BULLETIN NO. M-103-A

"SC" OPERATION AND CONSTRUCTION

AIRFLEX MAGNETIC CLUTCHES

EATON PowerTransmission Systems

BULLETIN NO. M-103-A

OPERATION AND CONSTRUCTION-AIRFLEX MAGNETIC CLUTCH

The Airflex Magnetic Clutch is a stationary field, multiple disc clutch actuated by electromagnetic force and designed for operation in either a dry or oil atmosphere. This clutch is completely assembled, adjusted and run-in at the factory. The customer need only mount the clutch on the power input member and the driven gear on the power output member. After connecting the coil leads to the proper D.C. power source, the unit is ready for operation.

The stationary field is aligned by a precision ball bearing. This stationary field eliminates the need for collector rings and brushes, thus doing away with all the mounting and service problems associated with them.

The Airflex Magnetic Clutch is designed to be used in either an oil or dry atmosphere. Where high cyclic rates and heavy loads are encountered, and where wear must be minimized, operation in oil is recommended.

The response of the Air-flex Magnetic Clutch is rapid and smooth even when operating at high cyclic rates. In addition, both torque and response time are consistent.

Normally, the high inertia portion of the clutch (the clutch body) is mounted on the power input member and the very low inertia portion of the clutch (driven gear and friction discs) is mounted on the power output side. Where circumstances warrant, this mounting can be reversed, but the application should be approved by the Airflex Magnetic Engineering Department. For further information on mounting and installation, refer to Bulletin M-103-B.

Standard Airflex Clutches are designed to operate on direct current at 90 volts. Normally, this is obtained by rectification of 110 volts A.C. power. Clutches can be provided for most any D.C. voltage if required.

