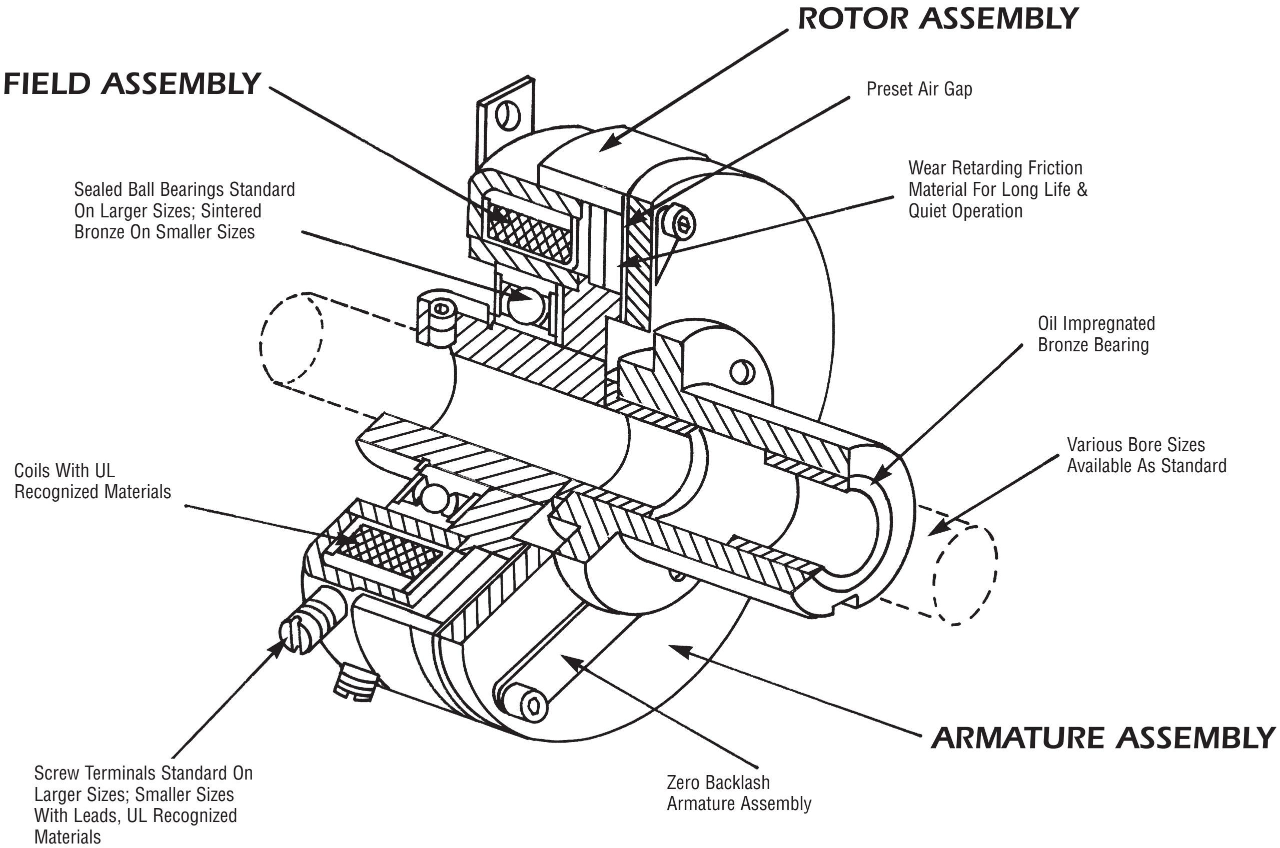
Power-On Clutches & Brakes Description



Typical Applications of Clutches & Brakes

- ☐ Copiers/Printers
- ☐ Packaging Machinery
- ☐ Microfilm Readers
- ☐ Medical Equipment
- ☐ Conveyors
- ☐ Postal Sorters/Readers
- ☐ Document Feeders
- ☐ Textile Equipment
- ☐ Mobile Power Equipment

Generating the Clutch or Brake Torque

Inertia Dynamics clutches and brakes are designed to start and stop inertial loads when the voltage is turned on. When DC voltage is applied to the coil, the magnetic force caused by the magnetic flux pulls the armature across the air gap against the force of the zero-backlash spring attached to the armature. The mating of the armature and rotor face produce torque.

