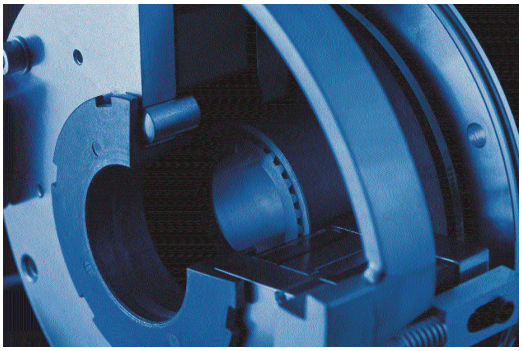
How to select your spring applied brake

Brake sizing advice – all you need to know

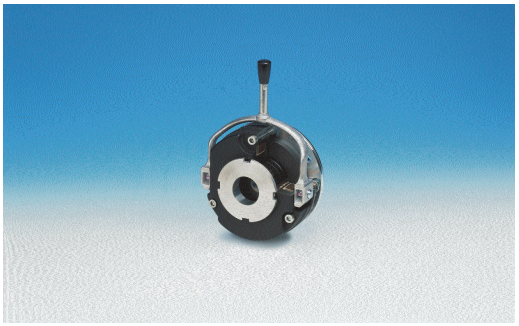
The Basics



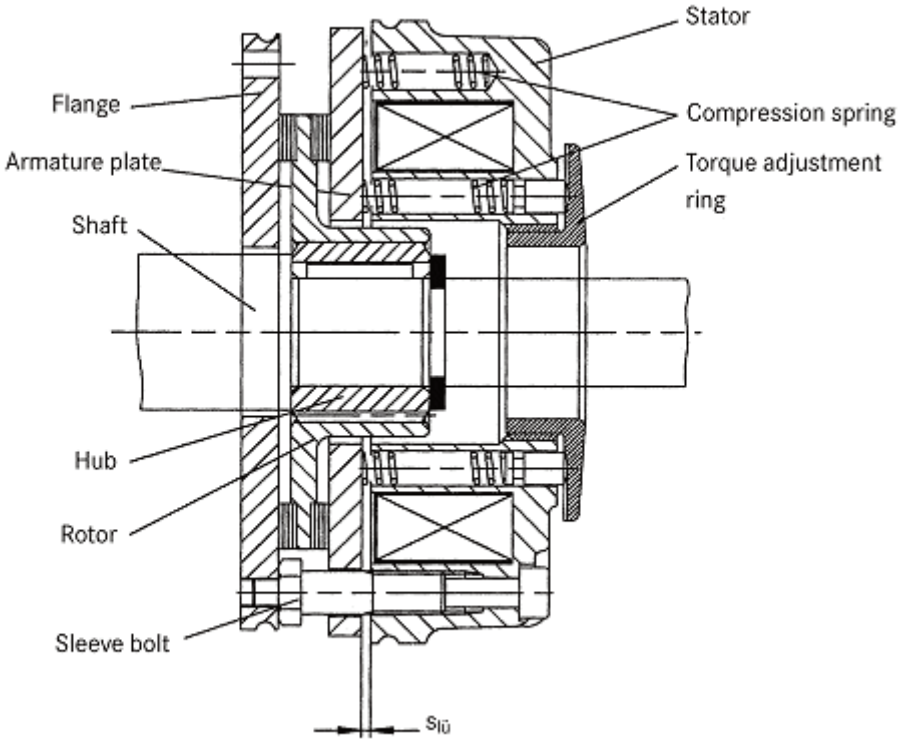
Spring applied brakes, also sometimes known as normally on brakes and failsafe brakes, are most commonly encountered as electromechanical devices with DC current release actuation. When the supply current is interrupted the brake engages and remains on. This suits them to emergency stop and holding duties. They are used in high numbers in applications such as cranes, hoists, industrial trucks, vehicles for the disabled, wind turbines, gates, escalators and brake motors.

Spring applied brake designs are well-developed with high reliability and a stable friction torque that suits both dynamic braking and static holding. Standard designs with modular options are readily available with body diameters 37 to 390mm and corresponding torques from 0.1 to 2400Nm.

How they work



Although there are a number of variants on the market, the majority of spring applied brakes are single disc designs with a DC coil for release. A rotating disc, usually referred to as the rotor, is connected to the machine shaft using a splined hub that allows axial movement of the rotor. In normal operation the axial movement of the rotor is 0.1 to 1.5 mm and the splines are sized to transmit the brake torque with low stress and wear. The rotor has a surface of friction material on both sides.



