The sizing of a Warner Electric clutch or brake depends on various factors. The most common of these factors are shown below in chronological order:

- Transmissible torque: In Nm
- Energy source: Electric, Pneumatic, Hydraulic, or Mechanical
- Actuation mode: Static or Rotating
- Operational environment: Oil, Dry or Mixed
- Heat dissipation: Duty Cycle, Inertia, Speed, etc.
- Orientation of mounting: Horizontal, Vertical, Inclined

The majority of applications can be computed using the formulas and calculation methods given below. For special cases we recommend that you contact the factory.

Transmissible Torque

Calculation of the torque provides a first approximation of the size of Warner Electric device required. The various transmissible torque's are:

Static Torque
The maximum transmissible torque when components to be coupled are in synchronism (zero relative speed).

Dynamic Torque
This is the torque developed by a clutch or brake during acceleration or deceleration until zero relative speed between the driving and driven component is achieved. This torque is a variable, as a function of the rotational speed, the friction factor, the type of friction material used, the operating ambient and the acceleration or deceleration time required to obtain the desired rotational speed.

Residual Torque
Normally applies for multi-disc devices only. This torque results from the friction between internal and external discs in a non-energized device.

Nominal Torque
The nominal torque of a power source can be calculated utilizing the following formula:

$$M_n = 9550 \cdot P / n$$

where:
M_n = required torque in Nm
P = power in kW
n = speed in min^{-1}

Calculation for Clutch Torque
In case the nominal torque is unknown, it is recommended to add a safety factor K as a function of the type of drive source and the coupling mode: single disc, multi-disc or tooth. This results in formula:

$$M_n = (9550 \cdot P / n) \cdot K$$

For quick selection based on drive power use K = :

2,5 - 3 for electric motors
4 - 5 for Diesel engines
5 - 6 for compressors

Method to determine the transmission torque for a Warner Electric clutch or brake. This method enables you to proceed on the basis of the machine characteristics and to accurately define the type of product most suitable for the application.

1) Calculate the load torque
This is the torque of the load and the friction of the mechanism, which the clutch has to overcome before rotation of the driven part is obtained. The value is basically equal to the tangential force exercised on a lever arm.

$$M_l = F \cdot R \cdot n_2 / n_1$$

where:
M_l = static source torque in Nm
F = force in N
R = radius in m
n_1 = speed of the clutch or brake shaft in min^{-1}
n_2 = speed of the mechanism's shaft in min^{-1}

2) Calculate the moment of inertia
The moment of inertia represents the mass to be brought to speed or to stop until synchronism between the drive shaft and driven shaft has been obtained. Consequently this is directly related to the inertia reflected on the clutch shaft. Rotational and linear inertia's are calculated utilizing following formulas:

Rotational Inertia

Solid cylinder

$$J = 1/2 \cdot m \cdot R^2$$

Hollow cylinder

$$J = 1/2 \cdot m \cdot (R^2 + r^2)$$

where:
J = in kgm^2
m = mass in kg
R = outer radius in m
r = inner radius in m

Next the total of the inertia's need to be referred to the shaft of the clutch as a function of the square of the speed ratios.

$$J_{total} = J_1 + J_2 (n_2 / n_1)^2 + J_3 (n_3 / n_1)^2$$

where:
J_{total} = Total inertia in kgm^2
n_1 = speed of drive shaft in min^{-1}
n_2 = speed of intermediate shaft in min^{-1}
n_3 = speed of driven shaft in min^{-1}
J_1 = inertia of drive shaft in kgm^2
J_2 = inertia of intermediate shaft in kgm^2
J_3 = inertia of driven shaft in kgm^2

Linear Inertia

$$J = 91 \cdot m \cdot v2 / n2$$

where:
J = inertia in kgm^2
m = mass in kg
v = speed in m/s
n = rotational speed in min^{-1}

Total Inertia

This is the sum of all rotational and reflected inertia's (including the inertia of the clutch or brake parts).

3) Time to accelerate or decelerate

$$M_d = (J_{total} \cdot n) / (9{,}55 \cdot t)$$

where:

M_d = acceleration/deceleration torque in Nm
J_{total} = total inertia in kgm^2
n = speed of clutch or brake shaft in min^{-1}
t = acceleration / deceleration time required in s

4) Time to accelerate or decelerate

$$M_{total} = M_d \pm M_l$$

(except lifting, for this kind of application, please contact us)

where :
M_{total} = in Nm
M_l = static torque in Nm
M_d = acceleration/deceleration torque in Nm
The nominal clutch or brake's torque has to be always bigger than the torque calculated with this method.