When DC voltage is interrupted, the magnetic field collapses, and the zero-backlash spring retracts the armature from the rotor face. There is no residual torque produced.

Special Features of the IDI Clutches and Brakes

- ☐ Precision oiltite sleeve and ball bearings for long life.
- ☐ Zero-backlash armature assembly providing a spring release for reliable and precise disengagement.
- ☐ Stationary field coil assembly means no slip rings or brushes.
- ☐ All parts effectively protected against corrosion.
- ☐ Asbestos-free friction material.
- ☐ Non-standard coil voltages available upon request.
- ☐ Metric bore sizes available upon request.

Determining the Clutch or Brake Size

First, determine which style clutch or brake you need. The type of unit selected depends upon the function to be performed.

Next, determine the size of the clutch or brake. There are two methods you can use to calculate the dynamic torque required.

$$T_d = \left[\frac{WR^2 \times N \pm T_L}{C \times t}\right] \times S.F.$$

Where:

- WR^2 = Total inertia reflected to the clutch/brake, lb.–in.^{2} (kg.m^2)
- N = Shaft speed at clutch/brake, RPM
- C = Constant, use 3696 for English units and 9.55 for metric units
- t = Desired stopping or acceleration time, seconds
- T_L = Load torque to overcome other than inertia, lb.–in. (N–m)
- S.F. = Service Factor, 1.4 recommended
- T_d = Average dynamic torque, lb.–in. (N–m)

Note: $+ T_L$ = engage a clutch or accelerate

$- T_L$ = brake or decelerate

Inertia Dynamics clutches and brakes are rated by static torque. For obtaining the proper size needed based upon the dynamic torque, refer to the Dynamic Torque Curves as a guide.

The clutch or brake size can also be determined using the selection chart. Find the intersection of the prime mover horsepower (HP) and shaft speed at the brake using the selection chart (Fig. A and B). The relationship between the horsepower and speed to determine the dynamic torque required is expressed as:

$$T_d = \frac{63{,}025 \times P}{N} \times S.F.$$

Where:

- T_d = Average dynamic torque, lb.–in.
- P = Horsepower, HP
- N = Shaft Speed
- S.F. = Service Factor
- 63,025 = Constant

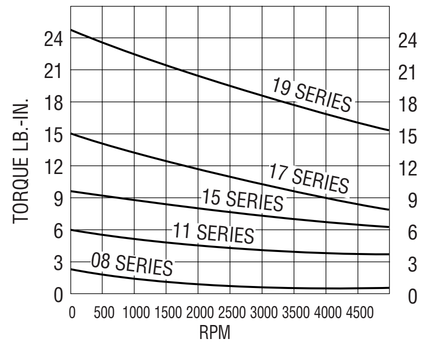
Additional formulas and conversion charts are found on pages 38 and 72.

Burnishing

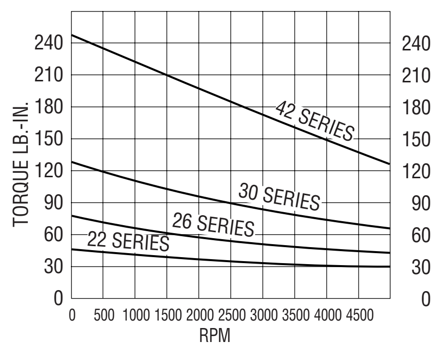
Burnishing is a wearing-in or mating process which will ensure the highest possible output torques. Burnishing is accomplished by forcing the clutch or brake to slip rotationally when energized. Best results are obtained when the unit is energized at 30–40% of rated voltage and forced to slip for a period of 2–3 minutes at a low speed of 100–200 RPM Units in applications with high inertial loads and high speed will usually become burnished in their normal operating mode. Whenever possible, it is desirable to perform the burnishing operation in the final location so the alignment of the burnished faces will not be disturbed. For additional information on burnishing procedures ask for burnishing spec. #040-1001.

