The Carlyle Johnson Machine Company, LLC

Maxitorq® Torq-Lok® Mechanical Bi-Directional Clutch

Technical Paper

1 Introduction

1.1 About Carlyle Johnson

Carlyle Johnson manufactures clutches, brakes, torque limiters, overload release clutches, fail-safe brakes, and power take-off packages for many applications. Electric, mechanical, pneumatic, and hydraulic powered clutches and brakes are available. From submarines to the Space Shuttle; military armored vehicles to commercial aircraft; machine tools to medical devices; packaging machines to printing presses; oil drilling equipment to rocket launchers; and hundreds of other applications where power-transmission equipment is installed, Carlyle Johnson Maxitorq® clutches and brakes provide long-life and trouble-free service. Original Equipment Manufacturers have known for over 100 years that their products will perform better and more reliably if Carlyle Johnson Maxitorq® power transmission components are specified.

This document deals with the model MTL mechanical “drive thru” bi-directional clutches. Similar devices are sometimes referred to by the name “no-bak”. The Carlyle Johnson MTL clutch performs the same function, but it has the additional feature of being bi-directional. It is referred to by the trade name “Torq-Lok®”, a family of devices which can handle torque from as little as 1 lb-in to over 1,000 lb-ft. Many special designs have been created to solve specific problems for our customers.

Maximum life of MTL clutches can be achieved with careful attention to size, installation, and application. This publication details the technical characteristics of the Maxitorq® model MTL bi-directional clutch. Engineering and applications personnel at Carlyle Johnson are always available to provide additional data, assist in applications, and suggest solutions to unique or difficult power transmission design problems. You may contact the factory toll-free at 1-888-MAXITORQ (1-888-629-4867) between 8:00 A.M. and 5:00 P.M. Eastern Time, during normal workdays, for technical assistance, pricing, and delivery information.

1.1 How to contact Carlyle Johnson

Carlyle Johnson may be reached from 8:00 A.M. to 5:00 P.M. in the Eastern Time Zone of the United States, during normal workdays.

Telephone: 1 - (860) 643-1531 Option “3” SALES then select from the following:

Option “1” for Spare Parts
Option “2” for Applications Engineering
Option “3” for Government and Aerospace products
Option “4” for International Sales

Toll-Free: 1 - (888) 629-4867 (1 - 888 - MAXITORQ) - same options as above

Internet: http://www.cjmco.com

E-Mail: maxitorq@cjmco.com

Mail: 291 Boston Turnpike, PO Box 9546, Bolton, CT 06043-9546

FAX: 1 - (860) 646-2645

2 History of No-bak type Devices

2.1 Carlyle Johnson's No-bak Expertise

The Carlyle Johnson Machine Company has experience in the design and application of no-bak devices as far back as the mid 1980s. New concept no-baks were developed at that time in response to the problems associated with 'wrap-spring' type designs, but the programs did not lead to significant technical breakthroughs and the effort was not pursued. The specific application addressed was on a military armored vehicle, where wrap-spring no-baks had a high field fall-out rate due to the inability of the unit to sustain torsional shock loading, excess torque, heat, contamination and shaft loading. This loading occurs during normal operations when a mechanism starts and stops or when a device is placed in a situation where the motion of a lift is inhibited by some external factor (such as contact of an artillery cannon barrel with a tree during traverse or elevation).

Our no-bak research efforts were restarted with a new approach utilizing ball cams in 2003, in response to a unique customer requirement. It was internally funded with company research and development monies. This IR&D program has led to the development of a new type of no-bak for which a United States Patent (Number 6974015B2) has been issued. Prototype and demonstration pieces were produced and full production began in late 2003 for military as well as other commercial applications. Our name for this device is "Mechanical Drive-thru Bidirectional Clutch", or "Torq-Lok®".