5) acceleration or deceleration real time

$$t = (J_{total} \cdot n) / (9{,}55 \cdot (Mn \pm Ml))$$

where:
t = in s
J_{total} = total inertia in kgm^2
n = speed of clutch or brake shaft in min^{-1}
M_n = nominal torque of the chosen clutch or brake ..... in Nm
M_l = static torque in Nm (– for a clutch, + for a brake)

Energizing Modes

The Warner Electric product line of clutches and brakes contains devices energized:

- Electromagnetically Hydraulically
- Pneumatically Mechanically

They can be activated by:

- Applying power or pressure; = the friction surfaces are compressed when the force is applied.
- Absence of power or pressure; = the friction surfaces are compressed by spring force which makes these products suitable for use as security devices.

The choice is also determined by the time of use in the rotating or stop position.

Engagement

When a speed difference between the drive and the driven axis is present, only the use of single or multi-disc clutches or brakes is permitted. With zero speed difference or engagement at standstill, the use of a tooth clutch or brake becomes possible.

Usually toothed devices have smaller diameters D than disc devices of the same ratings. Also they are normally activated by applying power. To establish the torque rating of a tooth device one should understand that under no condition can they withstand loads higher than specified in their data tables. (contrary to a friction clutch, the tooth clutch can never slip). Therefore one must know:

- The maximum peak torque produced by the drive system (watch out for accel/decelerations and inertia functions).
- The presence of shock and vibration in the drive system

Since in many cases it is difficult to know these elements, for devices engaged by power on, a safety factor K = 3 should be applied. For lifting motion, use of a tooth device is forbidden. For friction based devices, the torque ratings listed in our tables are based on "run in" conditions. In new conditions the transmissible torque may be below 50% of their nominal value. Nominal ratings are obtained after se eral operations with a differential speed above 1m/s. In order to obtain a high positioning precision and rapid acceleration a "run in" operation before use is recommended. In such applications the use of a Warner Electric power supply with boost current will help to reduce the engage and disengage times.

Operating Conditions

Lubricated - For applications with high energy per cycle, we recommend the use of a multi disc device in lubricated environment. This will keep the surface wear low and particularly the lifetime of the friction surface will be increased. The lubricant used should have a viscosity below 40 centistokes at 50°C without a high-pressure additive. If possible do not submerge the devices.

Dry - Recommended operation temperature -25°C to +40°C. The functional friction materials used in dry environments, generally steel/organic combinations, have a higher friction factor then those used in lubricated environments. This results in a higher level of wear as a function of the energy per cycle. As a consequence it is important to correctly select the product as a function of the operation parameters and heat dissipation capacity. Underrating will result in higher wear as well as deformation of the friction materials.

Mixed - For use in mixed environments a protection against grease and dirt particles should be taken into account.

Heat Dissipation

During clutching or braking, the mechanical energy is through friction transformed into heat. This lost energy needs to be absorbed by the clutch or brake without causing damage. In addition it affects its lifetime. Use the following formulae to calculate the heat dissipation:
Clutch or Brake

$$W = (J_{total} \cdot n^2 / 182{,}5) \cdot (M_n / (M_n \pm M_l))$$

where:
W = Work in Joules
J_{total} = Total inertia in kgm^2
M_n = nominal torque of the chosen clutch or brake .... in Nm

– M_l = static torque for clutch in Nm
+ M_l = static torque for brake in Nm
n = clutch or brake speed in min^{-1}

For vertical motion from top to bottom + and – are reversed

Torque limiter

$W = Md \cdot n \cdot t / 9{,}55$

where:
W = in Joules
M_d = slip torque in Nm
n = speed in min^{-1}
t = slipping time in seconds

Using the results obtained, verify the heat dissipation using the diagrams shown with each product to see if the product selected meets this requirement.

Mounting Position

In this catalogue each product has been clearly identified for horizontal or vertical use. In some cases devices specified for horizontal use may be used in vertical position. Please consult factory for more information.

Power Supply

Electric - Our electric clutches & brakes operate with DC or rectified AC voltage. The standard voltages are 24, 103.5 and 207 Volts. Warner Electric offers power supplies to convert the AC voltage and to maintain a DC switching ensuring short response times.

All power supplies meet the applicable CE standards. Switching is possible on the AC or the DC side, however, switching on the AC side is 5 to 6 times slower then DC side switching.

Certain electro release devices apply a bi-voltage, the high voltage is used during the actual engagement, while the low voltage is used to hold the armature in position. Typical voltage combinations are 103.5/48 or 207/103.5 VDC.