Dynamic Torque Curve

SERIES 08, 11, 15, 17, 19



SERIES 22, 26, 30, 42



Torque Data

CLUTCHES: CLUTCH COUPLINGS: POWER ON BRAKES			
SERIES	TYPICAL OUT-OF-BOX TORQUES LB. – IN.	RATED STATIC TORQUES LB. – IN.	TYPICAL TORQUES AFTER BURNISHING LB. – IN.
08	2	2.5	3
11	5	6	8
15	8	10	15
17	12	15	20
19	20	25	30
22	40	50	60
26	65	80	90
30	100	125	150
42	225	250	275

Selecting a Power-On Clutch or Brake

Response Times

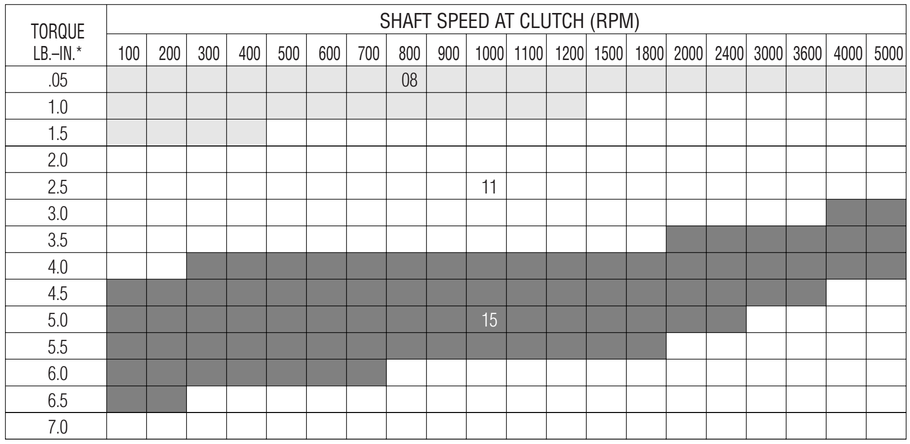
SERIES	RATED STATIC TORQUE LB. – IN.	TORQUE BUILD-UP TIME MILLISECONDS 80% OF RATED TORQUE	TORQUE BUILD-UP TIME MILLISECONDS 100% OF RATED TORQUE	TORQUE DECAY TIME MS 10% OF RATED TORQUE
08	2.5	4.8	7.5	6.6
11	6	7.2	10.5	11
15	10	9	12	17
17	15	10	14	14
19	25	33	48	35
22	50	27	42	20
26	80	22	40	30
30	125	43	60	36
42	250	45	70	50

NOTES:

1. Torque decay time is dependent on the type of arc suppression circuit used. Decay times shown in table assume use of a diode in parallel with the coil for arc suppression. If no arc suppression is used, torque will decay almost instantly.
2. Actual response times depend on several factors such as inertia being accelerated or decelerated, speed, load torque, and type of switching used.
3. Time to full torque can be shortened by applying overexcitation voltages up to 50 times the rated coil voltage.
4. The time to full torque is also dependent on the voltage supply. If the clutch or brake is underpowered (low voltage), a decrease in torque will result. The clutch or brake should be sized based upon the worst-case voltage condition. The DC voltage supply should be filtered full wave for highest efficiency. Half wave DC voltage will result in lower torque output.