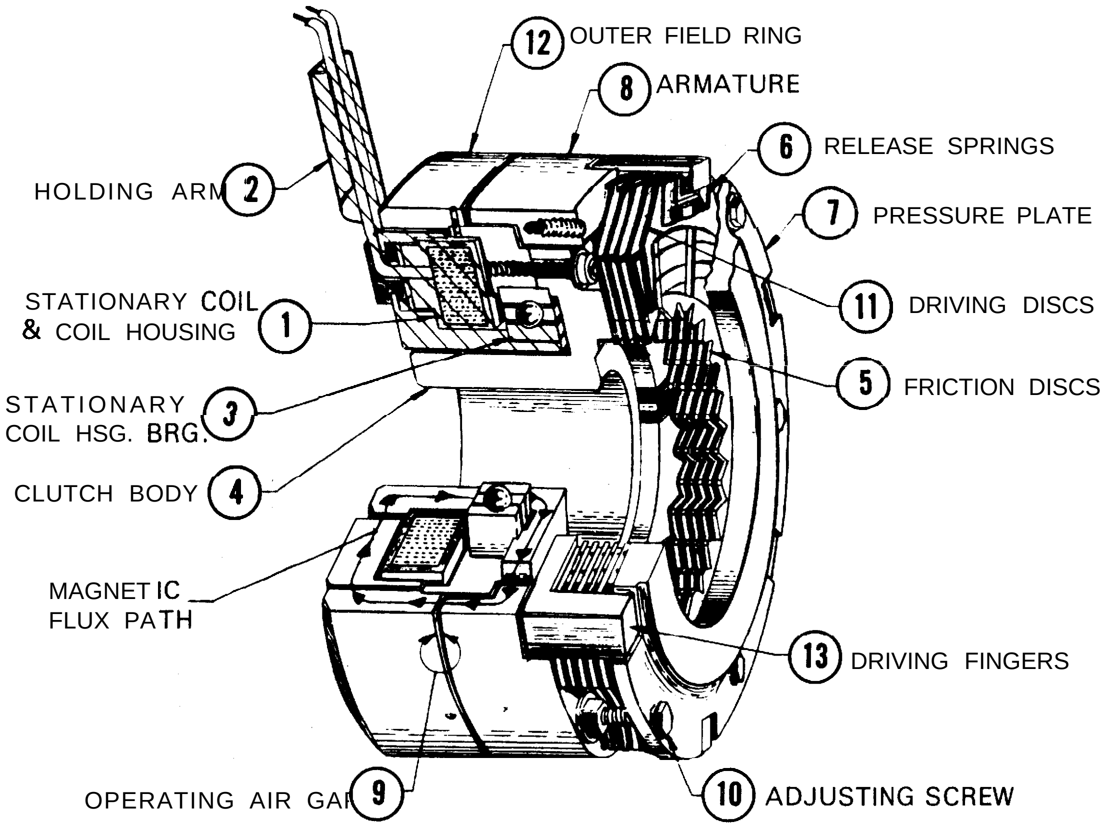


Figure 1A - Airflex Magnetic Clutch

PRINCIPLE OF OPERATION-AIRFLEX MAGNETIC CLUTCH

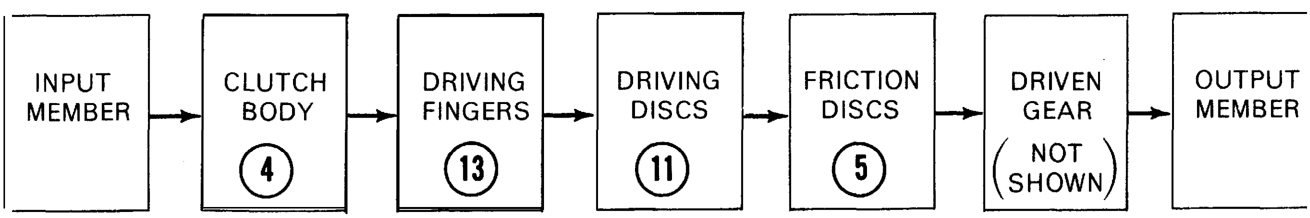
The principle of operation of the Airflex Magnetic Clutch is not difficult to understand. Fundamentally, flat steel “driving discs” are rotated by the power input through the “clutch body”. The sintered bronze “friction discs” are connected to the power output through the “driven gear”. When the coil is energized the friction discs are compressed between the driving discs thus coupling the output to the input.

To be more specific, refer to Figure 1A. The cross sectioned portion of the clutch [stationary coil and coil housing (1), holding arm (2) and the inner race of the coil housing bearing (3)] are stationary at all times. The clutch body (4) is keyed to the input member and rotates with it. Rotation of the clutch body causes rotation of all parts of the clutch except the friction discs (5) (when the coil is de-energized).

WHEN THE COIL IS DE-ENERGIZED and no magnetic flux flows, the release springs (6) separate the driving discs and move the pressure plate (7) and armature (8) to the right, opening the operating air gap (9) to its maximum open position, Note that the armature (8) and pressure plate (7) are mechanically connected by the adjusting screws (10). The friction discs (5) thus float freely between the driving discs. The friction discs are connected to the output by means of the driven gear (not shown) the teeth of which engage like a spline in the friction disc teeth.

WHEN THE COIL IS ENERGIZED a magnetic field is set up and magnetic flux flows around the path shown. The magnetic field causes the armature (8) to be attracted to the outer field ring (12). The armature moves to the left reducing the operating air gap (9) to its normal operating position. When the armature moves to the left, the pressure plate (7) also moves to the left because these parts are connected by six adjusting screws (10). The disc pack (driving discs and friction discs) are thus squeezed between the pressure plate (7) and the inside face of the clutch body (4). When the friction discs are compressed between the driving discs, they must rotate with the driving discs and the input torque will be transmitted to the driven gear and thus to the output member.

The “Torque Flow” is thus:



The following design features should be noted:

(1) Because the disc pack is compressed between the pressure plate and the clutch body, no thrust is imposed on the input or output shaft. In addition, no thrust is imposed on the coil housing bearing.

(2) The only load on the coil housing bearing is that due to the weight of the stationary coil housing assembly.

(3) Because the release springs positively separate the driving discs, the friction discs float freely when the clutch is de-energized and the residual torque is very low.

(4) Because the flux path is completely isolated from the disc pack, magnetic attraction between the plates is completely eliminated. This results in rapid disengagement and minimum residual torque.

