Note:

This is an updated version of the earlier proposal, including the identification of the power required and the reduction to the no-wind and no wave condition.
The corresponding example is based on the same data as the example in the meanwhile ISO DIS 15016.
The proposal is purposely still in a rather sketchy state.

Various explanations of the procedure proposed are to be found on the website of the author
http://www.t-online.de/home/m.schm ,
in particular notes of lectures in English and German, held at university institutes in Germany.

Contribution concerning a proposed ISO Standard „Guidelines for the assessment of ship speed and power performance by means of speed trials“

by Dr.-Ing. Michael Schmiechen

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Abstract

An attempt is being made to provide an adequate basis for the proposed standard on ship speed trials and their evaluation. The procedures of ship speed trials and their evaluation described permits to reduce and simplify the trials drastically and at the same time to rationalise their evaluation and to improve the quality of their results, providing not only estimates of the values in question but their confidence levels as well, necessary for serious judgements in accordance with ISO 9001.

The systems or rather parameter identification is based solely on the analysis of data measured on board of the ships and does not require reference to model test results and other prior data. It proceeds in two steps, or rather three:

- in the first step the power supplied, the powering characteristic of the propeller in the behind condition, as function of ship speed through water and frequency of revolution, and the current velocity, as function of time, are being identified as solutions of one set of linear equations;
- in the second step the powers required due to water, wind and wave resistance, as function of the relative water wind and wave speeds, are being identified as solutions of another set of linear equations;
- in the third step the results are reduced to the weather condition contracted.

The present draft is based on experience and insights gained in model and full scale testing of the German research vessel METEOR and the Blohm + Voss experimental SES CORSAIR and on the discussions of a preliminary version of this document at meetings of the ad-hoc Speed Trials Group at the DIN Normenstelle für Schiffs- und Meerestechnik (NSMT).

Various explanations of the procedure proposed are to be found on the website of the author http://www.t-online.de/home/m.schm , in particular notes of lectures in English and German, held at university institutes in Germany. A summary paper trl_sum.htm contains hyperlinks to all the material except for the latest evaluation of the ISO example.

Preface

The performance of ship speed trials and their evaluation is an important and a difficult problem. Common conventions for the evaluation of measurements have to be agreed upon in order to resolve possible conflicts between ship builders and ship buyers. The conflicts may arise due to the fact that weather and other conditions at the speed trials are in general quite different from the conditions for which the power predictions have been made and contracted.

The rational resolution of a conflict is based on the acceptance of a consistent set of concepts and conventions as well as rules for the definition of derived concepts and derivation of consequences from the conventions and, last but not least, the acceptance of the formally derived consequences. Only if this axiomatic system is as simple and plausible or 'evident' as possible this conventional system and its consequences will be generally acceptable and accepted for decision making. This fact is overlooked by logicians not requiring 'evidence' but only consistence.

Consequently an adequate modern standard for the evaluation of ship speed trials, which meets present day standards in other fields and which can be standardized, has to establish such a consistent and trustworthy axiomatic system of conventions meeting the requirements outlined. The present practice of trials evaluation and the suggested changes do not satisfy this demand according to the feeling expressed by shipbuilders.

The basic idea of the present proposal is to establish such a procedure as far as possible on the basis of full scale measurements taken at the trial trips only. This procedure avoids any unnecessary conventions and any references to theories, which as such and the relevance of which are not transparent, not only for non-scientists.

My firm conviction was and is, even stronger now, that an ISO standard should not just continue to refine past practice, but should meet the highest 'standards' and take advantage of the latest state of the art and technology of systems identification, not only in view of the legal implications, but the requirements of ISO 9001 as well. And it must be the result of a joint effort of the whole community concerned, including theoreticians.

My principles or goals are to keep the models as simple and the method as transparent as possible in order to make the results as truthworthy as possible. Consequently I adhered to the rule: keep separate problems separate as far as possible and keep the exposition as simple as possible.