An assembly of the coil and helical springs, known as the stator, is assembled over the rotor by 3 to 6 fixing bolts. This clamps the rotor between a floating plate in the stator, the armature plate, and the machine surface. Sometimes an intermediate mounting plate is used.

Within the stator assembly the armature plate is mechanically pre-set so it can be pulled back axially by magnetic flux from the DC coil. The movement of the armature plate is thus through the air gap of the brake (Slü) freeing the rotor when the coil is energised. When the supply is interrupted, a number of helical springs push the armature back to clamp the rotor. So in the absence of electrical power, torque is generated between the rotor and a combination of armature plate and mounting surfaces. When the coil is energised the armature plate moves back compressing the springs and the rotor is free to rotate.

Ultimately, these brakes are not truly failsafe although they are highly reliable as witnessed by B1Od figures of 3 to 6 million hours. However, lack of maintenance, overload or long-life fatigue can cause unpredictable failures. In safety-sensitive applications, spring loaded brakes should be selected with suitable service factors, usually 2.0 or higher.

The majority of brakes are powered by DC current connected to a single toroidal coil. DC is preferred to AC because it does not suffer from current inrush problems or from noise. However switching of DC coils is slower and precautions are required for use with falling loads.

More information on the principles of operation are available on Page 7 of our INTORQ BFK458 brake catalogue.

Braking torques

Spring applied brakes have catalogue rated torques. These are nominal figures and may require a small amount of running in before full torque is achieved. In particular a holding torque application without any dynamic friction may not achieve the rated torque.
The required brake torque M (Nm) to stop an inertia J (kgm²) from speed n (r/min) in t (seconds) can be approximated with the formula:

$$M = \frac{J\,n}{9.55t}$$

This is only an approximation as there are factors that affect the delivery of torque:

- There are short delay times whilst the energy in the coil decays and the armature moves. These are significant when the required stopping times are short.
- Friction in the machine works with the brake and shortens stopping times
- Gravity loads can either assist the brake or, as is more common, work against the brake and increase stopping times.

Further detail is given on page 28 of the INTORQ BFK458 brake catalogue.

Some brake designs have torques that are manually adjustable, usually by rotating a nut that compresses the inner set of springs. Also, brakes can have variable torques by factory setting of the springs. Typical ranges are -50 to +10% with adjuster nuts and -50% to +50% with factory setting (the highest torques suiting holding duties with infrequent dynamic stops).

Limiting speeds
The brake rotor will have a maximum rotational speed limit due to centrifugal loads on the rotating friction material. However thermal limits from the brake engagement will be lower. At high engagement speeds, the frictional energy that appears as heat cannot be conducted away from the surface quickly enough and the result can be surface burning, high wear and a reduction in the transmitted torque (brake fade).
In practice, limiting speeds are rarely a factor in brake selection, and brakes can be used at 2 pole motor speeds. However catalogue rated torques should be derated for engagement at high speeds and the factor can be around 0.7 in extreme cases.

Data is given on page 13 of the INTORQ BFK458 brake catalogue

Friction energy
Spring applied brakes function by converting the kinetic energy of the machine into heat. For high operating frequencies above about 1 per minute, and where the speed and inertia to be stopped are high, the thermal data of the application should be checked. This is particularly important in applications that are safety sensitive, for example the stopping of a gravity driven load in a hoist, crane or lift.

Further guidance is given on page 28 of the INTORQ BFK458 brake catalogue.

Operating conditions
Most spring applied brakes are designed for operation in dry conditions. Brakes should be protected from water, and particularly grease and oil which can cause a large drop in torque. Ambient temperature range is -20˚C to +40˚C. Below zero care should be taken to protect the rotor and armature plate from freezing. Cold Climate Version (CCV) brakes are available for outdoor and extreme conditions down to -40˚C as may be encountered in cold stores and wind turbines.

Brakes can be used in potentially explosive atmospheres to ATEX Zone 11 in holding duties, explosion group 11 and temperature class T4.
Brakes can be protected from severe environments by adding a seal on the outside diameter and a shaft seal. When shielded from water jets this approaches IP65 protection. Alternatively, a metal sealed enclosure can be used to achieve IP65 or higher. Spring applied brakes with protection to IP69 are available for the marine environment.

Lifetime and wear
Spring applied brakes require regular inspection and maintenance by qualified personnel. Qualified personnel are defined as persons who, because of their education, experience, training and knowledge including the corresponding standards and regulations, are authorised by the persons responsible for the safety of the plant to perform the required actions. They should be able to recognise potential hazards.