Our design approach offers additional features that were not available in traditional designs. The Torq-Lok® utilizes a series of ball ramps, and a friction disc similar to that in a standard friction clutch. The unit can sustain substantial torque overload and torsional shock loading with no damage. The level of overload capability can be 'designed in' and is determined based on the specific application. The use of a friction disc for locking the device ensures smooth rotation on the input side regardless of the direction of load - it is ratchet free.

2.2 Traditional No-bak Designs

There were traditionally three types of one way bi-directional clutches on the market, commonly referred to as "no-bak" devices.

The original design of a no-bak was a wrap-spring device developed by an aerospace manufacturer, for the control of slats and flaps on aircraft. Their use prevented wind forces on the flaps or slats from driving the devices backward and changing deployment position in flight. While this has been a successful design, it is capable of handling only limited torque and cannot withstand shock loading. To work properly, the unit required a second device to insure positive locking, or a torque limiter to absorb any shock or pulse loading which might occur in the system. These additional devices add complexity, cost, weight, and size to the overall mechanism. Complexity also affects predicted reliability; however if these additional devices were not present, the wrap-spring type no-bak may not be dependable or have a long life in service. Experience with the military armored vehicles has borne this out, with high field failure and replacement rate.

A second design option was the ‘locking wedge’ concept, and the designer of this concept coined the term (and original trade name) “No-Bak”. This device is operated by a wedging effect between a center locking bar that was offset from the centerline of the clutch. The design was popular in the 1950’s and 1960’s, but in severe service the failure rates were very high, often with catastrophic results. The center locking bar had sharp edges at both ends and two points of contact, to wedge into a stationary ring. The ring would deform over time, and the edges would ‘peen’ over, resulting in a non-locking device. This device has a short life expectancy and required frequent field replacement. It is not suitable where risk of injury is present, such as in a manual override device where back-driving from a motor could cause serious injury to the operator if the “No-Bak” were to fail during operation.

The third type of no-bak device is the use of sprag devices. Two standard one-way sprag clutches are placed in series with a driving mechanism between them, to unlock when driven from one side. There are several problems with this design. The sprags are constantly forced from a locking to an unlocking position when the operator (in a manual override) attempts to drive the input in the same direction as the load on the output shaft. The result is chatter or ‘ratcheting’ of the load as it is lowered, which is unacceptable.

2.3 Carlyle Johnson’s New Design

The Carlyle Johnson Machine Company has developed a new type of one way bidirectional clutch (“no-bak”) that incorporates several unique and desirable features not available with traditional design no-bak type devices. This design utilizes a friction disc to establish the locking torque. The disc is clamped and unclamped through a ball/cam arrangement. The friction pad, which is rigidly mounted to the locking disc with an integral cam, is forced into contact with the end cap by the normal force developed by a bias spring. This frictional force produced by the camming action is sized to be always greater than the torque applied to the output. The output will therefore not turn when force is applied.

When the input shaft with its integral locking cam is rotated in either direction with sufficient torque (any torque greater than that which is applied to the output shaft with its integral locking cam), the cam surfaces on the input shaft with its integral locking cam, and the floating locking cam are moved into contact, lifting the friction element from the stationary locking position, and torque is transmitted.

This proprietary and patented design incorporates a standard friction disc to achieve lockup that is reliable, long-lived, and smooth operating. In addition, variations of the design can result in a device where slip is allowed, but only after a pre-determined level of torque is applied.

2.4 Prototype Development

The Carlyle Johnson Torq-Lok® technology was proven in engineering prototypes, and in military applications where an artillery cannon could be raised and lowered electrically, and overridden manually when required - for example in the event of power or motor failure. Sample devices have also been built for demonstration purposes and are available for customer review and evaluation. The Model MTL Torq-Lok® clutch features a ball cam/friction disc system that can be configured to meet the backlash and torque requirements of almost any application.

The cam design also ensures that the device does not lock up and prevents the balls from becoming wedged in the cam during an overload. The floating spring plate and cam surface are designed to establish the critical point of either slip or lock, as required for the particular application. The design can be such that locking continues to occur until a specified overload point is reached. The result is that the device will not jam or break under any overload condition. This design is unique in the no-bak market.