The plan of this draft proposal is to outline, for the purpose of discussions in view of future standardisation, the principal details of such a systems identification procedure based on experience and insights gained during a research project on a rational theory of hull propeller interaction and model and full scale testing of the German research vessel METEOR and the Blohm + Voss experimental SES CORSAIR.

The procedure described permits to reduce and simplify the trials drastically and at the same time to rationalise their evaluation and to improve the quality of their results, providing not only estimates of the values in question but their confidence levels as well, necessary for serious judgements in accordance with ISO 9001.

As it stands the proposal is by no means finished but needs to be completed as indicated taking into account the vast experience existing with practical problems encountered in ship speed trials. But before this is being done the proposal needs to be discussed and accepted. This discussion has been started in the ad-hoc-Group of the DIN/NSMT.

In view of the legal implications the final version of this draft needs to be phrased in accordance with the requirements of various ISO Standards, ISO 9001 in particular. The structure of the exposition and the details of the procedure have already been chosen to meet these requirements.

Contents

The following first four chapters are to be filled in as required

- ***according to the established standards and codes***
- ***and the draft ISO/DIS 15016 of 2000-08-03 (begin of vote)***
- ***and, last but not least, in the light of what follows.***

At this stage they are not the primary concern of this draft.

1 Introduction

1.1 Aims of the Standard

1.2 Scope of the Standard

2 References

2.1 Normative references

The normative references quoted in ISO/DIS 15016 are to a certain extent obsolete in the sense that the ITTC Symbols and Terminology List, on which they are based, has been largely revised and is continuously updated since the Version 1993 was published on occasion of the 20th ITTC at San Francisco (Schmiechen 1993).

2.2 Other references

BSRA Code

SNAME Code

12th ITTC Guide 1969

21th ITTC Guide 1996

etc etc

ITTC Symbols and Terminology List, no longer published in print, but available in the World Wide Web at various sites, e. g. at DTMB Washington and USNA Annapolis.

Schmiechen, M. (Editor): 2nd INTERACTION Berlin '91. Proceedings of the 2nd International Workshop on the Rational Theory of Ship Hull-Propeller Interaction Berlin 1991. Mitteilungen der Versuchsanstalt für Wasserbau und Schiffbau, VWS, the Berlin Model Basin, Heft 56, 1991.

Schmiechen, M. (Editor): ITTC Symbols and Terminology List, Version 1993. Mitteilungen der Versuchsanstalt für Wasserbau und Schiffbau, VWS, the Berlin Model Basin, Heft 57, 1993.

3 Symbols and Terminology

3.1 Concepts

Symbol	Name	Unit
D	diameter of propeller	m
N_S	shaft (and propeller) rate of revolution	1 / s
P_S	shaft power	kW
p_0	power parameter	kg m
p_1	power parameter	kg m^2
Q_S	shaft torque	kN m
T	thrust	kN
t	time	s
t	thrust deduction fraction	1
t_0	thrust parameter	
t_1	thrust parameter	
t_H	thrust deduction fraction constant	1
V_C	current velocity over ground	m / s
V_G	ship hull speed over ground	m / s
V_H	ship hull speed relative to the water	m / s
ρ	density of the water	t / m^3

3.2 Operators: superscripts

Symbol	Name	
D	deviation (standard)	
E	expectation	
M	mean, estimate of expectation	
S	scatter, estimate of deviation	

3.3 Qualifiers: subscripts

Symbol	Name	
C	current	
C	contract	
G	(hull relative to) ground	
H	hull (relative to water)	
M	model scale	

R	reference	
S	shaft	
T	traditional	
X	extrapolated	

3.4 Indices, operational

Symbol	Name	
i	index of sample	1 .. n
n	number of samples	
j	index of current component	0 .. om
om	order of current model	

3.5 Units

All quantities are to be measured in coherent SI units, e. g.