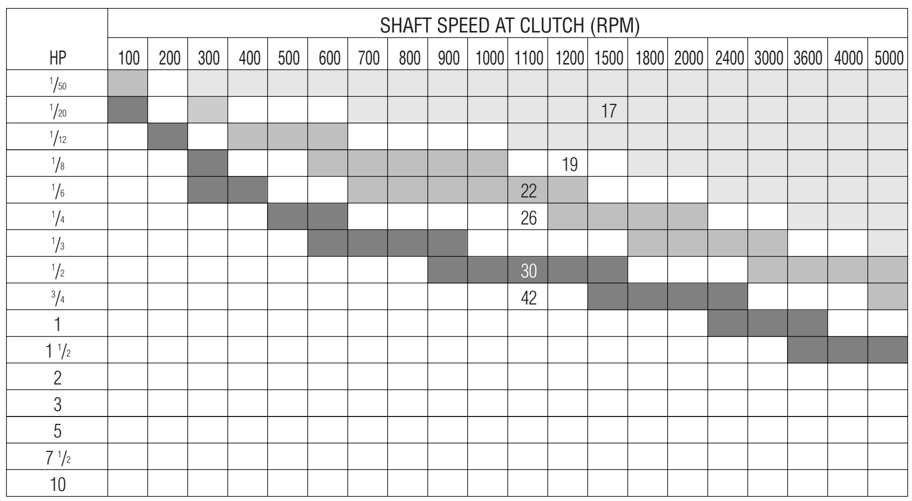
Fig. A. For SL, BSL, SO, FL, FO Series

Torque Rating vs. RPM (Sizes 08 thru 15) – Selection Chart

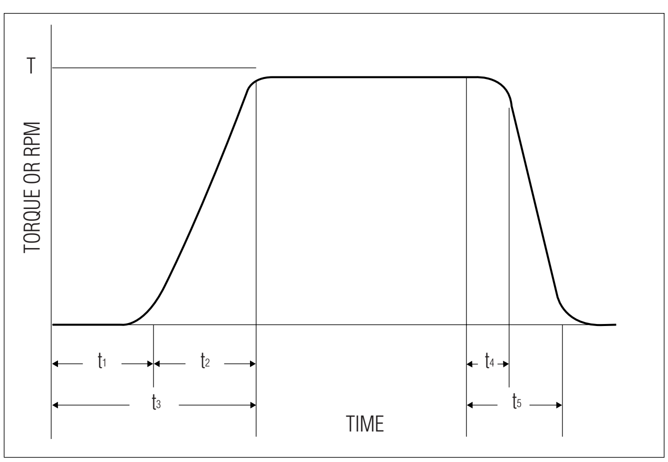


*Slightly higher torque ratings may be allowable for some speeds. Consult Inertia Dynamics.

HP vs. RPM (Sizes 17 thru 42) – Selection Chart



Response Times for Clutches & Brakes



Where:
t_1 = Delay time when engaging
t_2 = Torque rise time
t_3 = Time to full torque or speed
t_4 = Disengaging time (90% torque)
t_5 = Time to zero speed
T = Full torque or speed

Fig. B. For FB Series

Torque Rating vs. RPM (Sizes 08 thru 15) – Selection Chart

TORQUE LB.–IN.*	SHAFT SPEED AT CLUTCH (RPM)																			
	100	200	300	400	500	600	700	800	900	1000	1100	1200	1500	1800	2000	2400	3000	3600	4000	5000
.05									08											
1.0																				
1.5																				
2.0																				
2.5										11										
3.0																				
3.5																				
4.0																				
4.5																				
5.0										15										
5.5																				
6.0																				
6.5																				
7.0																				

*Slightly higher torque ratings may be allowable for some speeds. Consult Inertia Dynamics.