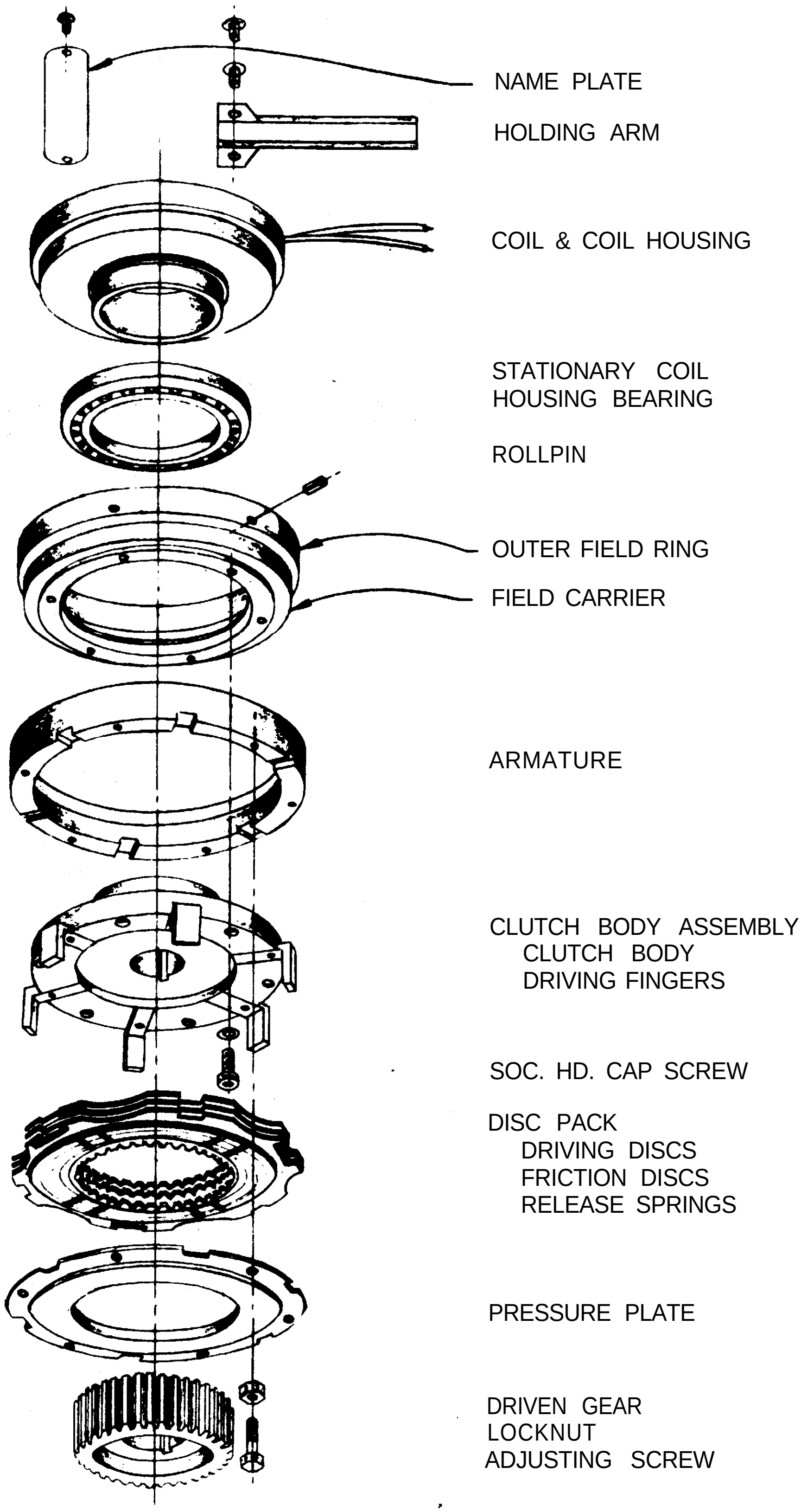


Figure 1B - Exploded View of Airflex Magnetic Clutch

CONSTRUCTION - AIRFLEX MAGNETIC CLUTCH

Figure 1B and the following paragraphs describe the quality components which go to make up the Airflex Magnetic Clutch. This description will help the designer who incorporates this clutch in his machine, gain a better understanding of the operation and application of the clutch.

Referring to Figure 1B and starting from the top:

The Name Plate identifies the clutch size, coil voltage, coil current and serial number of the clutch.