Symbol	Name	Unit
V	speed, velocity	m/s
N	rate of revolution	Hz, 1/s
Q	torque	kNm
P	power	kW

4 Trials conditions

4.1 Conditions of the Vessel

4.1.1 Hull

4.1.2 Propeller

4.2 Environmental Conditions

4.2.1 Waves

4.2.2 Wind

5 Measurements

5.1 Torque

5.1.1 Shaft torque

Strain gauge measurements.

5.1.2 Propeller torque

> ***In an earlier version of this draft the shaft and the propeller torque and power have been carefully distinguished. For the sake of simplicity the technical questions are not discussed in the present draft. They are in detail documented in the Annex to the German position concerning the first draft of the Japanese ISO proposal.***
>
> ***As a matter of fact the solution is not just a technical problem, but needs various conventions to be agreed upon at the time of contract as the following note indicates.***

The 'best' choice of the shaft power to be used in the evaluation is in I my opinion the shaft power measured. According to my understanding this is identical with **the brake power and the 'correct' reference. In proving the conformance with contract conditions it does not require further assumptions on top of those necessary for the strain gauge measurements in the usual absence of calibrations proper.** Care has to be taken in introducing or comparing with model data, being mostly in terms of delivered power.

5.1.3 Results

Results are the unbiased values of the rate of revolution

$$\mathbf{N_S = f_N (t)}$$

and values of the torque at the shaft

$$\mathbf{Q_S = f_Q (t)}$$

as functions of time, i. e. at certain time values.

In practical terms the result is a matrix of length

$$i = 1 \ .... \ n$$

of the triples

$$t_i , N_i , Q_{S\,i} \ .$$

5.2 Speed

5.2.1 Speed over Ground

GPS measurements

5.2.2 Speed relative to the water

5.2.3 Results

Results are the unbiased values of the velocity of the ship hull over ground

$$\mathbf{V_G = f_V(t)}$$

and, if required, values of the acceleration of the ship hull over ground

$$A_G = f_A(t)$$

as functions of time, i. e. at the same time values at which the corresponding values of the rate of revolution and the torque are recorded.

In practical terms the result is a matrix of length

$$i = 1 \ldots n$$

of the triples

$$t_i,\ V_{G\,i},\ A_{G\,i}\ .$$

5.3 Check of Data

The check of the data at this stage concerns systematic effects. The ultimate check will take place at a later stage. When the parameters of the model are identified by least square fit the residua must be random according to some criterion to be agreed upon.

6 Power supplied

6.1 Power, current

Derived concepts of interest are the shaft power

$$P_S \equiv 2\,\pi\,N_S\,Q_S\ ,$$

and the current velocity,

$$V_C \equiv V_G - V_H\ ,$$

the difference between the speed of the ship over ground V_G and the speed of the ship relative to the water V_H , undisturbed by the flow around the ship.

6.2 Power conventions

The first two conventions necessary concern the powering characteristic.

The first convention proposed is that the powering characteristic

$$\mathbf{P_S = f\,(N_S\,,V_H)}$$

is not affected by the disturbances, i. e. the propeller “does not notice” them directly, but only as a change of working condition due to changes in resistance, caused e. g. by changes in draft, trim, wind, waves, ice, velocity or others as compared to the reference conditions, provided the propeller is always working roughly at the reference conditions. For example during the trials measurements it has to be submerged if that is the reference condition.

The second convention is that for all practical purposes the powering characteristic may be approximated by the simple function

$$\mathbf{P_S = p_0\,N_S^{\,3} - p_1\,N_S^{\,2}\,V_H}$$

in the range of interest.

According to observations even in heavy weather (METEOR) and in ice (ITTC/PIC Madrid) both these conventions are valid in a very wide range of service conditions.

The consequence of the two conventions is that the propeller can be used as measuring instrument provided it is properly calibrated. This is of course well known to practitioners. And consequently the only problem to be solved is to specify the calibration procedure based on the measurements taken during the speed trials.

6.3 Current convention

If measurements of the ship hull speed V_H relative to the water are taken or tests are performed in water at rest and measurements of the ship hull speed relative to the ground V_H are taken, so that the condition

$$V_H = V_G$$

holds, the solution of the calibration problem requires in principle measurements of the speed V_H, the rate of revolution N_S, and the torque Q_S at only two, not necessarily steady conditions for the determination of the two constants of the powering characteristic.