HP vs. RPM (Sizes 17 thru 42) – Selection Chart

HP	SHAFT SPEED AT CLUTCH (RPM)																			
	100	200	300	400	500	600	700	800	900	1000	1100	1200	1500	1800	2000	2400	3000	3600	4000	5000
1/50																				
1/20																				
1/12												17								
1/8																				
1/6																				
1/4											19									
1/3																				
1/2											22									
3/4											26									
1																				
1 1/2											30									
2											42									
3																				
5																				
7 1/2																				
10																				

Allowable Cycles/Minute*

UNIT SIZE	RPM	INERTIA (LB. – IN.^{2})				UNIT SIZE	RPM	INERTIA (LB. – IN.^{2})			
		5	10	50	100			50	100	500	1000
08	225	300	200	30	12	19	225	200	120	20	8
	900	30	12	2	1		900	9	5	1	–
11	225	–	300	60	30	22	225	250	150	25	10
	900	45	20	3	2		900	12	6	1	–
15	225	–	350	120	60	26	225	300	200	30	12
	900	60	30	6	3		900	20	9	2	1
17	225	–	–	150	100	30	225	350	250	40	20
	900	80	40	7	4		900	25	12	3	1
*Chart intended as a guide. For other speeds and inertias, consult Inertia Dynamics.						42	225	–	300	60	30
							900	30	20	4	2

Selection Considerations

The required size is determined mostly from the clutch or brake torque needed. The inertia to be accelerated or braked, the speed, the acceleration or braking times, duty cycle, and life requirements are all considerations in clutch or brake sizing. Other conditions to be considered are ambient temperatures, humidity, dust, and contaminants which may affect the clutch or brake performance. For these reasons, clutch and brake performance should be evaluated under actual application conditions.

Clutch & Brake Location

Whenever possible, the clutch or brake should be mounted to the highest-speed shaft. This will allow a clutch or brake with the lowest possible torque to be used. However, the maximum allowable shaft speed should not be exceeded.

120 VAC Operation

All clutches and brakes include full wave rectification.

Maintenance

The air gap should be checked frequently to ensure proper operation. If the air gap exceeds the maximum recommended dimension, the clutch or brake may not function, and the necessary adjustments should be made. The friction faces must be kept free of grease and oil for proper operation.

Torque

$$T_d = \frac{63{,}025 \times P \times S.F.}{N}$$

Where:

T_d =	Dynamic Torque (lb.–in.)
P =	Horsepower (hp)
N =	RPM = shaft speed
S.F. =	Service Factor
63,025 =	Constant

Reflected Inertia

$$\text{Equivalent } WR_A^2 = WR_B^2 \left(\frac{N_B}{N_A}\right)^2$$

Where:

WR_A^2 =	Inertia of rotating load reflected to the clutch or brake shaft (lb.–in.^{2})
WR_B^2 =	Inertia of rotating load (lb.–in.^{2})
N_B =	Shaft speed at load (RPM)
N_A =	Shaft speed at clutch or brake (RPM)

Linear Inertia

$$\text{Equivalent } WR_A^2 = W \left(\frac{V}{2\pi N_A}\right)$$

Where:

WR_A^2 =	Inertia of linear moving load reflected to the clutch or brake shaft (lb.–in.^{2})
V =	Linear velocity of load (in./min.)
W =	Weight of linear moving load (lb.)
N_A =	Shaft speed at clutch or brake (RPM)
2π =	Constant

Thermal Capacity

$$TC = \frac{WR^2 \times N_A \times n}{4.63 \times 10^8}$$

Where:

TC =	Thermal capacity required for rotational or linear moving loads (hp–sec./min.)
WR^2 =	Total system inertia reflected to the clutch or brake shaft (lb.–in.^{2})
N_A =	Shaft speed at clutch or brake (RPM)
n =	Number of stops or starts per minute, not less than one
4.63×10^8 =	Constant

Linear Velocity

$$IPM = PD \times N \times \pi$$

Where:

IPM =	Velocity of object (inches per minute)
PD =	Pitch diameter of object (inches)
N =	Speed of shaft at the object (RPM)
π =	Constant

Inertia – (WR^2)

To calculate the inertia for a cylinder, the formula is:

$$WRz^2 = \frac{\pi}{32} \times D^4 \times L \times \rho$$

Where:

WR^2 =	Inertia – lb.–in.^{2} (kg–m^2)
D =	Diameter – inches (meters)
L =	Length – inches (meters)
ρ =	Density – lb./in.^{3} (kg/m^3)

Approximate values for ρ are:

Steel –	.284 (7860)
Aluminum –	.098 (2700)
Plastic –	.047 (1300)
Rubber –	.047 (1300)

For steel shafting, refer to the inertia chart, Fig. A.