Back EMF - When de-energizing the coil an important back EMF voltage is produced, particularly for higher torque rated models. This voltage may even damage components in the control circuit. We recommended that these peak voltages are suppressed by connecting a capacitor across the coil. (This protections is included in our power supplies).

Again do not hesitate to consult the factory for further information.

Pneumatic - The normal service pressure for Warner Electric clutches and brakes varies between 5 and 6 bars.

For devices activated by pressure, the transmissible torque is directly proportional to the pressure applied. We recommend the use of a filter/regulator and an air lubricator to prevent all risks of corrosion of the air chamber. To avoid pressure losses in axial supplies the use of an air tight connection between the hub and the shaft is recommended. For radial supplies, a flexible connection without constraints is recommended.

Hydraulic - The normal service pressure for Warner Electric clutches and brakes is listed in the product tables. Di ferent service pressures meeting your operating conditions can be used. In order to protect the gliding surfaces of the piston/cylinder the use of filtered hydraulic oil with 10 micron grade and a viscosity suitable to the operating conditions, is recommended. For the friction surfaces, use of an oil with a viscosity up to ISO VG46 and compatible for use with sintered bronze is recommended.

Units

Electricity

Capacity	F	Resistance	Ω
Current	A	Voltage	V
Inductance	H	Pressure	bar

Mechanical

Acceleration	m/s^2	Power	W
Angle	°	Temperature	°C
Torque	Nm	Time	s
Force	N	Energy	J
Gravity	m/s^2	Angular Speed	rd/s
Length	m	Linear Speed	m/s
Mass	kg	Rotational Speed	min^{-1}
Voluminal Mass	kg/m^3		
Inertia	kgm^2		

Material Density

acrylic	1.2	iron	7.9
aluminum	2.7	iron (cast)	7.3
bakelite	1.3	magnesium	1.7
brass	8.5	nickle	8.8
bronze	8.9	rubber	1.2
copper	8.9	steel	7.8
glass	2.6	teflon	2.2

Conversions

Length

Inch	feet	yard	mm	m	km
1	0.08333	0.02778	25.4	0.0254	-
12	1	0.3333	304.8	0.3048	-
36	3	1	914.4	0.9144	-
0.03937	3281x10^{-6}	1094x10^{-6}	1	0.001	10^{-6}
39.37	3.281	1.094	1000	1	0.001
39370	3281	1094	106	1000	1

Mass

dram	oz	lb	g	kg	Mg
1	0.0625	0.003906	1.772	0.001772	1.772x10^{-6}
16	1	0.0625	28.35	0.02835	28.35x10^{-6}
256	16	1	453.6	0.4536	453.6x10^{-6}
0.5644	0.03527	0.002205	1	0.001	10^{-6}
564.4	35.27	2.205	1000	1	0.0001
564.4x10^{3}	35270	2205	10^{6}	1000	1

Force

dram	oz	lb	N	kN
1	0.0625	0.003906	0.0173656	17.3x10^{-6}
16	1	0.0625	0.27783	277.83x10^{-6}
256	16	1	4.44528	4445.28x10^{-6}
57.592	3.59898	0.225	1	0.0001
57.592x10^{3}	3598.9896	225	1000	1

Torque

oz.in	lb.in	lb.ft	Ncm	Nm
1	0.0625	0.005208	0.706	0.00706
16	1	0.0833	11.3	0.113
192	12	1	135.6	1.356
1.4162	0.0885	0.0074	1	0.01
141.619	2 8.8512	0.7376	100	1

Inertia

oz.in^2	lb.in^2	lb.ft^2	kgcm^2	kgm^2
1	0.0625	0.000434	0.183	18.3x10^{-6}
16	1	0.006944	2.926	0.2926x10^{-3}
2304	144	1	421.344	0.421344
5.465	0.34156	2.3718x10^{-3}	1	0.0001
54650	3415.6	23.718	10000	1

Power

HP	kp m/s	Nm/s=J/s=W	kW	kcal/s	BTU/s
1	76.04	745.7	0.7457	0.1782	0.7073
13.15x10^{-3}	1	9.807	9.807x10^{-3}	2.344x10^{-3}	9.301x10^{-3}
1.341x10^{-3}	0.102	1	10-3	239x10^{-6}	948.4x10^{-6}
1.341	102	1000	1	0.239	0-Jan
5.614	426.9	4187	4.187	1	3.968
1.415	107.6	105	1.055	0.252	1