The prototype was tested up to 300 lb-ft. The first production units are also rated for 300 lb-ft. A smaller no-bak for other applications has been designed with different cam paths and springs. The friction facing is made from the same material, but its diameter is decreased. The biased spring in the no-bak can also be changed from a wave spring to a Belleville spring. The major design issues in applying the Torq-Lok® are cam path design, torque and overload safety factors. The development effort undertaken at Carlyle Johnson allows us to determine the exact parameters for any application.

3 **Typical Applications**

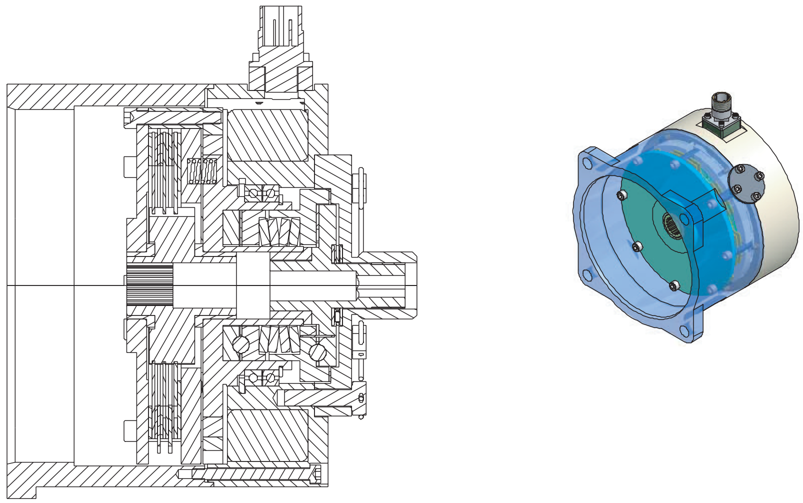
3.1 Model MTL Torq-Lok® as a Holding Brake and Bi-Directional Clutch

Model MTL Torq-Lok® clutches (known as type MTL-B) can be used as holding brakes, where little or no dynamic braking is required. This is generally the condition when coupled to a spring-set clutch and used as a manual override in a powered device. The system must be stationary and “at rest” before the spring-set clutch is de-energized (engaged).

When power is available and supplied to an electric motor, the spring-set clutch is energized (disengaged), allowing the motor to power the device in either direction. During a power failure, or when power is removed from the motor and the spring-set clutch, the clutch engages due to its internal springs, the motor is de-energized, and the clutch dynamically brakes the system since the spring-set clutch is locked by the Torq-Lok®. The Torq-Lok® clutch then allows manual override in either direction, by turning the input shaft. The Torq-Lok® clutch prevents back-drive through the motor/clutch/brake to the operator, but allows the operator to drive the load without ratcheting (for example in the case of lowering the barrel of an artillery cannon manually). In this application, the Torq-Lok® clutch acts as a holding brake whenever the operator stops driving the load through the manual override.

The only torque required to manually drive the device is a force in excess of the torque produced by the load being held by the Torq-Lok® device. With careful design and analysis, a well-balanced system can require very little manual effort to drive, and still prevents back drive through the system.

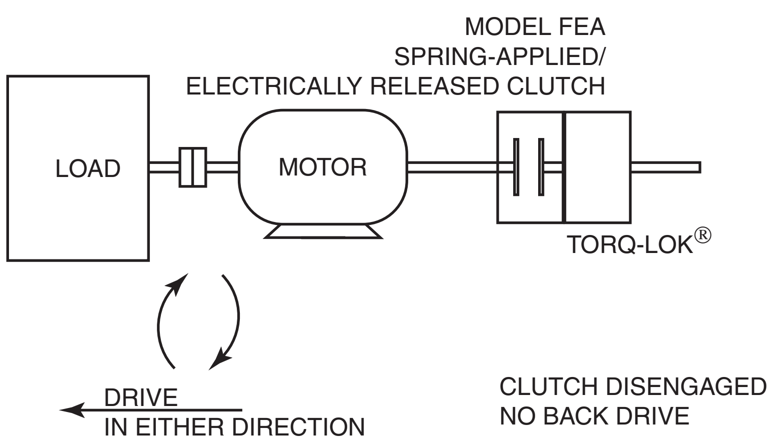
Figure 1 below shows a typical manual override design which is in current production.