But as a matter of fact the typical case is that currents, often, but not necessarily tidal currents, prevail during measured mile or speed trials. Consequently a further convention concerning the change of the current velocity with time is necessary.

In most cases a cubic or biquadratic polynomial law

$$\mathbf{V_C = \Sigma\, v_j\, t^j}$$

with

$$\mathbf{j = 0 \ldots 3 \text{ or } 4}$$

will be sufficient. The assumption of harmonic changes is in general neither adequate nor necessary.

6.4 'Calibration'

The calibration amounts now to the identification of the unknown parameters in the model equation

$$\mathbf{P_S = p_0\, N_S^3 - p_1\, N_S^{\,2}\, V_G + p_1\, N_S^2\, \Sigma\, v_j\, t^j\, sign(V_C/V_G)}$$

As a matter of fact this equation holds for all quasi-steady states and as a consequence this calibration procedure does not require steady conditions to be reached on adverse courses but only quasi-instantaneous values over quasi-steadily changing conditions.

After solving the set of linear equations

$$p_0\, N_{Si}^3 - p_1\, N_{Si}^2\, V_{Gi} + p_1\, N_{Si}^2\, \Sigma\, v_j\, t_i^j\, sign(V_C/V_G) = P_{Si} + e_i$$

for the parameters p_0, p_1 and $p_1 v_j$ the last have to be subdivided by p_1 to obtain the current parameters and subsequently the current velocity according to the convention adopted. Evidently this procedure completely avoids the usual involved iterative procedure based on estimates of resistance.

The usual, rather involved iterative solution of a problem with at least five unknows is replaced by the straightforward solution of a system of linear equations. But in view of the ill-conditioned problems arising there is no chance to solve the equations with do-it-yourself algorithms, singular value decomposition is an absolute requirement. The traditional procedure is obscured by the iterative identification of the 'laws' for power and current velocity. The variability of the data can be largely increased if quasi-instantaneous values are being used.

In addititon, if quasi-instantaneous values are being used, as strongly recommended, a proper statistical analysis can be performed in terms of the residua e_i and confidence ranges can be determined for the powering performance and the current velocity. A standard algorithm can be developed as soon as agreement has been reached on the procedure. As has been mentioned before the residua have to be random according to some criterion to be agreed upon.

6.5 Double runs

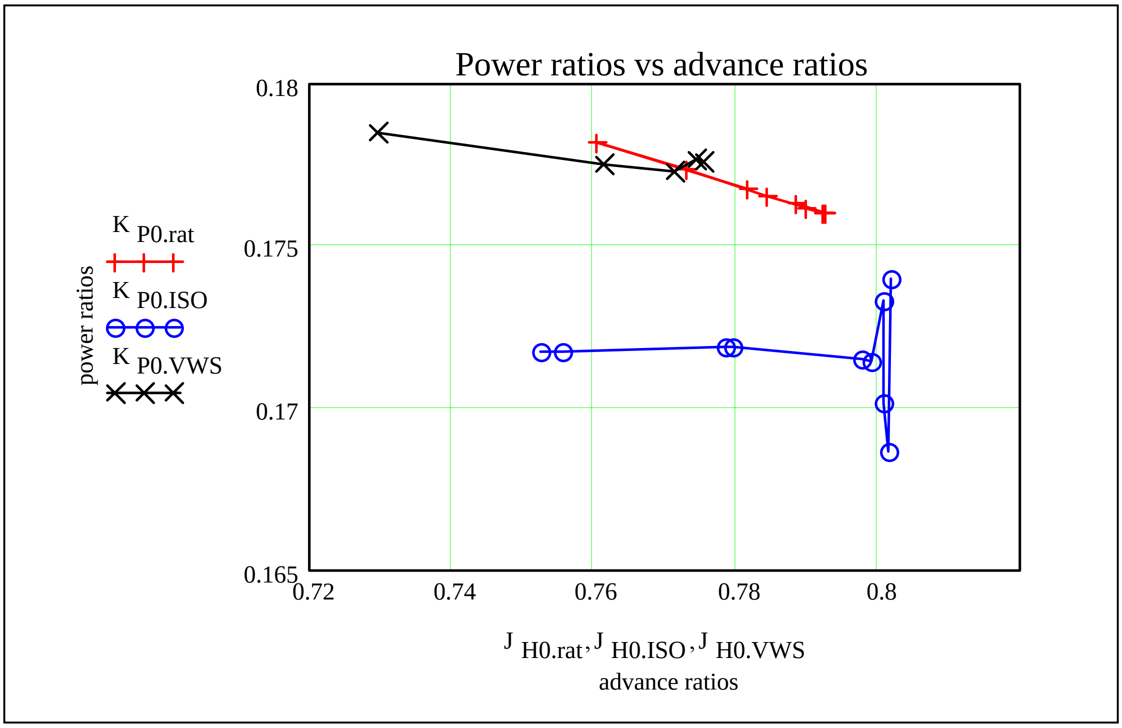
If one wants to stick to the traditional double runs the minimum number of such runs in the case of a current law of order three is three, leaving no degree of freedom in the statistical sense. If a higher order of current law needs to be introduced or more degrees of freedom are required in order to establish some confidence in the statistical sense more double runs will be required, at least four are desirable in general.

