing current curve.



$$V_{G1} = V_S + \{V_{C,2}(t+3\Delta t)^2 - V_{C,1}(t+3\Delta t) + V_{C,0}\}$$
$$V_{G2} = V_S - \{V_{C,2}(t+\Delta t)^2 - V_{C,1}(t+\Delta t) + V_{C,0}\}$$
$$V_{G3} = V_S + \{V_{C,2}(t-\Delta t)^2 - V_{C,1}(t-\Delta t) + V_{C,0}\}$$
$$V_{G4} = V_S - \{V_{C,2}(t-3\Delta t)^2 - V_{C,1}(t-3\Delta t) + V_{C,0}\}$$

And then, by substituting the above 4 formulae for the below formula of mean of means method, all terms of current are eliminated and only V_S remains.

$$\frac{V_{G1} + 3V_{G2} + 3V_{G3} + V_{G4}}{8} = V_S$$

- ✓ For mean of means method, the current speed is assumed to vary parabolically.
- ✓ 2 double runs (4 runs) shall be carried out with the same intervals in the same setting of engine output.
- ✓ Mean of means method is only applicable when the above two conditions are fulfilled.
- ✓ Introduced by Principles of Naval Architecture.

Iterative Method

✓ Function for current variation

Current speed is assumed to vary periodically with the semidiurnal period:

$$V_C = V_{C,C}\cos\left(\frac{2\pi}{T_C}t\right) + V_{C,S}\sin\left(\frac{2\pi}{T_C}t\right) + V_{C,T}t + V_{C,0}$$

4 unknown factors $V_{C,C}, V_{C,S}, V_{C,T}$ and $V_{C,0}$ are provisionally determined by the least square method, and fixed by the iterative method later.

✓ Ship speed corrected by current speed

Ship speed is calculated using current speed on the above current curve:

$$V'_S = V_G - V_C$$

✓ Speed-power curve

Function for speed-power curve is assumed for this iterative method:

$P = a + bV_S{}^p$ (proposed at ITTC PSS)

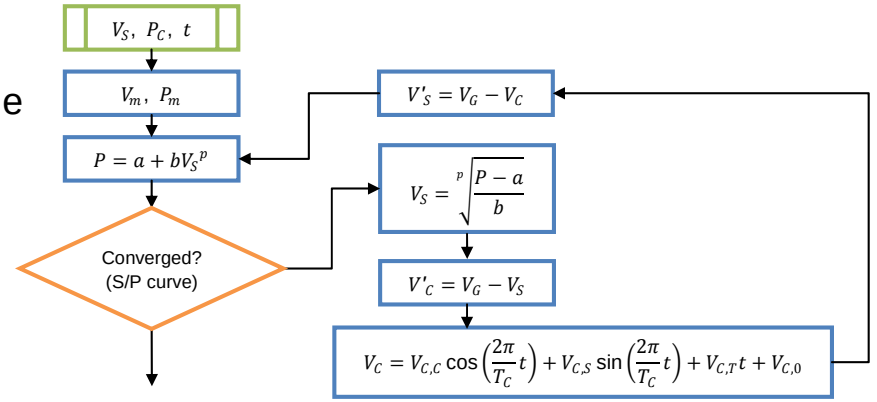
3 unknown factors $a, b,$ and p are provisionally determined by the least square method, and fixed by the iterative method later.

✓ Current speed

Current speed is calculated using ship speed on the above speed-power curve:

$$V'_C = V_G - V_S$$

✓ Iterative method is also used in BSRA method.



Comparison of two methods

✓ The function representing the current curve

- Iterative method : periodic function

$$V_C = V_{C,C}\cos\left(\frac{2\pi}{T_C}t\right) + V_{C,S}\sin\left(\frac{2\pi}{T_C}t\right) + V_{C,T}t + V_{C,0}$$

- Mean of means method : quadratic function

$$V_C = V_{C,2}t^2 - V_{C,1}t + V_{C,0}$$

✓ Relation among ship speeds and current speed

Relation among ship speed through the water, ship speed over the ground and current speed is expressed as follows for both method:

$$V_S = V_G - V_C$$

As described above, both method are based on the same idea, therefore, it's expected that the almost same result can be derived by either method, but ・・・

✓ While, it is necessary to pay attention to the following matter when mean of means method are applied.