The Holding Arm provides the means for restraining the rotation of the stationary coil assembly as well as providing protection for the coil leads.

The Coil is wound with copper magnet wire and is completely encapsulated in a high temperature, high strength epoxy resin, making it completely impervious to oil, water and all other contaminents.

The Coil Housing is made of high quality magnetic iron and the coil is secured in the housing by means of a high temperature, high strength epoxy adhesive. As seen in Figure 1A, the coil housing forms part of magnetic-flux path.

The Stationary Coil Housing Bearing is a precision made retainer type ball bearing and is provided with a non-magnetic retainer.

The Roll Pins are used to secure the outer field ring to the outer field ring carrier.

The Outer Field Ring is made of high quality magnetic iron and forms part of the magnetic-flux path as shown in Figure 1A.

The Outer Field Ring Carrier is non-magnetic and hence directs the flow of the magnetic-flux around the bearing and through the armature and outer field ring. Mechanically, it secures the outer field ring to the clutch body and serves as a housing for the coil housing bearing.

The Armature is made of high quality magnetic iron and forms part of the magnetic-flux path. It is the armature which draws the pressure plate against the disc pack (by means of the adjusting screws) creating the compression necessary to transmit torque.

The Clutch Body is made of high quality magnetic iron and forms part of the magnetic-flux path. The clutch body is keyed to the power input shaft.

The Driving Fingers are pinned and peened to the clutch body. They are made of forged steel and case hardened (58-60 Rockwell “C”) to resist wear from the driving discs. It is the driving fingers which transmit the torque from the clutch body to the driving discs in the disc pack.

Socket Head Cap Screws secure the outer field ring assembly to the clutch body

The Driving Discs are made of high carbon steel, are hardened and worked to a smooth, low micro-inch finish. Flatness is closely controlled.

The Friction Discs are composed of a steel core with a sintered bronze friction surface bonded to each side. The friction surfaces are grooved to provide rapid engagement and disengagement of the clutch when operated in oil. The inside diameter of the friction discs are cut with standard 20^{o} pressure angle AGMA stub involute gear teeth which engage the teeth on the driven gear. Flatness is closely controlled.

The Release Springs are made of spring steel and act to positively separate the driving discs when the clutch is de-energized. This positive separation results in very low residual torque. In addition, the release springs aid in rapidly disengaging the clutch when the clutch is de-energized.

The Pressure Plate is made of steel and the flatness and surface finish of the inside face is closely controlled. The pressure plate compresses the disc pack when the clutch is energized, thus producing torque output.

The Driven Gear is made of steel and is hardened to 30 Rockwell "C". The gear is cut with 20^{o} pressure angle AGMA stub involute gear teeth which fit into the internal teeth in the friction discs. The ends of the teeth are chamfered by "fly cutting" to facilitate the insertion of the driven gear in the friction discs. One face of the standard gear is counterbored to provide for clearance for snap rings or shaft shoulders used to restrict axial movement of the clutch body and driven gear.

The Locknuts for the adjusting screws are provided with an integral lockwasher and are specially heat treated. The locknuts are located between the pressure plate and the armature and are tightened down against the armature.

The Adjusting Screws are heat treated steel screws with a hex. head. The threads are national fine with a Class Three fit.

ASSEMBLY - AIRFLEX MAGNETIC CLUTCH

Normally, all clutch repair work (except disc pack replacement) should be done at the Airflex plant; however, there are occasions when some limited repair work must be done in the field. The following brief description of the factory assembly procedure will be an aid on these occasions. In addition, reading this assembly procedure will help one gain a better understanding of the Airflex Magnetic Clutch.

Referring to Figure 1B, the coil is cemented into the coil housing and the holding arm is secured in place. The outer field ring carrier is pressed into the outer field ring and the two are thus pinned together to form a permanent assembly. The stationary coil housing bearing is then pressed into the field ring carrier (applying the pressure on the outer race) and this assembly group is then pressed on to the stationary coil housing (applying the pressure on the inner bearing race). This bearing, outer field ring carrier and outer field ring are held on to the coil housing by staking the edge of the coil housing adjacent to the bearing inner race. (On the two largest sizes of clutches, a snap ring holds the inner race of the bearing on the coil housing.)