Even then the situation remains unsatisfactory as Professor Nakatake rightly points out in his discussion of the 21th ITTC Guidelines (1996). Contrary to the traditional procedure the method proposed does not need expensive extra steady double runs. One double run is sufficient and it does not need to be steady. Still all the information required is provided.

Compared to steady conditions on adverse courses conditions at accelerated motion may provide for more variability of the date, necessary for the reliable identification of the parameters in question.

6.6 Normalisation

While for the purposes of identification physical quantities are being used, for the purposes of visualisation normalised quantities are being introduced. This has the advantage that instead of two arguments, speed and rate of revolutions, only one, the advance ratio, is necessary. Further, systematic effects become evident.



7 Contract Conditions

7.1 General

Usually the contract or reference conditions are different from the trials conditions. In order to permit reliable corrections the trial conditions are permitted to deviate from the reference conditions only in the limits outlined in Chapter 4: Trials conditions. If the density of the sea water at the site of the trials differs from the reference density the values of the power parameters have to be corrected correspondingly.

A particularly important problem is the difference in the ballast and the full load conditions. If the propeller is submerged at the ballast condition the powering characteristic determined at this condition may be used without change at the full load condition as well. Evidently this procedure implies another far-reaching convention. If model tests are available at both conditions the powering characteristic may be corrected accordingly.

Evidently there are three direct approaches possible in comparing contract conditions with the results obtained so far. The same procedure is used in the examples attached for the purpose of comparing the results of traditional evaluations with evaluations according to the method proposed.

7.2 Power performance

Firstly: If the values of the required shaft power $P_{S.C}$ are contracted at given reference values $V_{H.R}$ of the hull velocity and given reference values $N_{S.R}$ of the rate of revolution, the reference values of the shaft power

$$P_{S.R} = p_0 N_{S.R}^3 - p_1 N_{S.R}^2 V_{H.R} ,$$

which are required at reference conditions, may be determined and compared with the contracted values of the shaft power.

The differences under discussion are

$$\Delta P_S = P_{S.R} - P_{S.C} .$$

7.3 Speed Performance

Further: If the values $V_{H.C}$ of the hull speed relative to the water to be reached with given reference values $P_{S.R}$ of the shaft power at given reference values $N_{S.R}$ of the rate of revolution are contracted the evaluation is equally evident.

