Motor/Gearbox Selection Procedure

The axle speed of a motor and gearbox unit can never exceed the value (given on the Data Sheet) which corresponds to the no-load speed of the motor.

The output torque at the axle, which determines the haulage capacity of the locomotive to which the unit is fitted, is greatly influenced by the gear efficiency. This applies particularly to single stage high ratio worm gearing, for which the efficiency of some older types can be as low as 15%.

Accurate measurement of the gear efficiency over the speed range of a unit is not easy, consequently, if the manufacturer's performance data is not available, the Data Sheet information is based on typical values shown in Figure 1. The results of these include the static friction in the gears and because the rotating friction is generally less than the static value the haulage capacity of the unit when fitted in a locomotive is normally somewhat better than the data suggests. If neither the manufacturer's data nor a Guild test result is available an appropriate value from Figure 1 is used.

Step 1 Specifying the Duty

The Technical Committee recommend that a model locomotive should emulate the performance of its prototype, although it is recognised that not all modellers wish to adopt this principle.

Nevertheless, the possibility of obtaining prototype performance should always be investigated before deciding whether there is any advantage in opting for less.

Each Data Sheet gives speed and torque ratings which enable motors to be matched to a specified duty. These ratings are based on providing the desired performance at not less than 75% of the no-load speed of the motor when supplied at the stated voltage. The torque at this speed will be approximately 25% of the stalled output torque given on the Data Sheet. If a more exact method of calculation is preferred refer to Data Sheet M1/0. (For more information on this subject refer to Clause 4.2 of Section 4 of Part 3 of the Manual).

Step 2 Calculation of the Reqired Tractive Effort

The tractive effort at the wheel tread required for the highest speed duty (TE_{rq}) in the formulae below). The latter is equal to the tractive resistance of the train plus that of the locomotive and tender. (The drawbar tractive effort is equal to the resistance of the train only). TE_{rq} can either be calculated as described in Section 1.6 of Part 3 of the Manual or the following average values may be used.

For main line passenger duty	200g
For secondary passenger duty	100g
For branch passenger duty	75g
For multiple units	10g per car
For main line freight duty	300g
For pick-up freight duty	150g

Step 3 Calculation of the Required Speed and Torque Ratings

Once speed and tractive effort have been calculated the required speed and torque ratings are calculated as follows:

Speed rating

$$(SR_{rq}) = \frac{196 \times \text{scale miles/hour}}{WD}$$

Torque rating

$$(TQ_{rq}) = \frac{TE_{rq} \times \text{model wheel diameter}}{20}$$

Step 4 Selecting a Motor/gearbox Combination from the Data Sheets

The speed and torque ratings of motors with adequate performance for the proposed application should not be less than these calculated values. However if the torque rating is higher than required and the speed rating is lower the motor may still be suitable because the train will run at above 75% of the theoretical no-load speed. This can be verified by calculating an amended speed rating for the as follows:

$$SR_a = \frac{SR_o}{0.75}\left(1 - \frac{0.25TQ_{rq}}{TQ_o}\right)$$

Where:
SR_a = the amended speed rating of the motor and gearbox.
SR_o = the original speed rating obtained from the Data Sheet.
TQ_{rq} = the required torque rating.
TQ_o = the original torque rating obtained from the Data Sheet.

The amended speed rating is unlikely to exceed 1.25 times SR_o
(The theoretical value for zero tractive effort is 1.33 x SR_o).

Step 5 Confirmation of the Suitability of a Motor and Gear Box for the Intended Range of Duties

In most cases a locomotive with a motor and gearbox combination selected in accordance with the above procedure will be able to undertake any likely duty, but in some cases the maximum torque rating and maximum current required should be determined in order to ensure that they are below the stall torque rating and motor current limit if one is specified by the motor supplier.

The maximum torque rating required for a duty (TQ_{max}) is derived from the total tractive resistance of the train plus locomotive (including the gradient and curve resistance) calculated by the method given in Section 1.6 of Part 3.

It should not exceed three times the torque rating given on the Data Sheet and the locomotive must be able to exert it without slipping (refer to Section 1.6). Conversely, as a general guide the weight on the driving wheels should not exceed five times the required maximum tractive effort.

Experience has shown that in most cases motors and gearboxes selected by this method will undertake any likely duty without overheating, but care is needed when applying coreless motors which, because of their low thermal capacity, are soon damaged by overloading.

In the absence of specific information a general rule is that for iron cored motors used on intermittent duty the current when running on level track with the maximum load should not exceed about 0.3 times the stall current on the nominal voltage. For motors required to run continuously and for coreless motors the current should not exceed 0.2 times the stall current without verifying that a higher value will not cause overheating. In some cases the manufacturer specifies a maximum current. If this is given on the data sheet it should not be exceeded at the maximum tractive effort required for the duty.

Further information on motor application is given in Section 2 of Part 3.

(For practical purposes the tractive effort to haul a given load, and hence the current, is independent of speed. For more information on this subject refer to Section 4.2 of Part 3).

Calculation of the Motor Current

The current at a torque rating of TQ_{rq} is approximately:

$$\frac{I_{st} \times TQ_{rq}}{TQ_s} + 0.07 I_{st}$$

Where:
I_{st} = the stall current obtained from the Data Sheet.

TQ_{rq} = the required torque rating.

TQ_s = the stall torque obtained from the Data Sheet.

Calculation of Speed and Torque Ratings

The speed and torque ratings for a motor and gear ratio combination not listed on a Data Sheet can be calculated as follows:

Speed Rating

$$\frac{\text{Motor no-load speed} \times 0.75}{GR}$$

or

No-load axle speed x 0.75

Torque Rating

$$\frac{\text{Motor stalled torque} \times GR \times \mu}{400}$$

or

Stalled axle torque x 0.25

Where:
GR = the unit gear ratio.
μ = the % gear efficiency obtained from Figure 1.

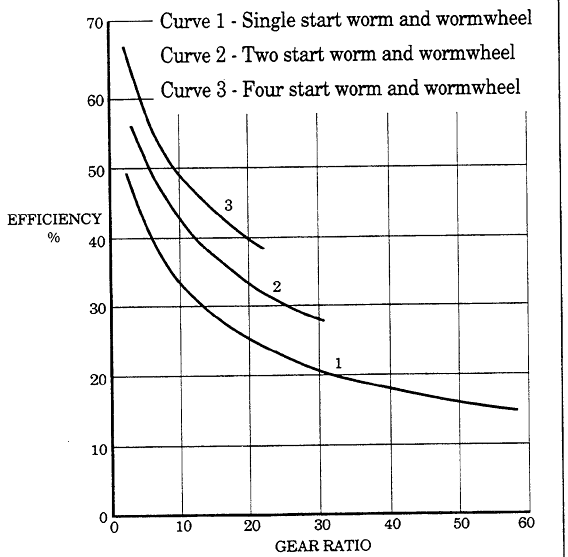

Figure 1. *Nominal Efficiency of 'Model Quality' Worm Gearing*