The clutch body assembly is made by securing the driving fingers to the clutch body. The driving fingers are pinned to the body and then firmly peened in place.

The armature is slipped on to the clutch body assembly and the entire coil housing assembly is pressed on to the clutch body assembly and secured by socket head screws which go through the body and thread into the tapped holes in the outer field ring carrier. The outer race of the coil housing bearing pilots into the clutch body.

The release springs are placed on the proper driving disc (see below) and the driving and friction discs are assembled to the clutch body. The pressure plate, adjusting screws and locknuts are then assembled to the clutch and the adjusting screws are threaded into the armature. The air gap is then adjusted as shown in the Maintenance and Service Instruction Bulletin M-103-C.

The release springs are a small, but very important part of the clutch assembly. Correct installation of these springs is important for good clutch operation. Figure 1C illustrates a typical release spring and Figure 1D illustrates the correct method of installing the release springs on the driving discs.

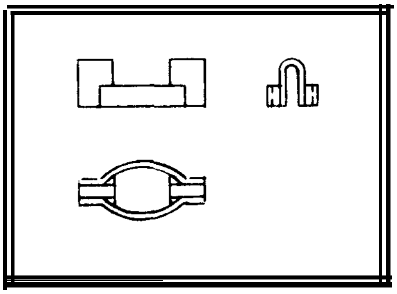
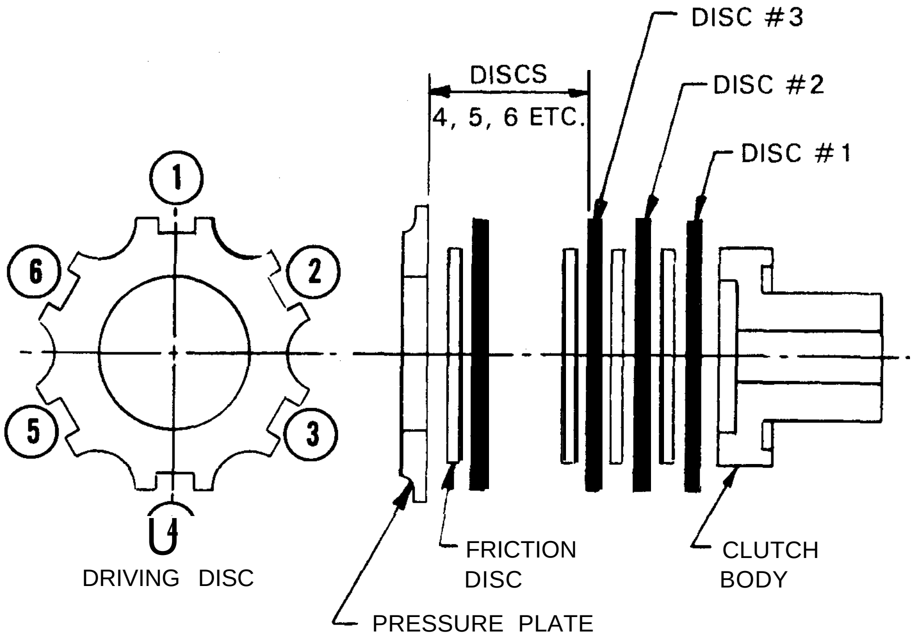


Figure 1C
Release Spring



SPRING LOCATION & ASSEMBLY ORDER FOR DRIVING DISCS									DRIVING DISC	FRICTION DISC	NO. SPRINGS
USED ON	DISC #1	DISC #2	DISC #3	DISC #4	DISC #5	DISC #6	DISC #7	DISC #8			
SC-225 SC-275	——	1-3-5	——	1-3-5					4	4	6
SC-325 SC-375	——	1-3-5	——	1-3-5	2-4-6				5	5	9
SC-450 SC-550	——	1-3-5	——	1-3-5	——	1-3-5			6	6	9
SC-650 SC-775 SC-825	——	1-3-5	——	1-3-5	——	1-3-5	2-4-6		7	7	12
SC-950 SC-1000 SC-1150 SC-1325	——	1-3-5	——	1-3-5	——	1-3-5	——	1-3-5	8	8	12

Figure 1 D-Release Spring Installation Diagram

In certain special applications requiring the best possible separation of the plates, a double set of springs can be provided. In this case, six springs per driving disc are used. When the clutch contains an odd number of driving discs, the last two discs can only have three springs each.