Model FEA 550 Spring-set Clutch
with integrated Torq-Lok® Bi-directional Clutch

Figure 1

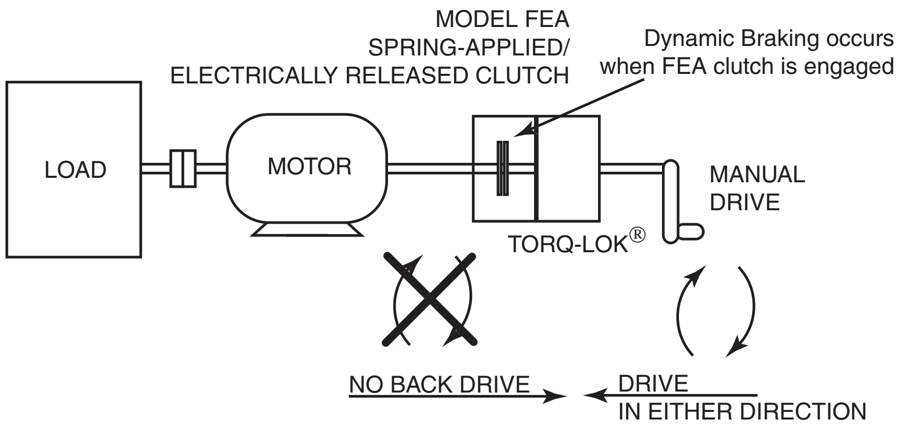
The schematics in Figures 2 and 3 below show how the Torq-Lok® permits only one-way operation and prevents back-driving.



Load Driven by Motor: FEA Spring-applied/Electrically Released Clutch Disengaged

Figure 2

In this mode, the motor and clutch are energized. The Torq-Lok® is disengaged from the system.



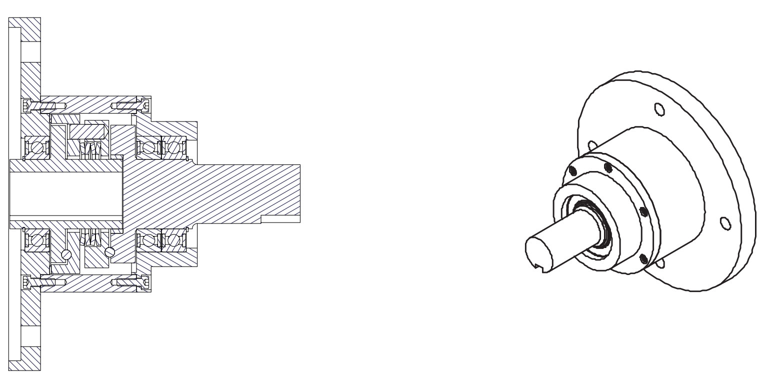
Motor and FEA Spring-applied Clutch De-energized
Manual Override through Torq-Lok® Drives Load

Figure 3

3.2 Model MTL Torq-Lok® as a Drive-thru Bi-Directional Clutch and Stopping Brake

Model MTL Torq-Lok® clutches (known as type MTL-S) can be used as stopping brakes, where dynamic braking is required to stop a device during power failure, or in an emergency or overload condition. In applications of this type, the load is driven by a motor or other drive through the Torq-Lok® device. As long as the input or driving force produces torque in excess of that required to move the load, motion in either direction will be transmitted through the mechanism.