- There is application limit that 2 double runs (4 runs) shall be carried out with the same intervals in the same setting of engine output.
- There is possibility that wrong estimation may occur.

Iterative method is free from the above problem

Verification of current correction based on sea trials

SAJ conducted the sea trial with an additional double run for some vessels to confirm the accuracy of " Mean of means method" .

✓ Typical Sea trial procedure

> Double run for 65-70% of M/E output
> Double run for 85-90% of M/E output
> *Additional Double run for 85-90% of M/E output*
> Double run for 100% of M/E output

✓ Analysis procedure

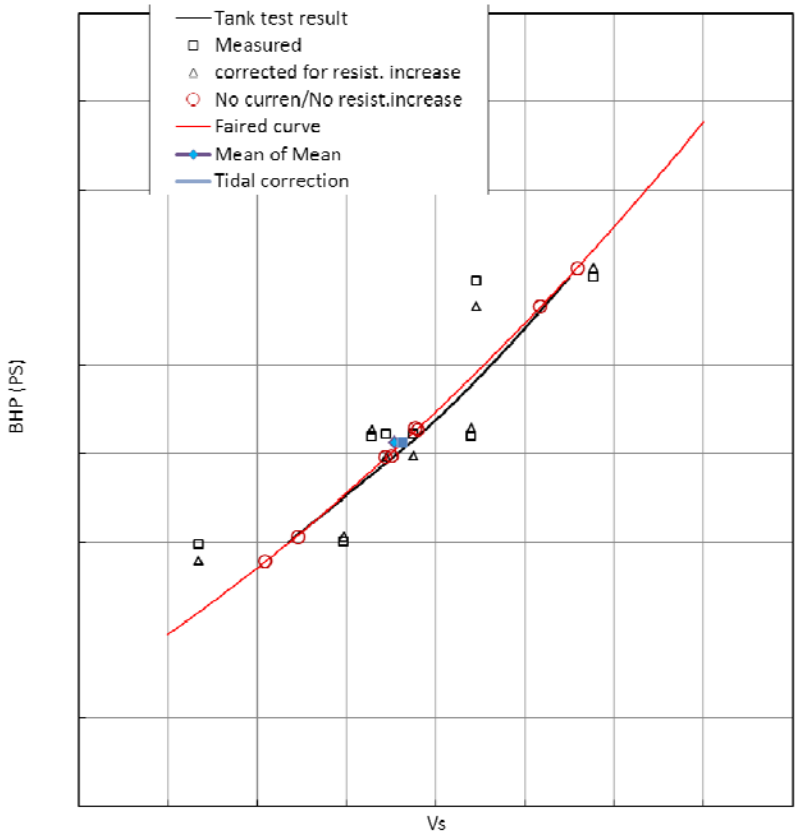
Analysis of speed trial was carried out based on the " Iterative method " .
" Mean of means method " was also applied to the two double runs data corresponding to the 85-90% of M/E output.
Analyzed results between two methods were compared.