The reference values of the hull speed

$$V_{H.R} = p_0 N_{S.R} / p_1 - P_{S.R} / (p_1 N_{S.R}^2) ,$$

which are reached at reference conditions, may be determined and compared with the contracted values. Consequently the differences under discussion are

$$\Delta V_H = V_{H.R} - V_{H.C} .$$

7.4 Rate of revolution

Finally: If the values N_C of the rate of revolution to be maintained at given reference values $V_{H.R}$ of the speed relative to the water and at given reference values $P_{S.R}$ of the shaft power are contracted the evaluation is slightly more involved.

The reference values of the rate of revolution N_R , which are maintained at reference conditions, are solutions of the cubic equation

$$p_0 N_{S.R}^3 - p_1 N_{S.R}^2 V_{H.R} - P_{S.R} = 0$$

and may be determined numerically, in any modern programming environment, see Chapter 10: Examples. The values are compared with the contracted values and the differences under discussion are

$$\Delta N_S = N_{S.R} - N_{S.C} .$$

7.5 Interpolation

The differences determined can be used to establish the linear equation

$$\Delta P / \Delta P_S + \Delta V / \Delta V_H + \Delta N / \Delta N_S = 1$$

for the deviations from the contract conditions. This equation may be useful for the purpose of interpolation, if certain conditions are to be met.

7.6 Contracted values

Contrary to the traditional procedure the problem is evidently not the transformation from the trials conditions to some reference conditions, but the establishment of the contracted values. And this is done by reference to model test results providing detailed information on the powering performance including all hull-propeller interactions.

7.7 Resistance

If more data are taken, thrust values in particular, the analysis can be carried further. After introduction of the convention of the thrust performance

$$T = t_0 N_S^2 - t_1 N_S V_H$$

and of the convention of the thrust deduction fraction

$$t = t_H V_H / (D N_S)$$

and the corresponding calibrations the total resistance,

$$R = T (1 – t) = t_0 N_S^2 – (t_1 + t_0 t_H / D) N_S V_H + t_1 t_H / D V_H^2 ,$$

including the inertial resistance if any, can be determined at any time.

In particular the differences in resistance at the trials conditions and at the reference conditions can be determined.

Thrust measurements cannot be performed routinely with sufficient precision. The above procedure is therefore usually replaced by the convention that the thrust performance and the thrust deduction at the ship are the same as at the model. The latter convention has been shown be incorrect due the scale effects in the wake (e. g. Schmiechen, 1991), but is acceptable for all practical purposes.

7.8 Averages

Many problems in the evaluation of trials are due to waiting for steady conditions, ignoring all interesting information, and using ill-defined average values. sofar the author has never been given access to original data, except for those he has measured himself on board the METEOR and the CORSAIR.

The author has fully endorsed Recommendation of the SC on Trials to the ITTC concerning the recording of 'time histories'. Even if runs are considered stationary sound performance and confidence analyses have to be based on quasi-instantaneous values of the data. The discussion of the ITTC Report is also to be found on the website of the author.

In the METEOR and CORSAIR trials **quasi-steady test manoeuvres** have been shown to be much superior to steady testing, the former **providing not only much more information, but at the same time the necessary references for the suppression of the omnipresent noise, even at service conditions in heavy weather.**

8 Power required

8.1 General

Due to the fact that the first proposal concerning the evaluation of ship speed trials did not include the reduction to the no wind and no wave condition it was considered to be incomplete and unacceptable by practitioners. Subsequently the author realised that the problem could be solved according to the same principles set forth and followed in the first step of parameter identification.

The approach taken is to establish local models of the resistance due to water, wind and waves as functions of the relative water, wind and wave speeds, respectively. **These models are of conventional nature, they are open for discussion and finally need to be agreed upon exactly as in the traditional procedure. The same applies to any extensions accounting for other deviations from contract conditions.** In order to permit the identification these effects correctly trials have to include the corresponding variability.

The idea can be extended to phenomena as e. g. changes of trim etc, as soon as the corresponding changes are being performed during the trials and the parameters are available for purposes of correlation. And **in due course the effects of waves, shallow water etc will have to be considered consistently with the procedure developed sofar.** Of course this will leed in many cases to the use of data, which have been used up to now as well.