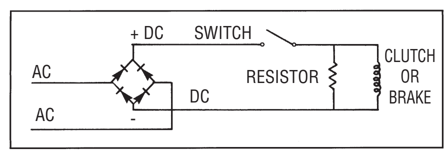
Arc Suppression

When the clutch or brake is de-energized, a reverse voltage is generated in the coil. The reverse voltage can be very high and may cause damage to the coil and switch in the circuit. To protect the coil and switch, the voltage should be suppressed using an arc suppression circuit. Arc suppression does not affect the clutch or brake engagement time.

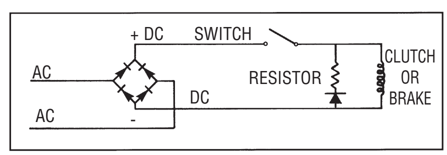
Resistor/Diode/Zener Diode –

Normal Disengagement Time

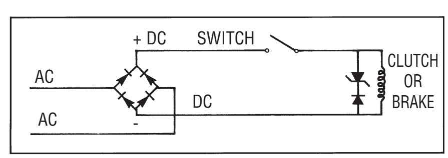
For most applications, a resistor connected in parallel with the clutch/brake coil is adequate. The resistor should be rated at six times the coil resistance and approximately 25% of the coil wattage.



To eliminate the added current draw, a diode may be added as shown below.



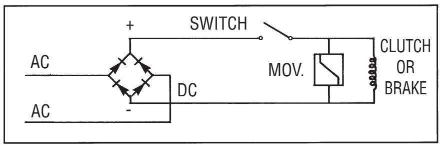
For faster release, use a zener diode with a rating two times the coil voltage.



Metal Oxide Varistor (MOV) –

Fast Disengagement Time

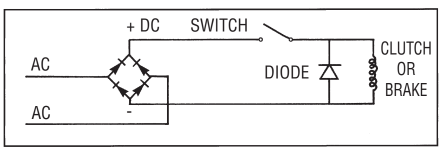
For applications requiring fast clutch or brake disengagement, an MOV connected in parallel with the clutch/brake coil should be used.



Diode

Slow Disengagement Time

For applications where a delayed disengagement is desired, a diode should be used in parallel with the clutch/brake coil or switch the AC side of the circuit.



Inertia Conversion Chart

To determine the inertia of a rotating member of a material other than steel, multiply the inertia of the steel diameter from Fig. A at right by:

MATERIAL	MULTIPLIER
Bronze	1.05
Steel	1.00
Iron	.92
Powdered Bronze	.79
Powdered Metal Iron	.88
Aluminum	.35
Nylon	.17

Fig. A
Inertia Chart
I = WR^2 of Steel (per inch of length)

DIA. (IN.)	WR^2 (LB. – $IN.^2$)
1/4	.00011
5/16	.00027
3/8	.00055
7/16	.00102
1/2	.00173
9/16	.00279
5/8	.00425
11/16	.00623
3/4	.00864
13/16	.01215
7/8	.01634
15/16	.02154
1	.0288
1 1/4	.0720
1 1/2	.144
1 3/4	.288
2	.432
2 1/4	.720
2 1/2	1.152
2 3/4	1.584
3	2.304
3 1/2	4.176
3 3/4	5.472
4	7.056
4 1/4	9.072
4 1/2	11.376
5	17.280
5 1/2	25.488
6	36.000
6 1/4	42.624
6 1/2	49.680
6 3/4	57.888
7	66.816

NOTE:

1. To determine WR^2 of a given shaft, multiply the WR^2 given above by the length of the shaft or the thickness of the disc in inches.
2. For hollow shafts, subtract WR^2 of I.D. from WR^2 of O.D. and multiply by length.