Technical amendment - Current correction -

Results

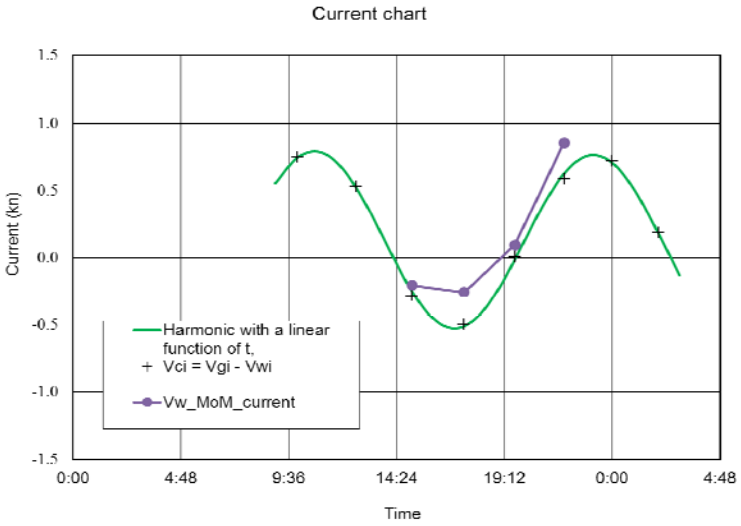
◆ : Mean of means method

○ : Iterative method



Sample data for printing materials.

Comparison of current curve



Remarks from Verification

- Analyzed results by “ Mean of means method ” and “ Iterative method ” showed a small deviation within 0.05knot difference for eight vessels.
- In case that the current curve is assumed as harmonic curve, mean of means method’s current curve defined by quadratic function may not show a good agreement, especially, during peak to peak on the current curve.
- “Iterative method” can keep the same or better accuracy than “Mean of means method” with half number of runs.

Technical amendment - Wave correction -

➢ Calculation method for resistance increase in waves

In addition to the tank test,

Three options are selected for the calculation method

- NMRI method (Theoretical method with practical correction)
- STAWAVE1 (Simplified correction method)
- STAWAVE2 (Empirical correction method with frequency response function)

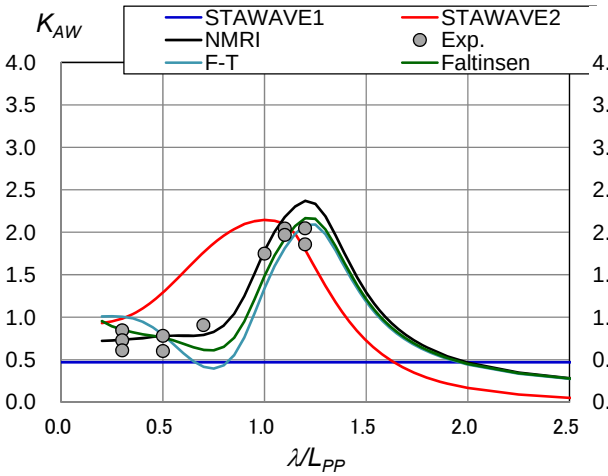
Option	Tank test data for transfer function	Input Data	Ship motion considered
NMRI method-A	○	・Principal dimention and atatic data ・Cp(long. prosmatic coef.) and Cwp(water plane area coef.) curve	Yes
NMRI method-B	×	ditto	Yes
STAWAVE1	×	two parameters (Breadth & distance of the bow)	No
STAWAVE2	×	five parameters (Lpp, Breadth, draft, Cb and kyy)	Yes

➢ Calculation method for resistance increase in waves

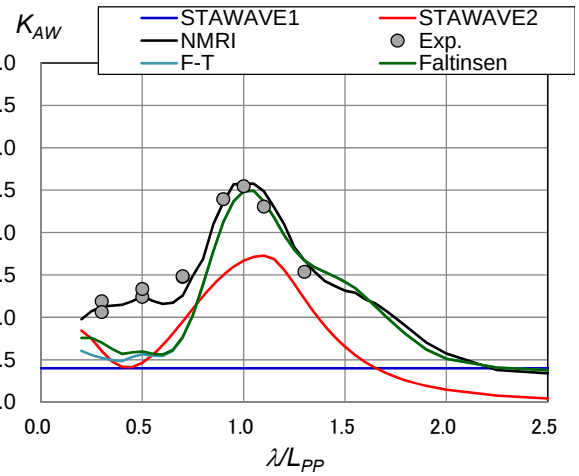
Comparative study on accuracy of estimation