OPERATING CHARACTERISTICS-AIRFLEX MAGNETIC CLUTCH

The Airflex Magnetic Clutches have certain operating characteristics which make them particularly adaptable to modern machine drives. An understanding of these unique characteristics will help the designer to fully utilize the capabilities of this clutch.

Figure 1E illustrates the relationship between clutch current and clutch torque. As can be seen, throughout the operating range (and well above it) the torque output varies directly with clutch current. This characteristic, when properly controlled, can be used either to limit the torque output of a machine or to apply driving torque to a load in an automatically sequenced manner.

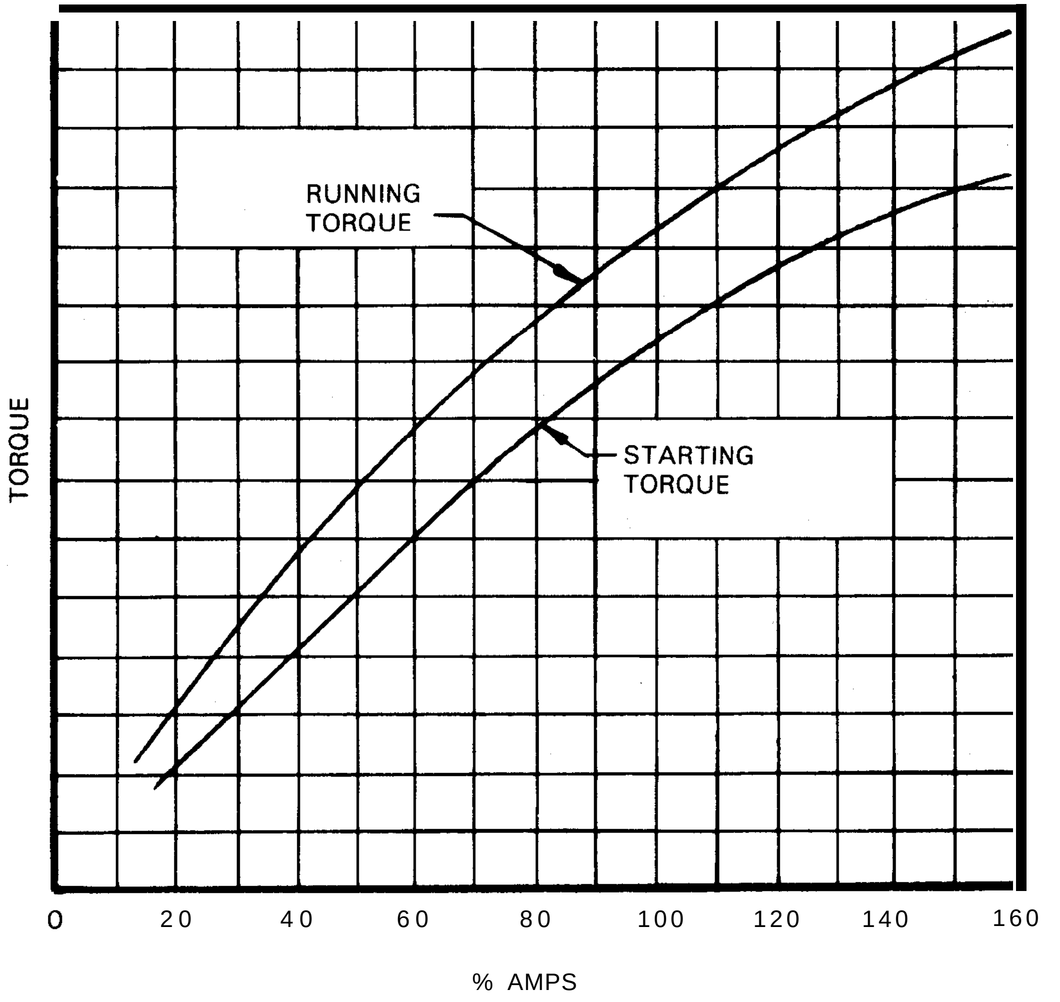


Figure 1E-Typical Curve of Torque vs. Clutch Current

The Airflex Magnetic Clutch exhibits this same characteristic when operated either in oil or dry.