In that sense **the whole exercise is to be considered as a necessary rationalisation of the traditional procedure, if one wants to adhere to it. I repeat my former appeal: naval architects should do this better themselves before other people tell them what to do better.**

8.2 Water resistance

Simple models for powers required due to water resistance

$$P_{Water} = a_1 V + a_2 V^2 + a_3 V^3$$

8.3 Wind resistance

and due to wind resistance

$$P_{Wind} = b \mid V_{Wind,\, rel} \mid V_{Wind,\, rel} V \; .$$

8.4 Wave resistance

Similarly the added power due to waves can be accounted for. An explicit example is shown in the evaluation of the ISO example.

9 Contract conditions, cont'd

9.1 General

With the parameters identified the powering data can be transformed to any weather condition, particularly to the no wind and no wave condition within the range of validity of the models and data,.

I wonder how contract conditions are being phrased. According to my present knowledge this is being done differently from yard to yard. I would appreciate any detailed information concerning this matter. ***I am sure that convincing simplifications, keeping the limited possibilities of identifying the relevant parameters in mind, are possible and will be welcome.*** *An example is the agreement on brake power mentioned.*

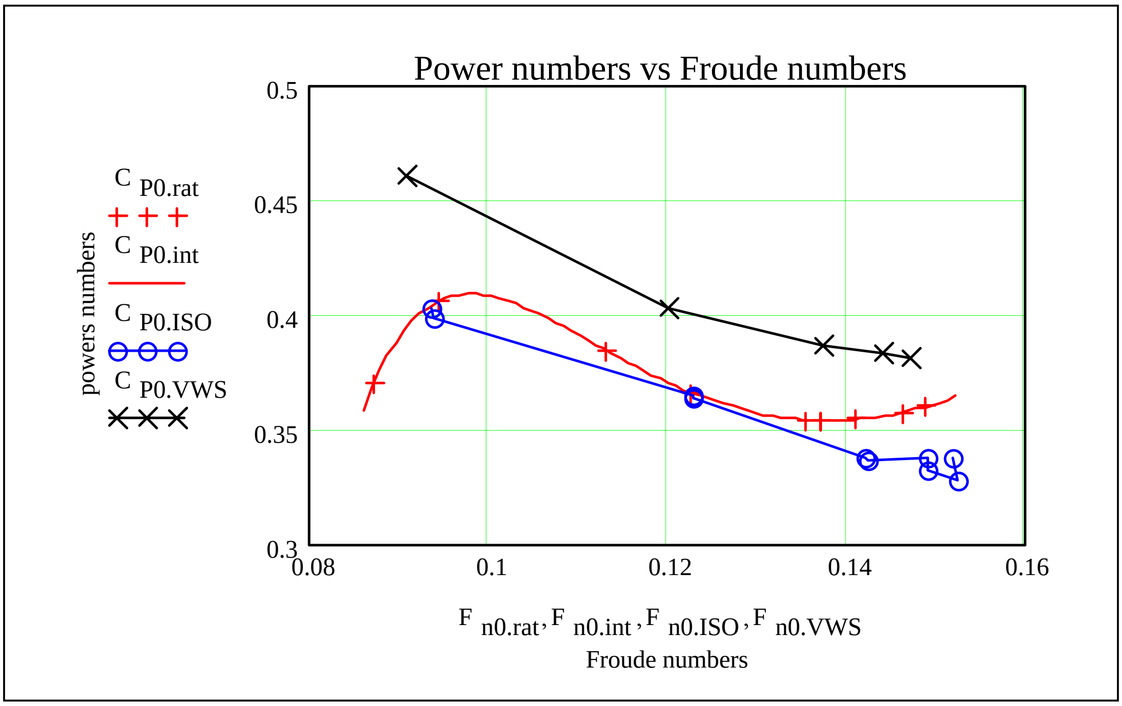
9.2 No wind

The power required at the no wind condition is simply

$$P_{Air} = b\, V^3 \; .$$

9.3 Example

A complete example based on the data of the ISO example is to be found on the website of the author.