INERTIA		
TO CONVERT FROM	TO	MULTIPLY BY
g – cm^2	lb.–$in.^2$	3.417×10^{-4}
g – cm^2	lb.–$ft.^2$	2.373×10^{-6}
kg – cm^2	lb.–in^2	3.417×10^{-1}
kg – cm – sec^2	lb.–$in.^2$	335.1
N – m – sec^2	lb.–$in.^2$	3417
kg – m^2	lb.–$in.^2$	3417
N – m^2	lb. – $in.^2$	348.47
lb. – $in.^2$	kg – cm^2	2.926
lb. – $in.^2$	kg – m^2	2.9265×10^{-4}
lb. – $in.^2$	N – m^2	2.870×10^{-3}
lb. – $in.^2$	lb. – in. – $sec.^2$	2.590×10^{-3}
lb. – $in.^2$	lb. – $ft.^2$	6.944×10^{-3}
lb. – $in.^2$	oz. – $in.^2$	16
lb. – $ft.^2$	lb. – $in.^2$	144
lb. – $ft.^2$	oz. – $in.^2$	2304
lb. – $ft.^2$	oz. – in. – $sec.^2$	5.969
oz. – $in.^2$	oz. – in. – $sec.^2$	2.590×10^{-3}
oz. – $in.^2$	lb. – $in.^2$	6.25×10^{-2}
oz. – in. – $sec.^2$	oz. – $in.^2$	3.8609×10^{-2}
oz. – in. – $sec.^2$	lb. – $in.^2$	24.125

MISCELLANEOUS		
TO CONVERT FROM	TO	MULTIPLY BY
horsepower	ft.–lb./min.	33,000
kilograms	pounds	2.2
meters	millimeters	1000
millimeters	inches	3.937×10^{-2}
Newtons	pounds	.225
radians	degrees	57.30
revolutions	radians	6.283
revolutions/min.	degrees/sec.	6
square–inches	square–millimeters	645.2
temp. (°C) + 17.78	temp. (°F)	1.8
temp. (°F) – 32	temp. (°C)	$^5/_9$

TORQUE		
TO CONVERT FROM	TO	MULTIPLY BY
kg–m	lb.–in.	.6026
N–m	lb.–in.	8.850
N–m	oz.–in.	141.69
lb.–in.	g–cm	1152
lb.–in.	kg–cm	1.152
lb.–in.	kg–m	1.6596
lb.–in.	N–m	.1130
lb.–in.	oz.–in.	16.0
lb.–in.	lb.–ft.	.083
lb.–ft.	lb.–in.	12.0

Acceleration Time– The amount of time to move a load from zero to full speed once the spring is wrapped down.

Actuator Limit Stop – The actuator limit stop is a pin or plate that prevents the actuator from bottoming out on the solenoid and causing wear. The actuator is used on DCB models.

Anti-Backup (AB) – This spring prevents oscillation between the clutch and brake springs and prevents the output load from reversing. If stopping accuracy is required, this modification must be specified in the part number.

Anti-Overrun (AOR) – This spring prevents an overhauling load from overrunning the input. The anti-overrun applies when an eccentric load is encountered, maintaining the same output speed as the constant input speed. This spring must be specified in the part number.

Anti-Rotation Slot – A slot in the mounting plate of DCB products. The mounting plate should be retained by a loose-fitting tab or pin through the slot to prevent radial rotation of the clutch/brake.

Control Tang – A tang on either end of the wrap spring which will engage and disengage the input and output hubs.

Deceleration Time – The amount of time required to bring a load to rest once the spring has unwrapped.

Overrunning (OR) – A function of SC clutches. The clutch transmits torque in one direction and allows the load to overrun when the input is stopped or reversed.