Transfer Function

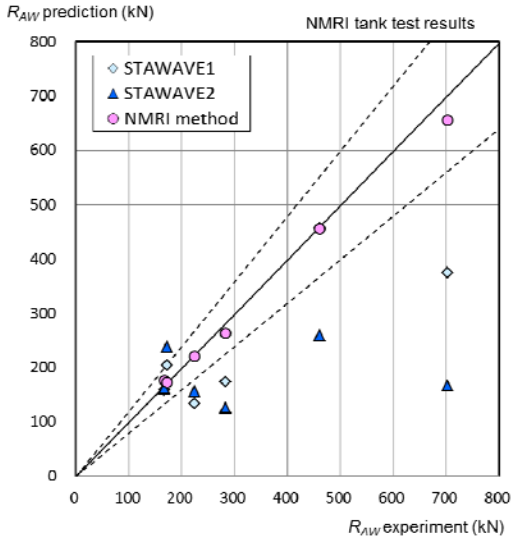
Bulk carrier (Full)



Bulk carrier (Ballast)



Short crested irregular wave

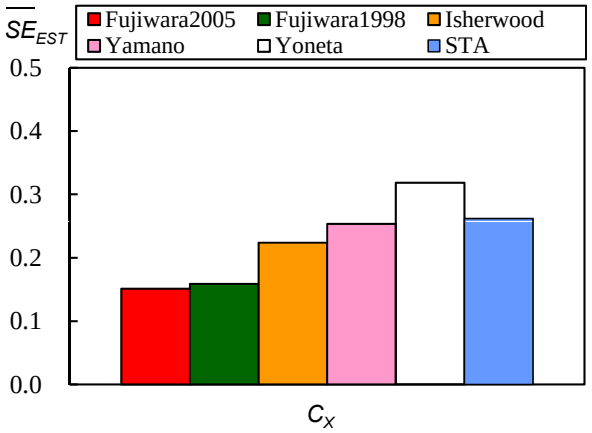


STAWAVE shows the tendency to underestimate the resistance increase in waves.
Further confirmation will be necessary.

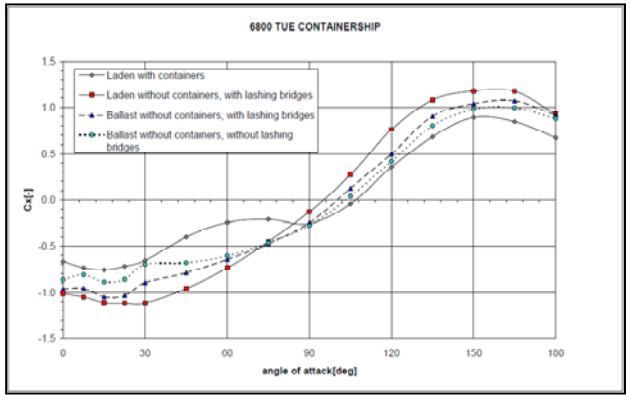
➢ Calculation method for wind resistance

Three options are selected for the determination of Cx.

- Wind tunnel test results
- Fujiwara's formulae (Empirical formulae)
- STA database (In case of ships of similar type)



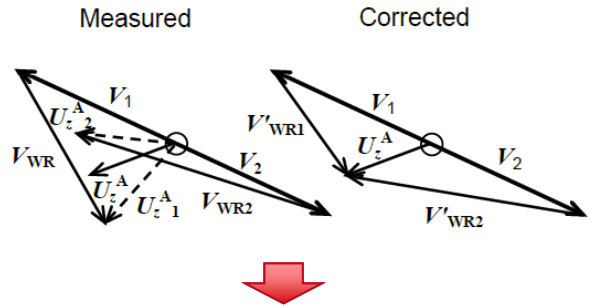
Fujiwara's formula was selected based on the comparative study of estimation accuracy



