Measuring underwater radiated noise from cavitating ship propellers

MARIN The world's oceans are becoming increasingly noisy. With a steady increase of the commercial fleet since the 1960s, anthropogenic noise in the oceans has actually increased eightfold. This shows that ships are not only more numerous but that individual vessels have also become noisier due to increased size, speed and delivered power. This often leads to more cavitation, which is one of the main sources of underwater radiated noise (URN), write Frans Hendrik Lafeber, Thomas Lloyd and Johan Bosschers from the Maritime Research Institute Netherlands (MARIN).

Figure 1: Silent towing carriage in MARIN's depressurised wave basin

Recently, shipping noise has received regulatory attention. Class rules include noise limits for fishery and seismic research vessels because self-noise can influence the operability of such vessels. Nowadays, there are underwater radiated noise (URN)-related class notations for other ship types. These can be used to show that the URN of such a vessel has been controlled to reduce the impact on marine life. It is likely that in the near future local regulations concerning URN will come into force to protect marine life in specific sensitive areas.

Furthermore, the European Union has included URN in methodological standards to classify the environmental status of the sea. Presently the focus is on monitoring URN such as the ECHO initiative lead by the Vancouver Fraser Port Authority in Canada.

Model tests in the design stage

The URN of a ship can be estimated by means of computations and model tests during the design stage. MARIN regularly carries out model tests to determine the URN of cavitating propellers in its depressurised wave basin. This unique facility is a towing tank combining a free surface with the capability to lower air pressure and enabling the use of a complete ship model. Effects such as the wake field, wave pattern and dynamic trim and sinkage of the ship are automatically taken into account.

Hydrophones are attached to a bottom-mounted mast to measure the URN below the keel and to the side of the ship. The ship model sails over the hydrophones, thereby mimicking a full-scale noise range. A typical upper frequency limit for the measurements is 20 kHz at full scale.

Background noise

Background noise has to be low enough to avoid interference with the cavitation noise measurements. The main sources of background noise are the towing carriage and the propeller drive train. Therefore, MARIN has installed a lightweight, silent towing carriage fitted with polyurethane wheels (Figure 3). To reduce noise from the propeller drive train, solid shafts and special bearings are used.

To check the background noise, MARIN carries out a measurement for non-cavitating conditions or with a dummy hub replacing the propeller. The noise of the cavitating condition should be at least 3 dB, and preferably more than 10 dB, higher than the (non-cavitating) background noise.

Test conditions are based on propulsion characteristics of the ship and the scale factor. In some cases, a reduction of the cavitation number is applied to mitigate the viscous scale effects on the inception of vortex cavitation. MARIN has recently tested this new method and achieved good results.

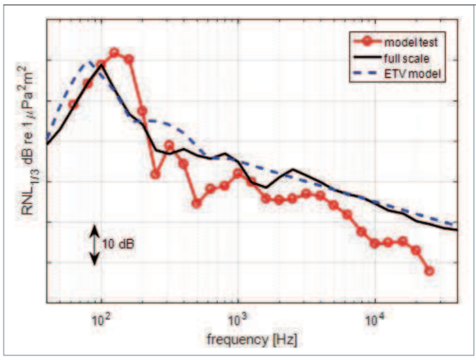

Figure 2: Comparison between model test, full-scale measurement and computation of URN of a merchant vessel

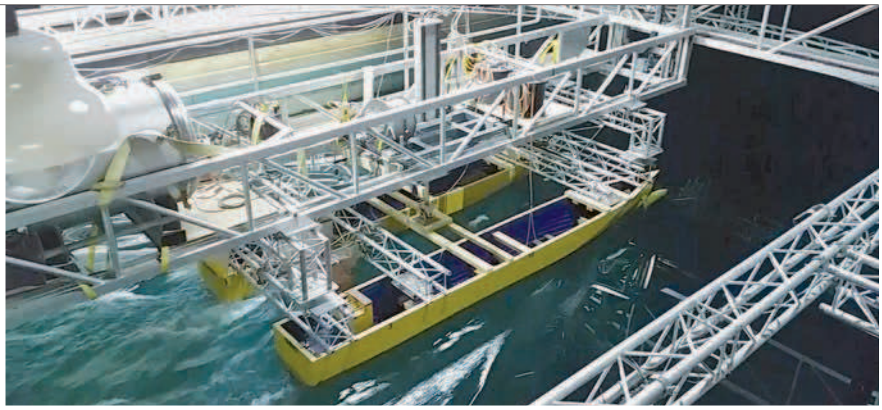

Figure 3: Silent towing carriage towing a model

Data Analysis

The measured data should be processed accounting for the influence of acoustic characteristics of the facility. Only the part of the measurement where the distance between the noise source and the receiver is smaller than the reverberation radius should be analysed. Interference between direct noise and reflections of sound from the free surface influences the measured noise levels and should be corrected for. Noise levels are then normalised to a distance of 1m while taking the time-dependent distance between the ship model and the hydrophones into account. Finally, MARIN converts the results to full-scale values in one-third octave bands.

Validation studies

Several validation studies have recently been carried out to determine the accuracy of the scaled-up results of the URN model tests. One such study was performed within the EU FP7 SONIC project. Another case is a single-screw merchant vessel for which an extensive full-scale data set is available from the CRS [1, 2] (see Figure 2). These validation studies show that model tests are a reliable way of checking the noise levels from propeller cavitation, which can be used to assess environmental impact. This helps to make shipping silent and to keep the oceans quiet.

References

[1] Lafeber, F.H., Lloyd, T.,Bosschers, J., „Validation of underwater radiated noise predictions for a merchant vessel using full-scale measurements", InterNoise, August 2017, Hong Kong.
[2] http://www.crships.org

This article is an edited version of a text first published in MARIN's report, August 2017, no. 121.