Motor Selection Procedure

Section 4 of Part 3 of the Guild Manual gives the full theory of motor selection for a specified application, including the derivation of the complete motor speed/torque characteristic and calculation of the tractive effort required for a specified duty. However, in most cases there is no need to go to this extent and the simpler method described in this introduction to the M1 series of Motor Data Sheets will prove adequate.

The method is intended to be used when there is a free choice of gear ratio, if the choice is limited using speed and torque ratings as described in Data Sheet M2/0 may be preferred.

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.

When a choice of motor and gearing for the highest speed duty has been made the tractive effort required for any other proposed duty can then be calculated to verify that the locomotive will be able to perform it. For further information on motor application refer to Sections 2 and 4 of Part 3 of the Manual.

The basis of the calculation is the maximum train speed expressed as the equivalent prototype speed in miles per hour on straight level track and the model tractive effort at the wheel tread in grams required to achieve it with a specified load.

Step 2 Calculation of the Required Tractive Effort

The tractive effort at the wheel tread 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).

The total tractive resistance of the train and locomotive can be calculated by the method given in Section 1.6 of Part 3 of the Manual. Alternatively the following typical 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 an Approximate Gear Ratio

This step calculates the gear ratio (GR_{75}) which will give the desired train speed at 75% of the motor no-load speed and is the basis of the nominal gear ratios given on the Data Sheets. Note that this calculation alone is not sufficient to confirm that the combination of motor and gear ratio will produce adequate tractive effort for the proposed duty.

First select a motor which appears to be suitable from either the supplier's data or from the Data Sheets, then:

$$GR_{75} = \frac{(NLS \times WD)}{(S_d \times 261)}$$

Where:
S_d = the desired train speed on straight level track (prototype MPH).
WD = the model driving wheel diameter (mm).
NLS = the motor no-load speed (rev/min) obtained from the Data Sheet.

Step 4 Calculation of the Tractive Effort at 75% of the Motor No-Load Speed (TE_{75}) with the Gear Ratio Obtained by Step 2

$$TE_{75} = \frac{0.05 \times ST \times GR_{75} \times \mu}{WD}$$

Where:
ST = the motor stall torque (g.cm) obtained from the Data Sheet.
GR_{75} = the gear ratio calculated by Step 2.
WD = is the model driving wheel diameter (mm).
μ = the % gear efficiency obtained from Figure 1.
If TE_{75} is less than the required tractive effort a more powerful motor must be chosen.

Step 5 Correction of GR_{75} to More Nearly Meet the Specified Duty

Two corrections of GR_{75} may now be necessary. Firstly, if the calculated tractive effort at 75% of the motor no-load speed exceeds the tractive effort required for the duty by more than about 10% it is desirable, but not essential, to increase the gear ratio. The new ratio is calculated as follows.

$$GR_c = \frac{(TE_{75} - TE_{rq}) \times GR_{75} \times 0.385}{TE_{75}} + GR_{75}$$

Where:
GR_c = the corrected ratio.
GR_{75} = the approximate gear ratio calculated in Step 2
TE_{75} = the calculated tractive effort at 75% of the motor no-load speed.
TE_{rq} = the tractive effort required for the duty.
Secondly, it is unlikely that the exact calculated

ratio will be available and consequently the nearest available lower one (GR_a) should be adopted. If it is lower than GR_{75} use the nearest available higher ratio.

Step 6 Confirmation of the Suitability of a Motor and Gear Ratio 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 tractive effort and maximum current required should be determined in order to ensure that they are below the stall tractive effort and motor current limit if one is specified by the motor supplier.

The maximum tractive effort required for a duty (TE_{max}) is equal to 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 75% of the stall tractive effort (TE_{st}) and the locomotive must be able to exert it without slipping (refer to Section 1.6). Conversely, to ensure that slip will occur before stalling, the weight on the driving wheels should not normally exceed four times the stall tractive effort.

$$TE_{st} = \frac{0.2 \times ST \times GR_a \times \mu}{WD} \text{ (grams).}$$

Where:
ST = the motor stall torque obtained from the Data Sheet.
GR_a = the actual gear ratio.
μ = the % gear efficiency obtained from Figure 1.
WD = the model wheel diameter in mm.

The current at a given tractive effort (I_g) is given by:

$$I_g = \frac{I_{st} \times TE_g}{TE_{st}} + I_{nl}$$

Where:
I_{st} = the motor stall current obtained from the Data Sheet.
I_{nl} = the motor no-load current obtained from the Data Sheet.
If no value of I_{nl} is shown on the Data Sheet use 5% of the stall current.

Experience has shown that in most cases motors 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 Clause 4.2 of Section 4 of Part 3).

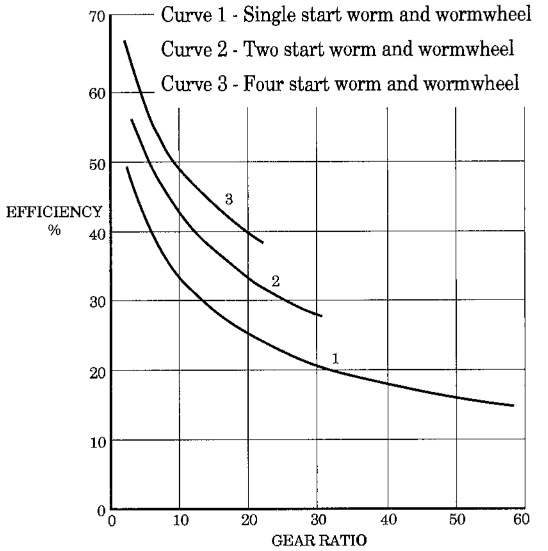

Figure 1. *Nominal Efficiency of 'Model Quality' Worm Gearing*

The curves show nominal efficiencies for 'model quality' single stage worm gearing which does not include special features to reduce friction but the actual values can differ considerably from them and for recent designs of high ratio worms may be significantly higher.

If other types of gearing are used either singly or in combination with a worm gear, the nominal efficiency of a single stage of spur or bevel gears should be taken as 85% and that of crossed helical gears 75%.

To obtain the efficiency of multi stage gears multiply the percentage efficiency of the first stage by the efficiencies of subsequent stages expressed as a decimal. For example, a 9/1 worm gear with a 3/1 second stage giving 27/1 overall will have an efficiency of 38.5 x 0.85 = 33% (to the nearest whole number).