A DISCUSSION OF NOISE GENERATED BY

ICEBREAKING LNG CARRIERS

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Marine mammals rely to a large extent on acoustics for orientation and communication, thereby maintaining the social structure of herds and other groups. The effectiveness of their acoustic systems is limited by noise. Noise is present in each component of the acoustic systems but noise in the medium is likely to be the single most detrimental factor. At least one group of marine mammals, the baleen whales, has acoustic signalling at frequencies below about 200 Hz where natural, ambient noise tends to decrease and where attenuation is very minor (Wenz 1964). This use of such a low frequency band by whales is significant for a long-range communication ability (Payne and Webb 1971). At present, however, low frequency ocean ambient noise has been raised considerably due to propeller-driven ship traffic; consequently, the range of the signals of these animals has decreased (Payne and Webb 1971).

The reason for concern in relation to the Arctic Pilot Project is founded in the proposed introduction of noisy shipping on a year-round schedule into arctic areas that until recently have been almost without ship traffic. Areas proposed for LNG carrier traffic include important feeding and migration grounds for a large number of marine mammal species which are the basis of the economy of northern regions of Greenland and Canada. It is, therefore, important to estimate the noise levels likely to be generated by LNG traffic and other traffic that may follow the Arctic Pilot Project.

Estimation of probable levels of LNG-generated noise and evaluation of the accuracy of such estimates is by no means a simple undertaking for several reasons. First, the ships would be so powerful that no full-scale comparisons can be made with data from existing ships. Second, the propellers are designed to be resistant to ice, which compromises their ability to operate with low cavitation. As a third point, the load on the propeller during icebreaking will be extremely high and operating conditions would be quite different from those on which the classical noise level estimates on which these formulas are based. A study of these problems has been presented to this workshop by the Defence Research Establishment Atlantic (DREA), Dartmouth, Nova Scotia (Leggat, Merklinger and Kennedy 1981).

For the open water case (26 kt, 61 MW), DREA has employed an empirical equation from Ross (1976) which was designed to describe the overall level above 100 Hz of traditional ships from the Second World War. The source level predicted for LNG carriers by this equation is 194.7 dB re 1μPa, which at 100 Hz amounts to 174.7 dB re 1μPa $Hz^{-\frac{1}{2}}$. According to Ross, the actual level for standard ships is usually not more than 5 dB from the estimated level. However, the crucial question is whether the World War II experiences can be used to predict behaviour of a new design such as that proposed for the LNG carriers. DREA has concluded that the prediction is not valid and has deducted 3 dB from all values. Recalling that the propellers are designed for icebreaking rather than for low-noise performance, it seems more reasonable to expect noise generation to be higher rather than lower than those values predicted by the Ross equation. A conservative approach would, therefore, suggest maintenance of 175 dB re 1μPa as the preliminary estimate for the 100-Hz level.

The next problem is the noise levels at frequencies below 100 Hz where the Ross equation cannot be used. DREA has proposed to use the 100-Hz value, reduced by 3 dB, for the entire range. However, ship noise spectra are known to peak in the 40- to 300-Hz region with the specific frequency reflecting the size of the propeller (Brown 1976). For the proposed 8-m diameter propellers, the peak will be at the low end of the spectrum in the 40- to 50-Hz region. Therefore, it seems reasonable to extend the

-20 dB/decade slope down to such low frequencies. Accordingly, the 50-Hz source spectrum level would then be 175 + 6 = 181 dB re 1μPa $Hz^{-½}$. This power level is eight times higher than that of the DREA study.

To estimate the heavily loaded condition of the propellers operating at full power and slow ship speed (4 kt), DREA used an empirical equation proposed by Brown (1976) to describe a situation with a sample of thrusters. Assuming full cavitation, the outcome at 100 Hz is 178 dB re 1μPa $Hz^{-½}$, which is only 3 dB above the open-water condition in spite of the doubled shaft power and the adverse operating conditions.

The predictions from the Ross equation for a normal mode and from the Brown equation for a heavily loaded mode are identical for a case in which all three propellers are cavitating on 50% of the surface of all blades. This much cavitation, however, is hardly compatible with the operating conditions of the ships described by the Ross equation for a normal mode.

A different way to illustrate the problems of using the Brown equation in the present context is to compare the estimates for noise level for a known ship, the cruiser Cardiff cited in Ross (1976 p. 274), using the DREA Equation 1 for an open-water, 24-kt situation, and Equation 4 for the fully cavitating situation. The estimate derived by the first method is 172 dB, which corresponds closely with the measured value, while the second method yields 171 dB. The latter value is clearly absurd and could indicate that the Brown equation was applied outside its valid range.

Besides the broad-spectrum noise so far discussed, pure tone components related to propeller revolution rate and number of blades are also generated. DREA researchers have pointed out that estimates of the intensity of these components are not feasible at the present state of the art. Values about 200 dB re 1μPa are offered but confidence limits for this figure are not stated. Since the intensity of such line spectra tend to be very high, this phenomenon should be considered when evaluating the effects of ship noise at very low frequencies.

The conclusion of this presentation is that, notwithstanding statements to the contrary, the figures presented by DREA for LNG-carrier-generated noise at frequencies in the 20- to 50-Hz range in open water are likely to be low by one order of magnitude and that the effect of heavy propeller loading during icebreaking is also underestimated.

REFERENCES

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