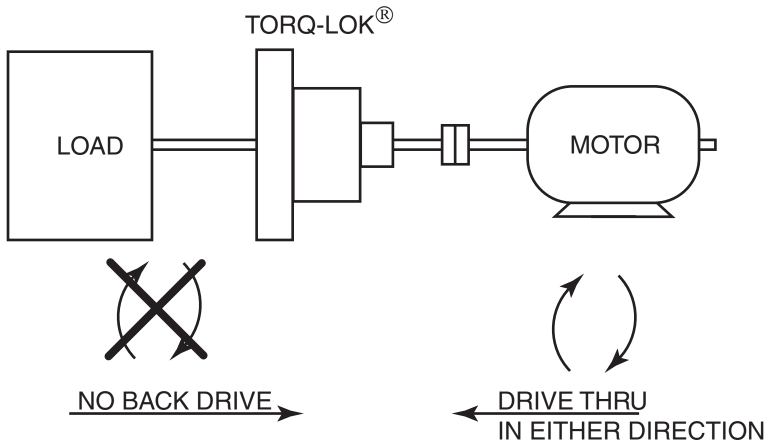
When power is removed from the input, any back-drive from the driven device will cause the Torq-Lok® unit to lock and hold the load. An example of this type of application would be a electric motor driven escalator, or a conveyor. If there were a power failure, or an emergency shut down of the drive, the Torq-Lok® clutch would lock and prevent any escalator or conveyor movement until power was reapplied to the input shaft. In the case of a product conveyor, the Torq-Lok® clutch would be used in normal stops as well, regardless of the incline or load attempting to 'back-drive' the conveyor. Even in this type of application, a manual override would be possible by connecting a crank or similar device to the motor and turning it manually, provided sufficient manual effort could be generated to move the load



Torq-Lok® Bi-directional Clutch and Stopping Brake

Figure 4

The schematic in Figure 5 shows the Torq-Lok® as a stopping and holding brake when power is removed from the driving device.



Motor Drives Load through Torq-Lok®
No Back-drive Possible if Motor De-energized
Torq-Lok® acts as Stopping and Holding Brake

Figure 5

3.3 Model MTL Torq-Lok® as a Torque Limiter

The Torq-Lok® Bi-directional clutches can also be used as torque limiters. By properly sizing the braking capabilities of the unit, the device can be designed to initially “slip” rather than immediately “hold” a load. This can be a useful feature if it is necessary to gradually dissipate energy during a stop using the dynamic braking capabilities of the brake.

When applied as a holding brake, the Torq-Lok® brake will lock up immediately when power is removed. As a stopping brake (for example when driving a conveyor), it is frequently desirable to decelerate the load gradually in order to prevent the high stresses associated with too-rapid braking.

4 Design Guidelines

4.1 Dry vs. Oil Bath

Model MTL Torq-Lok® Bi-directional clutches can be run either dry or in an oil bath. If run in oil, the oil must not contain any extreme pressure additives. Extreme pressure additives will degrade the ability of the unit to prevent back drive.

The use of ATF oils such as Dexron II® are recommended for oil-bathed applications.

4.2 Constant-slip Applications

Maxitorq® Torq-Lok® Bi-directional clutches are not designed to be run in constant-slip applications, whether run dry or in oil. Although the friction surfaces are synthetic and have a very long service life, the heat generated in constant slip will degrade them rapidly, and cause the units to fail.

4.3 Efficiency

Torq-Lok® clutches are highly efficient. When driving through the device, the input and output shafts are mechanically linked, transmitting essentially 100% of the torque through the unit with little frictional losses.

4.4 Mounting

Carlyle Johnson can supply Torq-Lok® units with adapters for mounting directly on the housing of a motor, or the brake can be mounted to a stationary surface. However mounted, they must be accurately positioned so that the shaft of the Torq-Lok® Bi-directional clutch is precisely perpendicular to the mounting surface. Misaligned or improperly mounted brakes will accelerate wear on internal components and will not provide acceptable service life.

The proper hardware and the proper tightening torque must be used to secure the brake. Loctite® must be used in high-vibration applications. We recommend the use of Loctite® in all mounting hardware to prevent loosening during operation.

