Form of Written Discussion at the 27th ITTC Conference

Discusser	
Name	Borusevich Valery
Affiliation	Krylov State Research Centre

Name of Technical Committee or group to be discussed	Specialist Committee on Hydrodynamic Noise

Written Discussion (within 1,000 words of length)

ITTC intend to provide the procedures “as generic as possible” for wide applications. But useful for practical purposes. “Questionnaire” indicates that noise measurements can be conducted at cavitation tunnels and at basins as well. The guideline proposed by the committee is valid both for tunnel and for basin. But to make the procedure for practical use being also applicable both for basin and for tunnel is doubtful. The reasons for that could be mentioned as follows:

1. Different sources of background noise (moving along with the ship model in one case and located in particular areas in the other case).
2. Fixed location of hydrophones refers to the ship model in one case and moving ship model along hydrophones array in the other case.
3. Non limited time of measurements in one case with stable conditions, limited time of the measurements in the other case.
4. Different low frequency limits for measurements depend on physical size of the facility itself.

Thus methods to conduct the experiment in such a way as to measure the signal above background noise are different, methods of analysis are different, sources of uncertainty are different.

Thus, in my opinion, the procedure for towing tank will not be applicable for the tunnels and vice versa in case ITTC will provide practical details in the procedure. In case it will be kept as generic as the guideline at present, it is not very helpful as a procedure.

The task of the Hydrodynamic Noise Committee was to develop a relevant guideline for model scale cavitation noise measurements (see Terms of Reference No. 3). Since most of the principal prerequisites and parameters – such as test set-up including propeller + ship models, sensors + arrangement, definition of test conditions to receive similarity in cavitation phenomena, required overall instrumentation, basic measurement procedures including calibration + background noise, influence of air content + countermeasures, noise scaling procedures etc. – are similar independent of the type of test facility, these can be summarized within one guideline. The questionnaire revealed a large variety of facilities varying from small cavitation tunnels in which incidentally noise measurements are made to large cavitation tunnels specific designed for noise measurements. While most of the facilities are closed jet tunnels, the questionnaire also revealed that noise measurements are made in a few free surface cavitation tunnels and a depressurized towing tank. From a practical point of view it is not possible to give detailed guidelines for each type of facility as there are too many differences.

For the bullet point in detail:

1. A main aspect of noise measurement is that the facility background noise should be significantly below the cavitation noise in the frequency range of interest and at the location of the hydrophone (at least 10dB). The type of noise source should not have an effect on the signal to noise ratio and the quality of noise measurement. The analysis of the measured data then has to consider the moving or fixed noise source for determination of the source level.

2. The varying distance of a fixed hydrophone and a moving ship model has to be taken into account not only at model scale but also for full scale measurements. The influence of a varying distance is not discussed in the model scale guideline as it is considered too specific for model scale noise measurements.

3. Both test set-ups – fixed hydrophone and fixed / moving ship model – offer specific advantages (i.e. high Reynolds number versus consideration of the effect of wave pattern). But also at full scale the measurement time is limited and has to be taken into account in the averaging analysis. Again, the influence of varying distance, or limited measurement time, is not discussed in the model scale guideline as it is too specific for the particular facility while not relevant for other facilities.

4. The low frequency limits depend on the size of the cavitation tunnel (varying in width between 0.6 m and 3.05 m)and towing tank. Due to the different propeller and water speeds the model scale frequency range is also different (Froude scaling or not) and has also to be taken into account. Again, these variations prohibit the inclusion of a specific value for the low frequency limit.

Summarized the guideline is generally applicable for all type of test facilities and will help to receive similar cavitation phenomena and to assure high quality cavitation noise measurements. ITTC can not be made responsible for working out the details of the present guidelines for each size and type of facility that is mentioned in the questionnaire.

Form of Written Discussion at the 27th ITTC Conference

Discusser	
Name	FRECHOU Didier
Affiliation	DGA Hydrodynamics

Name of Technical Committee or group to be discussed	Specialist Committee on Hydrodynamic Noise

Written Discussion (within 1,000 words of length)

Concerning the similarity rules to apply at model scale for cavitation noise survey, what would be the recommendation of the committee for cavitation number similarity to apply:
Either

$\sigma_{fs} = \sigma_{ms}$ or $\sigma_{fs} - \sigma_{inception\ fs} = \sigma m_s - \sigma_{inception}\ m_s$

Or other law?

Answer:

The terms of reference of this committee included to check the existing methods and to develop relevant guidelines for performing model scale and full scale noise measurements.
The recommendation for standard cavitation tests for merchant vessels at design or ballast condition, e.g. for tankers, containers and bulkers, is the similarity of the cavitation number $\sigma_{n,m} = \sigma_{n,s}$ since sheet cavitation dominates in these cases the noise excitation. This is the commonly used procedure (18th ITTC, 1987) within the 18 model basins being part of the questionnaire.

In case of naval twin screw vessels operating close to or above tip vortex cavitation inception there are specific procedures at most of the model basins not included in the present questionnaire. The influence of Reynolds number on cavitation inception is discussed in the report, but it is not clear yet at what cavitation number the noise measurements should be performed. Some theoretical work in this area has been published suggesting that the influence of difference in Reynolds number can be neglected when the cavity size is larger than approximately 150% of the viscous core size (Bosschers, 2009). For small cavity size, Baiter (1989) has suggested that the ratio $\left\{ \left(\sqrt{\sigma_{inc} - \sigma} \right) \big/ \sigma_{inc} \right\}$ should be identical for model scale and full scale. However, as far as known to the committee, no experimental evidence for these relations have not been published in open literature which is why this is not discussed in the report.