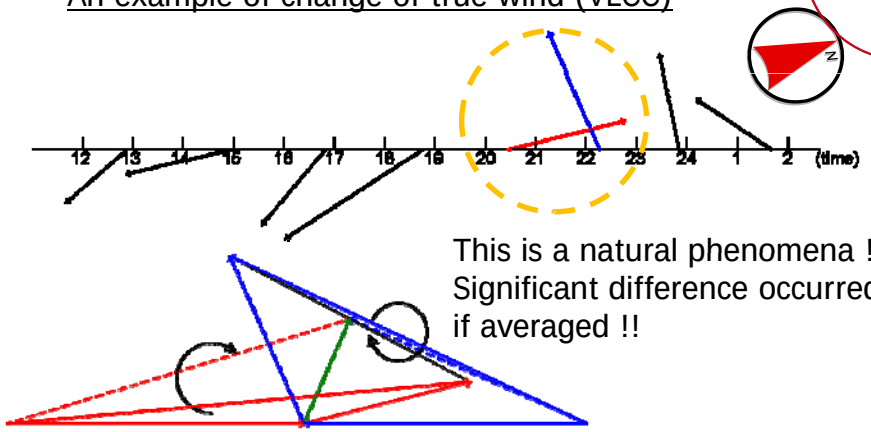
Example of STA database

➢ Calculation method for wind resistance

Averaging of true wind vectors (Effect of superstructure)



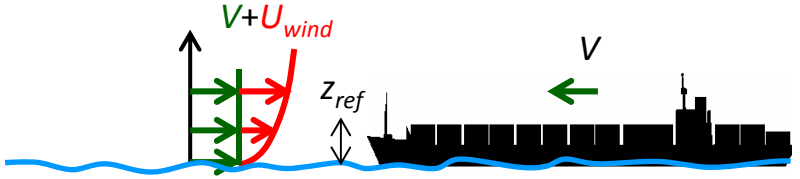
An example of change of true wind (VLCC)



This is a natural phenomena !!
Significant difference occurred if averaged !!

Correction for the height of anemometer

$$U_z^{A}(z_{ref}) = U_z^{A}(z)\left(\frac{z_{ref}}{z}\right)^{1/7}$$



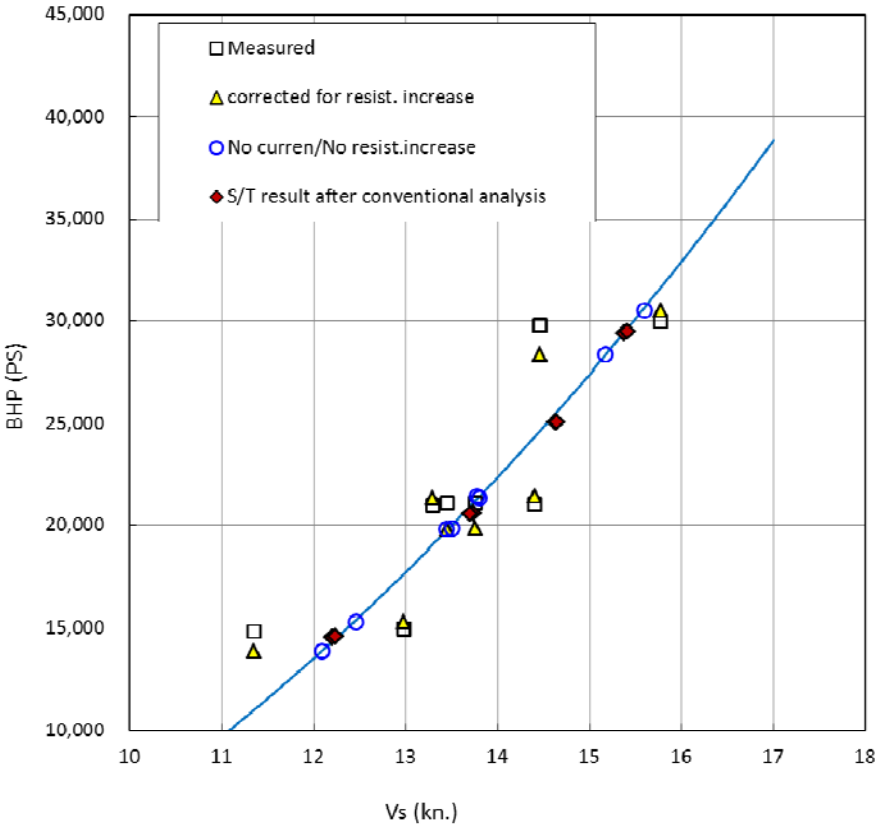
This treatment depends on the type of wind profile applied for wind tunnel test