4.5 Backlash

When Maxitorq® Torq-Lok® Bi-directional clutches are used in holding applications, there will be a small amount of backlash prior to the unit achieving a “locked” holding position. This occurs because of the behavior of the ball-ramp design, where the back-drive moves the balls up a ramp, driving the friction braking surfaces against the stationary end cap.

In normal holding applications, there will be up to 10° of ‘lost motion’ or backlash when power is removed, before the output shaft is stationary and the load begins to be held by the brake. Total backlash will be a function of the holding torque. Custom brakes can be designed with lower backlash for applications where minimal backlash is required.

In stopping applications, the output shaft will continue to rotate until the energy of the driven load is dissipated to a point where the braking capability of the Maxitorq® Torq-Lok® clutch exceeds the torsional loading resulting from the inertia of the rotating parts, thereby allowing the brake to lock the output shaft.

5 Operating Parameters

5.1 Torque Ratings

Special designs have been completed to meet specific customer requirements. Our Engineering staff can create a design for your unique custom application depending on the capabilities you require. Typical applications include torque capabilities from 1 lb-in to 1,000 lb-ft.

Care must be exercised in not oversizing the Maxitorq® Torq-Lok® Bi-directional clutch applied to an application, particularly where a stopping brake is being applied. As the size of the brake increases, its braking capability increases. An oversized unit will cause a very abrupt and violent stop if its torque handling capability significantly exceeds the actual load.

In the case of a holding brake application, this factor is less important, but excess capability increases cost and does not provide appreciable additional benefit to the system.

5.2 Cycle Rate

Maxitorq® Torq-Lok® clutches may be used in applications requiring frequent starting and stopping, but they must be sized carefully to give satisfactory service. In uses like film payout or web applications, placing the brake downstream of a gear reducer will generally yield better results than if the brake is placed on the high-speed motor side of the mechanism.

Proper sizing is important to be sure adequate heat dissipation capability exists, and to prevent the device from being in a condition approaching constant slip.

5.3 Rotation / Speed

Torq-Lok® units may be used in high-RPM applications when used as holding brakes (provided little or no dynamic braking is present in the mechanism). Higher speed devices can be designed for custom applications which may require special bearing designs and different materials of construction. Contact the factory for Engineering assistance on high-speed environments.

Brakes used for dynamic braking are sized differently, and have different maximum speed limits. Exceeding the recommended RPM range for these brakes will accelerate the wear of the friction pads (or in more serious overspeed conditions damage them quickly) due to the heat load of braking. Contact the factory for assistance in solving high-RPM dynamic braking applications.

5.4 Alignment

Depending on the type of Torq-Lok® required, the factory will supply specific specifications for alignment requirements.