References:

Baiter, H.J. (1989), “On Cavitation Noise Scaling with the Implication of Dissimilarity in Cavitation Inception”, ASME International Symposium on Cavitation Noise and Erosion in Fluid Systems, 1989

Bosschers, J. (2009), “Modeling and analysis of a cavitating vortex in 2D unsteady viscous flow”, 7th International Symposium on Cavitation CAV2009, Ann Arbor, Michigan, USA.

Form of Written Discussion at the 27th ITTC Conference

Discusser	
Name	Emin Korkut
Affiliation	Istanbul Technical University

Name of Technical Committee or group to be discussed	Specialist Committee on Hydrodynamic Noise

Written Discussion (within 1,000 words of length)

I would like to thank the committee for their extensive and hard work on such a complex field. I have two questions.

(1) The committee mentioned in their presentation and report that the machinery noise is dominant at low frequency range before the cavitation inception speed. Is it valid for all ship types or machinery types? Or how would you comment on the contribution by propellers?

(2) For propeller noise prediction in full scale, what will be the better method to predict the propeller noise in full scale?

- To carry out noise measurements in model scale and apply the scaling formulae recommended by the 18th ITTC Cavitation Committee
- To perform full-scale noise calculations by using BEM/RANS with full equation.

I would be very glad if the committee make comments on these questions.

Answer:

1) The wide variety of ships in combination with all the possible propulsion systems installed, makes rather difficult a definitive response to this question. The severity of machinery noise can depend significantly also on the amount and the efficacy of the noise reduction measures adopted.
Full scale measurements of the noise radiated from a cargo ship performed at different speeds [1], indicated that engine noise is the dominant source at low frequency and below cavitation inception speed. In [2] the results of full scale acoustic tests relative to cruise vessels, equipped by different propulsion plant type, performed at two different speeds demonstrated that, for this kind of vessels, machinery noise is, in most cases, dominant at low-mid frequencies. Similar considerations are drawn in [3] for the case of small ships.
Moreover, among different propulsion systems, the noise generated by medium size diesel engines has the higher intensity.

In general, above the cavitation speed, the characteristics of noise spectrum depend on the amount and type of cavitation on the propulsion plant type and again on noise reduction measures.

2) At present CFD does not have the capability to simulate at full scale, with a satisfactory degree of accuracy, the underwater noise from a ship in cavitating conditions. Model scale measurements in combination with scaling formulas still represent the prediction method that provides the best engineering estimation of underwater noise.
Limitations of model scale measurements and extrapolation procedures to predict noise are discussed in detail in the report of the Hydrodynamic Noise Committee.
However, it is worthwhile to say that model scale tests are relevant in possibility identifying major noise sources for a particular ship or ship configuration. Further, they allow the capability to better understand the fundamental mechanisms underlying noise generation and propagation. These aspects will remain crucial in the future.
On the other side, it is reasonable to think that, in few years, the accuracy of CFD predictions will improve significantly and thus can be used to estimate noise, at least for specific ship configurations. It is expected that, due to limitation in mesh size and time step, the simulated upper frequency will be smaller than the maximum frequency considered in full scale and model scale noise measurements.
As stated in the conclusions of the final report of this Committee, to evaluate the accuracy of numerical prediction methods or predictions based on extrapolation of model scale tests results, accurate full scale data is required in which the contribution of cavitation noise can be well distinguished from other noise sources. Much of this will be the focus of the Committee's 28th ITTC efforts.

[1] Arveson, P. T. and Vendittis, D. J., 2000, "Radiated noise characteristics of a modern cargo ship", Journal of the acoustical Society of America, Vol. 107 (1), pp 118-129.
[2] Kipple, B., 2002, "Southeast Alaska Cruise Ship Underwater Acoustic Noise", Technical Report NSWCCD-71-TR-2002/ 574.
[3] Gloza, I., 2011, "Identification Methods of Underwater Noise Sources Generated by Small Ships", Acta Phisica Polonica A, Vol. 119, pp 961-965.

Form of Written Discussion at the 27th ITTC Conference

Discusser	
Name	Zhiguo ZHANG
Affiliation	Huazhong University of Science and Technology

Name of Technical Committee or group to be discussed	Specialist Committee on Hydrodynamic Noise

Written Discussion (within 1,000 words of length)

The numerical prediction of hydrodynamic noise using CFD methods is important for developing a helpful method to reduce the level of hydrodynamic noise of different vessels.

My question is what kind of standard should people follow to do this prediction? To get the right resistance of ships, it only need 2 m grid nodes(??) which the resistance is less than 3% compared with the ZFD. But I believe 2 m grid point (node) is not enough for the hydrodynamic noise. So at this time may we ignore the resistance and look??? for the detail of noise prediction or we should get the resistance of ships right than move forward for the noise prediction like using the FW-H model.

Thanks.

Answer:
The numerical approach for hydrodynamic noise prediction is a relatively new field of research, and different techniques are still being developed.
With increasing capability of the computer technology, the numerical approach of CFD simulations combined with acoustic analogy is developed and applied to hydrodynamic noise predictions in recent years. For CFD simulations, in order to solve fluctuating (cavitating) flow field and fluctuating hydrodynamic forces, the grid resolution in space must be high enough and the quality of the mesh, such as aspect ratio, skewness etc., should be guaranteed. In this way the grid numbers in CFD simulations for hydrodynamic noise prediction are much more than those used for ship resistance or propeller thrust/torque computations, generally one or two orders of magnitude more. Meanwhile, the upper frequency of the fluctuating flow field (and fluctuating forces) is limited because of the mesh size and time step used.
As reported in the final report, different methods can be applied for noise evaluation corresponding to different noise sources. At present, the numerical approach combining CFD simulations and acoustic analogy still needs more validations and verifications. This should be done parallel to the work related to resistance as not all aspects of the resistance prediction are relevant for noise.