May be, shipbuilder will check followings and judge the data based on the documented mutual agreement among the Owner, the Verifier and the Shipbuilder.

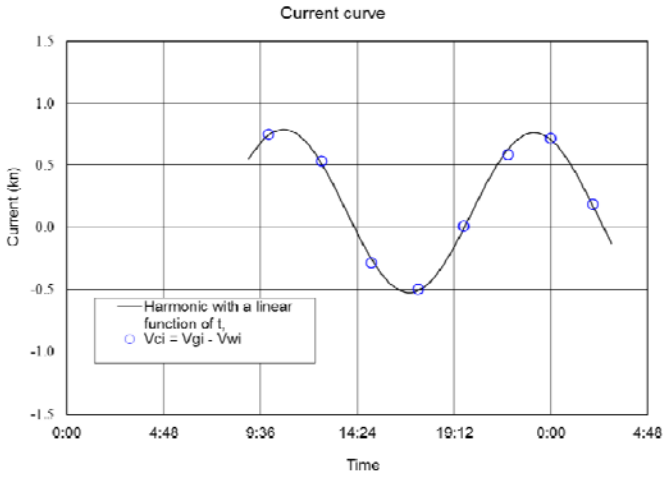
a. Consistency of the time series curve of the true wind vector for each run
b. The time series of the temperature and the atmospheric pressure of each run.
c. Public weather information etc.

➢ Evaluation of the accuracy of harmonized ISO method

- To confirm the accuracy of the harmonized ISO method, SAJ carried out the evaluation study by applying two correction methods (ISO15016:2002 and harmonized ISO) for the existing trial data.
- Results show a good agreement to each other.



Sample data for printing materials.



TC8/SC6/WG17 held in London in Sep, 2013

- Time and Venue

  Meeting date: 16-17 September, 2013
  Place: London, United Kingdom

- Participants

  22 members **ASEF members**
  (**China**, Denmark, Germany, **Japan**, **Korea**, Netherland, Romania, United States, BIMCO, ITTC, IACS, STA-group)