10 Disputes

10.1 Confidence

The basic confidence is gained by the transparency of the models and the by the transparency of the parameter identification as proposed.

In more technical terms confidence is a matter of statistical analysis. The differences mentioned are open for discussion. In scientific and legal disputes they are useful only in conjunction with the confidence ranges mentioned earlier. The adequate model to be invoked is the theory of samples.

The problem is to present this well established and in all fields widely applied theory in such a way that it is generally accepted for the disputes concerning the results of the trials evaluation. Before developing the details in future versions of this proposal only the basic ideas are outlined.

Both, the predicted and contracted values and the values evaluated along the lines explained are at best unbiased estimates of the expected values together with estimates of the standard deviation. This implies that the true values of the quantities under consideration are known only within confidence ranges with prescribed probabilities.

10.2 Equal Risk

Consequently the true values of the observed differences e. g. of speed ΔV are known to lie with 95% probability within the the range

$$| V_{H.R}^{M} - V_{H.C}^{M} | < 2 \, (V_{H.R}^{S\,2} + V_{H.C}^{S\,2})^{1/2} .$$

This implies a risk of 5% that the true value lies outside this range and this risk is equal for both, the shipbuilders and the shipbuyers. Therefore fair decisions will be obtained, if differences inside the range are considered insignificant.

11 Conclusions

11.1 Review

This proposal for a standard of the evaluation of ship speed trials is an attempt to address all the issues involved in an adequate and rational fashion in order to clarify the nature of the problems independent of professional traditions and hopefully bring them to a solution widely acceptable. In view of this goal the present solution is based on only very few, transparent conventions, requiring no reference to theories of added resistance etc. **Reference to model tests is only implicit, in terms of predicted and contracted values.**

Avoiding unnecessary restrictions of data acquisition to steady states the procedure described permits to reduce and simplify the trials drastically and at the same time to rationalise their evaluation and to improve the quality of their results, providing not only estimates of the values in question but their confidence levels as well, necessary for serious judgements in accordance with ISO 9001.

11.2 Outlook

More work has to be done to further clarify the conventions proposed and reach not only their acceptance, but the acceptance of the whole probabilistic approach proposed. Clearly the proposal is not restricted to ship speed trials under waves and wind, but is a rational procedure for trials in general.

In view of the legal implications the final version of this draft needs to be phrased in accordance with the requirements of the ISO Standard 9001. The transparent structure of the exposition and the details of the procedure have already been chosen to meet these requirements.

12 Examples

In the meantime a large number of various examples have been published on the website of the author. They are all in terms of Mathcad 'documents', which are self-explaining. The problems need only to be defined in the usual way and are solved without further programming. If parameters are changed at a stage the subsequent evaluation is updated. Of great advantage is the handling of different units as typically occur in this type of computation and the ease of graphical presentation of (intermediate) results.

The first of the original examples is based on randomly chosen trials data from four double runs of a ship, '4711', the conditions of which and the conditions of the seaway in which it was tested are not supposed to be disclosed and do evidently not matter if only deviations of the powering characteristic identified from that contracted are to be considered.

The comparison shows that there are only very small differences in the results of the traditional procedure followed by the German yard and the results of the proposed procedure. The same powering characteristic has been used for the ballast and the full load condition. This procedure implies another convention, which needs thorough discussion as has already been mentioned earlier.

The second of the original examples is based on the data of the example, which was attached to the first draft of the Japanese proposal with all details of the conditions of the ship, the SAN DOMINGO, and the seaway. Again the data of four double runs are available and four 'predictions' according to the traditional procedure. The comparison shows that the predictions based on model tests are not very satisfactory, the precision of the rates of revolution being 'only' about one percent in the two extreme cases.

Much more interesting is the new example in the ISO DIS 15016 providing all necessary data for five double runs. This example has been used to develop the analysis of the power required and the reduction to the no wind and no wave conditions.

Status: 2000.11.16

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