APPENDIX

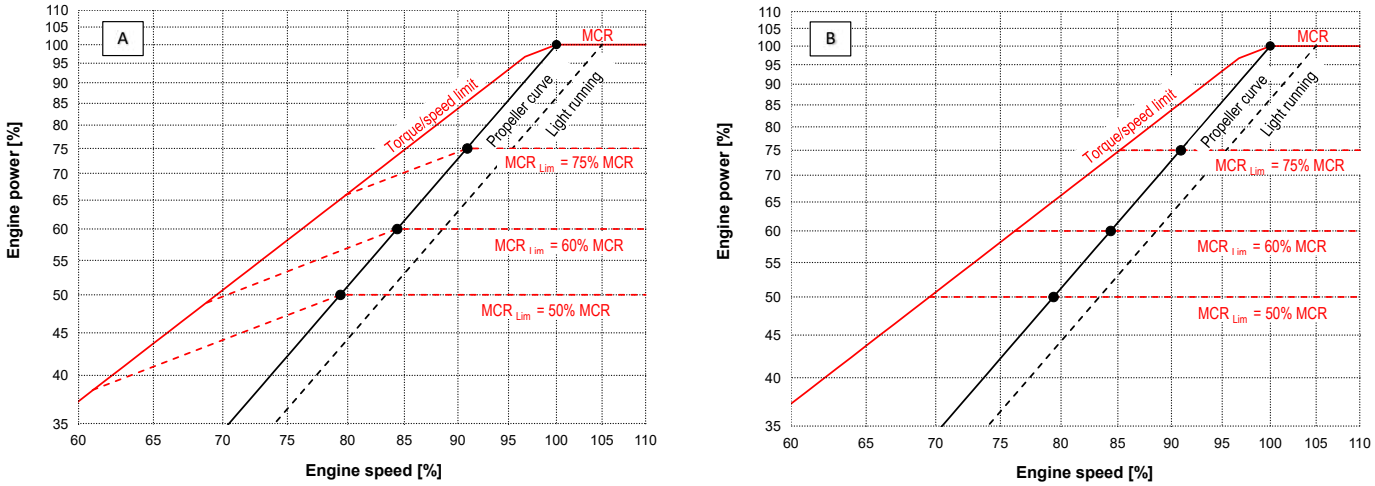

Figure 1: Load diagram for restriction of fuel index by EPL (A) and power by EPL or ShaPoLi (B)

The load diagram

To assess the variation of the nautical manoeuvring tracks after installation of the power limitation, the load diagram of the main engine should be considered. A typical plot for 2- stroke engines is given in Figure 1. The load diagram is usually presented in the EPL report by the engine maker.

The propeller curve is the theoretical relation between propeller speed and power. To avoid overload of the propeller in case of headwind, heavy seas or hull fouling, the propeller is designed with a light running margin. The plot above illustrates this with a light running margin of 5%, meaning that maximum continuous rating (MCR) power will be achieved in ideal, calm water conditions with 105% of nominal propeller speed. When operating with tailwind, the propeller will be on the right side of the light running curve, meaning with higher RPM for a specific propulsion power. Conversely, in headwind conditions, the operation shifts to the left side. On the left side of the propeller curve, the propeller's operation is constrained by the torque/speed limit of the main engine. This limit is determined by the acceptable thermal load of the engine.

Performance of nautical manoeuvres

If the additional resistance is so large that the main engine power increases to the torque/speed limit for constant RPM, the main engine cannot maintain the RPM, and the propeller speed will decrease along the torque/speed limit until the main engine stabilizes at a lower RPM. The same phenomenon occurs when the rudder is set to hard rudder for the turning circle. In Figure 2, the process is presented from the initial condition of 85% MCR (according to IMO Res. MSC.137(76)), with increasing load due to the rudder angle and subsequent effects from the turning ship. This results in a descent of RPM until stable turning is achieved after a distinct reduction in RPM.

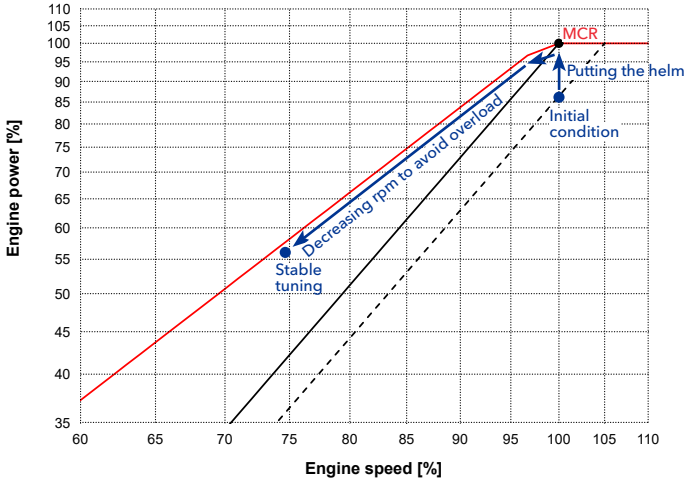

Figure 2: Engine performance during turning circle in unlimited mode (e.g. newbuilding sea trials)

For the presentation of the turning circle on the wheelhouse poster, only the ship speed during stable turning and the time from the beginning of the manoeuvre are recorded for each 90° turn. The corresponding RPM might be given in the manoeuvering booklet. From the load diagram, it can be determined whether the torque/speed limit is modified by the power limitation for this specific RPM. If the torque/speed limit is lowered, the RPM will further reduce during the turning circle, resulting in a reduced turning speed. Otherwise, the turning radius and speed for stable turning remain unchanged.

The power limitation will reduce the approach speed, resulting in less advance and transfer during the turning circle. This effect is the same as before installation of the power limitation, however, when the turning circle was carried out with reduced ship speed.

The reduced approach speed is the main influencing factor of the power limitation on the stop tests as well. With a lower approach speed, the stopping distance will be shorter. Usually, the astern RPM is reduced to around 80%, so the power limitation has only low effect on the astern operation and the adverse running of the propeller during crash stop.

The Williamson turn will be performed with shorter track and time when the approach speed is reduced by the power limitation. The heading deviation to turn rudder from hard starboard to hard port should remain the same.

The zig zag tests which are performed to demonstrate compliance with maximum overshoot angles according to IMO Res. MSC.137(76), are less critical with reduced approach speed. Therefore, the nautical tests in unlimited condition can be considered as worst-case scenario.

Nautical manoeuvers with power limitation

Summing up, it should be noted that setting the rudder always introduces additional resistance, resulting in heavy load running of the propeller and a decrease in RPM. The power limitation restricts the upper RPM range but does not alter operation in the lower RPM area. Therefore, the manoeuvring characteristics are not significantly changed by the power limitation; instead, available torque at low RPM, rudder size, and displacement of the ship determines the manoeuvring behavior. This means that the original newbuilding sea trial nautical manoeuvring tracks still accurately represent the manoeuvring information. Considering the reduced approach speed after installation of the power limitation, the distances at the beginning of the manoeuvring decrease. However, after a short while, the track is more characterized by available torque than by the initial ship speed.

Clarifications on permanent power limitation

Further on, please note that in case of permanent power limitation by engine modification (e.g. T/C cut-out) the torque/speed limit is shifted over a wider RPM range. For propeller retrofits, the relation between propeller curve and torque/speed limit of the propulsion engine is changed across the entire RPM range. Consequently, the manoeuvring characteristics should be determined by new nautical manoeuvring test trials, and the corresponding tracks should be plotted on the new wheelhouse poster.