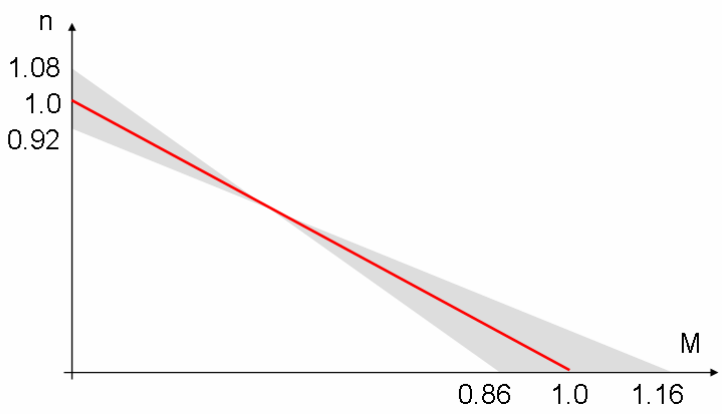
Tolerances of Motor Data and Temperature Effects

Tolerance in winding resistance
One of the main sources for tolerances in maxon motors is the winding resistance which is specified to +/-7%.
The reason for this is not a tolerance in the number of winding turns. This is a number that can be counted exactly. The tolerance comes from the varying wire diameter due to the wire production process and the winding process. Within one production lot we usually do not exploit the full tolerance range. But if the same winding is made half a year later the average winding resistance can be different resulting in this large total tolerance.

Tolerance of permanent magnets
A second major source for tolerances stems from the permanent magnets. The magnetic values are currently specified as +/- 8%. Magnetic tolerances have a direct influence on the torque and the speed constant.

- on k_M directly proportional ΔkM +/- 8%
- on k_n indirectly proportional Δkn -/+ 8%
- weaker magnet enhanced n_0
- stronger magnet reduced n_0

Influence on speed-torque gradient and motor data
Together with the winding resistance they also affect the speed torque gradient. Weaker magnets and higher resistance result in a weaker motor. Accordingly the speed torque line is steeper and the no-load speed is enhanced.



Conlusion 1: As a general rule motor data have tolerances in the order of 5 to 10%.

Temperature influence on motor data
The influence of temperature on motor data is twofold. First, the winding resistance increases by about 0.4 percent with each centigrade of temperature. Second, the magnets become weaker at higher temperatures.
The different magnetic materials are affected to a different degree. Least sensitive to temperature are AlNiCo magnets. Ferrite magnets are very sensitive. And Neodymium magnets lie in the middle. High grade Neodymium magnets exhibit a temperature change of about 0.1 % per Kelvin.

Reversible demagnetization of permanent magnets

Magnet material	Losses	Losses
	in % / K	when heated by 100°C
AlNiCo	0.01	1 %
NdFeB	0.1 ... 0.13	10 ... 13 %
Ferrit	approx. 0.2	approx. 20 %

Example: A general motor temperature increase of 50 Kelvin results in winding resistance which is about 20% higher. An RE motor with Neodymium magnet is about 5% weaker. The stall torque feels the combined effect of winding and magnet: its value is reduced by approx. 20%.

Conlusion 2: The most important feature of these temperature influences is that motors get weaker the hotter they are. This has to be considered in situation where the motor operates at its limits, particularly if there is no current reserve available. In rare cases it can happen that a cold motor is able to accelerate a load while several working cycles later - when the motor has become hot – it is not possible to move the load anymore.