Overtravel Stop (OTS) – Disengages the output at a predetermined position every cycle, absorbing a portion of the load. Combined with AB, will provide 20% braking capacity.

Single Revolution (SR) – Control function that results in the output rotating one revolution and stopping in the same position. In SC units, the stopping accuracy is a function of output loads. DCB units maintain ±1° stopping accuracy (noncumulative) independent of output load conditions.

Start Stop (SS) – Control function that results in the output rotating one revolution and then coasting to a stop.

Static Torque – The maximum torque the clutch can generate statically when the wrap spring is completely wrapped down before slipping or damage occurs.

Stop Collar – The stop collar has detent positions to control the clutch or brakes engagement and disengagement. The standard stop collar has one detent, but special collars are available with up to twenty-four detents, or stops, per revolution.

Wrap Spring – The high tensile strength coiled wire in clutches and brakes which allows transfer of a high amount of torque when wrapped tightly around two hubs.

Acceleration Time – The amount of time required to change the speed of an inertial load, from the instant an electrical signal is applied to the time the system is at full speed.

Air Gap – The space between the armature and field when the clutch or brake is disengaged.

Brake-Power Off – Unit used to stop a load when turned off electrically.

Brake-Power On – Unit used to stop a load when turned on electrically.

Build Up Time – The time required to build up 90% of the flux which yields 80% of the rated torque.

Burnishing – A "wearing in" process of the mating friction surfaces for maximum torque.

Clutch – Unit used to couple two parallel shafts via pulleys, gears, or sprockets.

Clutch Coupling – Unit used to couple two in-line shafts.

Decay Time – The time required to decay to 10% of the flux which yields 10% of the rated torque.

Deceleration Time – The amount of time required to stop an inertial load, from the instant an electrical signal is applied to the time the system is at rest.

Dynamic Torque – Torque measured at instant of clutch or brake engagement when one friction member is rotating and the other is stationary or rotating at a different speed. Approximately 80% of static torque.

Field – Coil and housing assembly which forms part of the electromagnet.

Flange – Mounting plate located on brake magnets and clutch fields.

Frictional Torque – The torque required to overcome static friction in the system.

Friction Material – Composition material (nonasbestos) inserted between poles of clutch or brake magnet, used to retard wear rate of iron poles and armature.

Inertia – The property of matter that causes an object to remain at rest or in motion until acted on by an outside force.

Inertial Torque – The torque generated by accelerating or decelerating a load.

Moment of Inertia – WR^2 = Weight of an object times its radius of gyration squared.

Overexcitation – Applying a high voltage for a brief time period to shorten the engagement time. Sometimes referred to as "spiking."

Positive Engagement – An engagement with no slip.

Radial Bearing Load – The maximum load that can be applied to a clutch at maximum speed without causing premature wear.

Residual Magnetism – A condition in magnets where low levels of magnetism remain after electric current is removed.

Rotor – The rotating component of a stationary field clutch that carries the friction material.

Spline Drive – Heavy duty clutch or brake drive comprised of mating armature and hub splines.

Static Torque – Torque measured at instant of breakaway when both friction members are locked in at the same speed or at rest.

Thermal Capacity – Brake rating that takes into consideration number of stops/minute, total inertia, and brake rotational speed.

Time to Speed – The amount of time required to change the speed of an inertial load, from the instant an electrical signal is applied to the time the system is at full speed.

Time to Zero Speed – The amount of time required to stop an inertial load, from the instant an electrical signal is removed to the time the system is at rest.

Torque – The action of a force producing rotation. Torque is comprised of a force (lb.) acting upon a lever arm of length (in.). The product of the force and lever arm is pound–inches (lb.–in.) used to express torque. See "static" and "dynamic" torque.

UL – Underwriters Laboratories – An organization which tests electrical equipment for product safety.

Zero Backlash Armature – A spring mounted armature used to eliminate backlash and dragging of the armature against the field magnet.