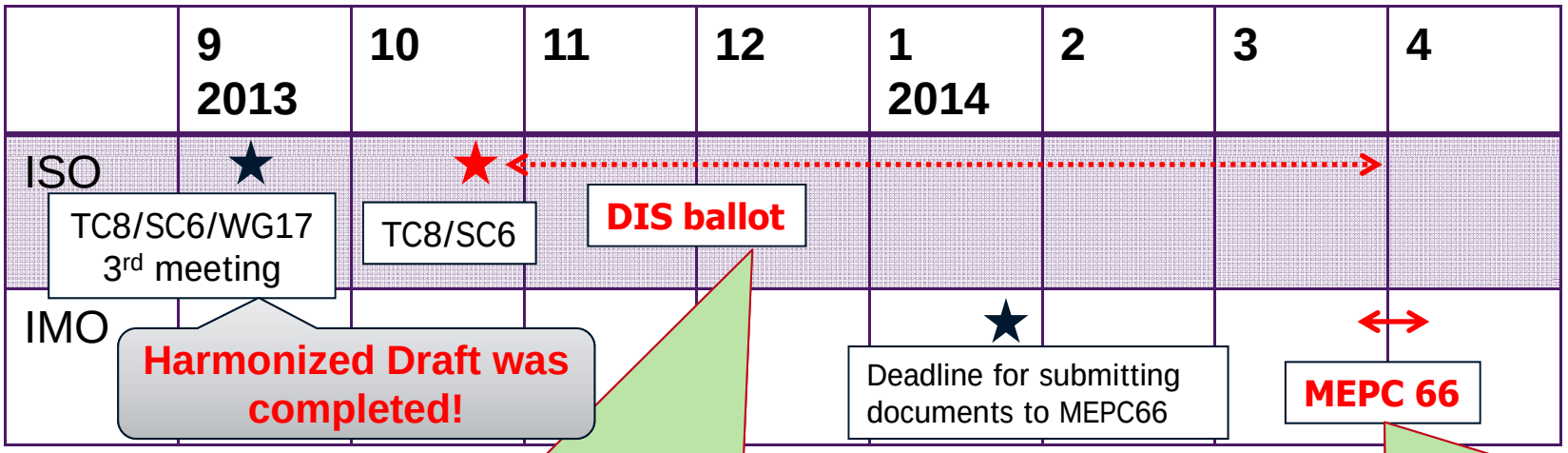
- Results

  All the participants agreed the substance of ISO working, and agreed to request ISO/TC8/SC6 for PAS voting of the harmonized ISO 15016.

  The harmonized draft between ISO and ITTC was COMPLETED!!

ITTC method or ISO 15016:2002 ⇨ Unified method

Future perspective



The 1st hurdle to clear

According to the Resolution MEPC.234 (65), “Revised version of ISO 15016 should be available by early 2014”.

The 2nd hurdle to clear

Revised ISO 15016 should be an acceptable way for sea trial in the EEDI guidelines.

If ISO15016 is revised and considered to be an acceptable way for sea trials, work under ISO/TC8 will meet the expectations not only from IMO but also maritime industry.

Point of compromise in London meeting

➢ Exception Case

If it is physically impossible to meet the conditions in this standard, a practical treatment shall be allowed based on the documented mutual agreement among the Owner, the Verifier and the Shipbuilder.

- Averaging wind velocity and direction
- Run direction against wave (Head)
- Minimum run duration time (10 min/1 mile)
- Restriction for trim and displacement

➢ Observation of wave height

Empirical criteria for maximum allowable correction of resistance increases due to wave

Lpp=300m

- Wave spectrum measured: $H_{1/3} \leq 2{,}25\sqrt{L_{pp}/100}$ **3.9m**
- Visual observation: (Including STWAVE) $H_{1/3} \leq 1{,}50\sqrt{L_{pp}/100}$ **2.6m**
- NMRI method with Tank test: $H_{1/3} \leq 0{,}50\sqrt{L_{pp}/100}$ **0.9m**

➢ Annex-F

The effects of water temperature and salt

- Changed from "Informative" to "Normative"

$$R_{AS} = R_{T0}\left(\frac{\rho}{\rho_0} - 1\right) - R_F\left(\frac{C_{F0}}{C_F} - 1\right)$$

Conclusion

- According to the establishment of EEDI regulation, transparent correction method for speed trial is required by verifiers (Class)
- Harmonized method between ISO and ITTC is thus essential. Troublesome affairs could occur if harmonized ISO is deleted at MEPC66 by any possibility.
- SAJ confirmed the accuracy of the harmonized ISO, and consider it to be a reliable and transparent method, analysis results of which is always sole and can be derived even by non-experts.
- Although compromised issues still exist, ASEF members who occupy the major part of shipbuilding industry can overcome this situation by our close cooperation.
- Your kind assistance to the DIS ballot for harmonized ISO is highly appreciated.

Thank you for your attention !

고맙습니다

真谢谢你了

有難うございました

THE SHIPBUILDERS' ASSOCIATION OF JAPAN

JMU Japan Marine United Corporation