In applications with dynamic braking, spring applied brakes will exhibit wear on the rotor. This can easily measured at the working air gap between the stator body and the armature plate when the brake is engaged. As new, air gaps range from 0.1 to 0.5mm depending on brake size and they can be allowed to increase by a factor of up to 150% due to wear. At that point the brake is required to be reset back to the initial air gap. This adjustment can be done up to 5 times before the rotor has to be replaced.

The wear rate depends on the operating conditions, particularly the frequency on engagement, rotational speed and the loads. It is not possible to accurately predict the required frequency of inspection and maintenance although in some cases an estimate can be made. It is recommended that initially inspection be done after short periods and a long term schedule be based on actual experience.

Safety sensitive applications
Spring applied brakes are not truly failsafe although they are highly dependable. Lack of maintenance, incorrect sizing, overload or long-life fatigue can cause unpredictable failures in extreme circumstances. In safety sensitive applications spring applied brakes should be selected with a suitable service factor, usually 2.0 of higher.

For machine safety evaluation to DIN EN ISO 13849-1, there are B10 and B10d values available for INTORQ brakes available from Lenze. A data sheet can be downloaded from the website www.techdrives.co.uk.

Brake safety can be enhanced by choosing optional micro-switch monitoring of status. This can be used to detect a wear limit or operational malfunction.

Brake switching
Spring applied brakes with DC coils can be operated from low voltage supplies, for example 12, 24, 36 and 48V DC. Switchgear should be sized for the relevant current. However many applications utilise an AC supply with a rectifier that converts to DC voltage. When switching the brake on the AC side of the rectifier, brake engagement times are extended by a factor of 3-4 over catalogue values.

The simplest form of connection to a motor, in parallel with the rectifier and brake coil, further extends the engagement time. This is because the motor which is already switched off but still turning, continues to excite the brake. With falling loads such as hoists, lifts and cranes, it is ESSENTIAL to switch the brake coil on the DC side of the supply. A spark suppressor is required to prevent inductive voltages from damaging the brake coil or rectifier. Reducing the brake torque also prolongs brake engagement times.

The disengagement time is not influenced by AC or DC switching. It can only be shortened by over-excitation of the coil, for example by using a force voltage rectifier. Three types of rectifier are available:

- Full wave rectifier which gives a ratio of 1.1 between AC input and DC ouput, i.e. 230V supply gives 209V DC. Rectifiers are chosen to match available brake stator voltages which are up to a maximum of 250V DC. Optionally the rectifiers can include spark suppression and terminals for DC switching.
- Half wave rectifiers which give a ratio of 2.2 between supply and output, for example when using a 400V supply and a 180V brake coil. Spark suppression and DC switching are optional.
- Forced voltage rectifiers which use a combination of half and full wave rectification to over-voltage the brake coil for a short period and so speed brake re lease. Forced voltage rectifiers can alternatively be used to achieve a lower holding voltage which reduces energy consumption and speeds brake engagement.

Further information is available on pages 20 – 27 of the INTORQ catalogue, also the product manual, which are downloadable from the Techdrive product page.

Brake options

Modular options are readily available to customise the brake for specific duties and mountings, although not every option is available for every size of brake.

- Manual release, also known as hand release, allows the brake to be disengaged without applying current. Combining a manual release with a monitoring mi croswitch can prevent starting whilst the release is in use.
- Brake seal is a rubber protective ring that fits on the outside of the brake.
- Mounting flange and friction plate are optional mounting surfaces. Brakes re quire a ferrous friction surface that is flat with turned smoothness and is square to the shaft.
- Long life variant has mechanical strengthening for high frequency applica tions and ratings in excess of 10 million operations.
- Microswitches fitted to the brake stator can monitor operation or wear.
- Terminal box connection instead of the flying leads which are the norm.
- Cold Climate Version to suit operation in ambient temperatures from -40˚C to +40˚C.
- Double brakes that are piggy-back mounted for increased safety, often used in stage machinery.
- Noise reduction options include a plastic coating for the rotor splines and damping elements to cut out impact noise between the armature and the stator.

Further advice on sizing and installation

Spring applied brakes are established products and a high volume of knowledge on selection and installation is in existence. Particularly for performance-critical and safety sensitive applications, advice should be sought from specialists.

Contact us by email: sales@techdrives.co.uk or by telephone: 01234 753201.