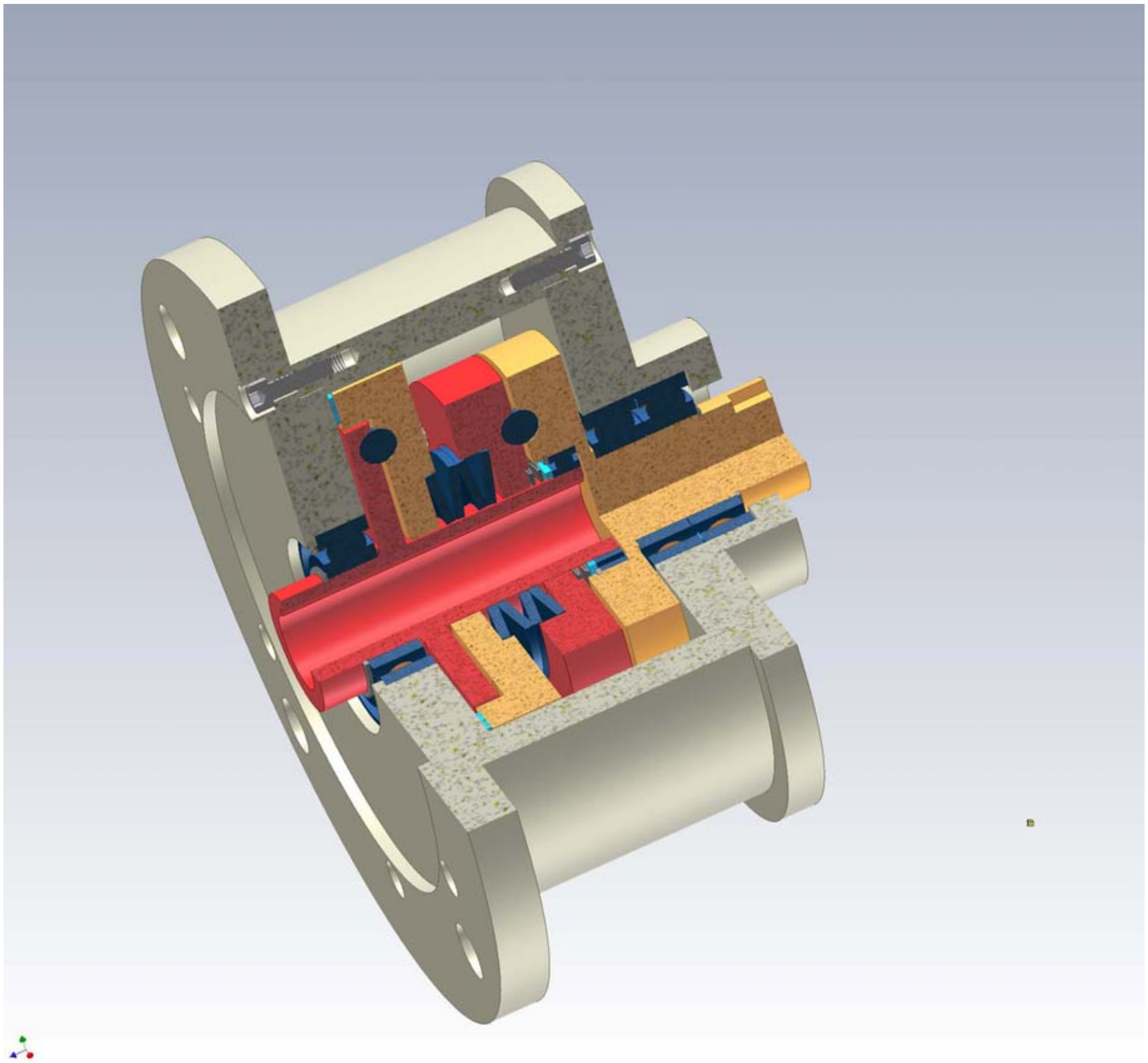
If necessary, Carlyle Johnson can design custom Maxitorq® Torq-Lok® units which can be directly mounted on a customer's motor or other shaft, thus minimizing most alignment issues.

5.5 Clutch / Brake Packages

When applied as a manual override device, the use of a Carlyle Johnson Model FEA Spring-Applied clutch is recommended. Parameters for selecting the proper FEA clutch are contained in Carlyle Johnson Bulletin 95 "Spring Applied Electric Multiple Disc Clutches and Brakes".

Model FEA Spring Applied clutches are engaged when power is "off". In this type of application, the clutch is energized in parallel with the motor, so that energy is applied to both devices simultaneously. Power to the FEA clutch magnetically compresses the engagement springs, disengaging the clutch from the brake and allowing the motor to power the application. When power is removed from the motor and FEA clutch, the clutch engages and dynamically brakes the motor and inertia load, because the output of the clutch is coupled to the Maxitorq® Torq-Lok® clutch. The manual override is then coupled to the output shaft.

Most Maxitorq® Torq-Lok® applications are custom designed to fit particular power transmission devices. Design engineers at Carlyle Johnson are always ready to assist you in recommending solutions for your power transmission problems. Contact us for immediate support.



Maxitorq® Torq-Lok® Clutch (Cut-away View)

Figure 6