Typical clutch time response is shown in Figure 1F. When the voltage is applied, the clutch current starts to build up. Because of the electrical inductance, the current builds up in an exponential manner. For a short period of time called the mechanical lag and marked as t_1, no torque is transmitted. When this time has elapsed, the torque builds up as shown. The torque decays in the time t_3.

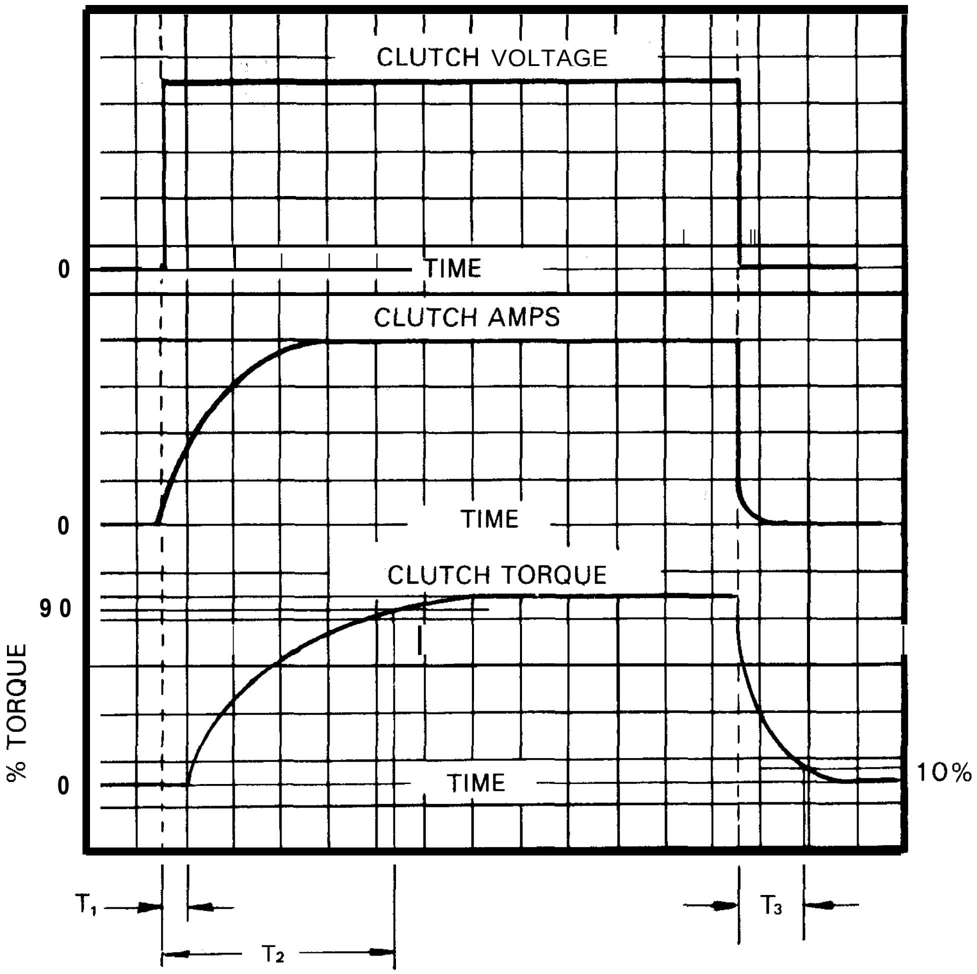


Figure 1F-Typical Clutch Response vs. Time

Generally speaking, the mechanical lag (t_1) is about 10% of the torque build-up time (t_2). Exact values of torque build-up time (t_2) and torque decay time (t_3) are to be found on Data Sheet MAL-171-2 in Bulletin M-103-E.

The time response of the Airflex Magnetic Clutch is both smooth and rapid; however, in applications involving cycle times which are extremely short, it is possible to speed the response time by the application of over voltage. Figure 1G illustrates how response time varies with voltage.

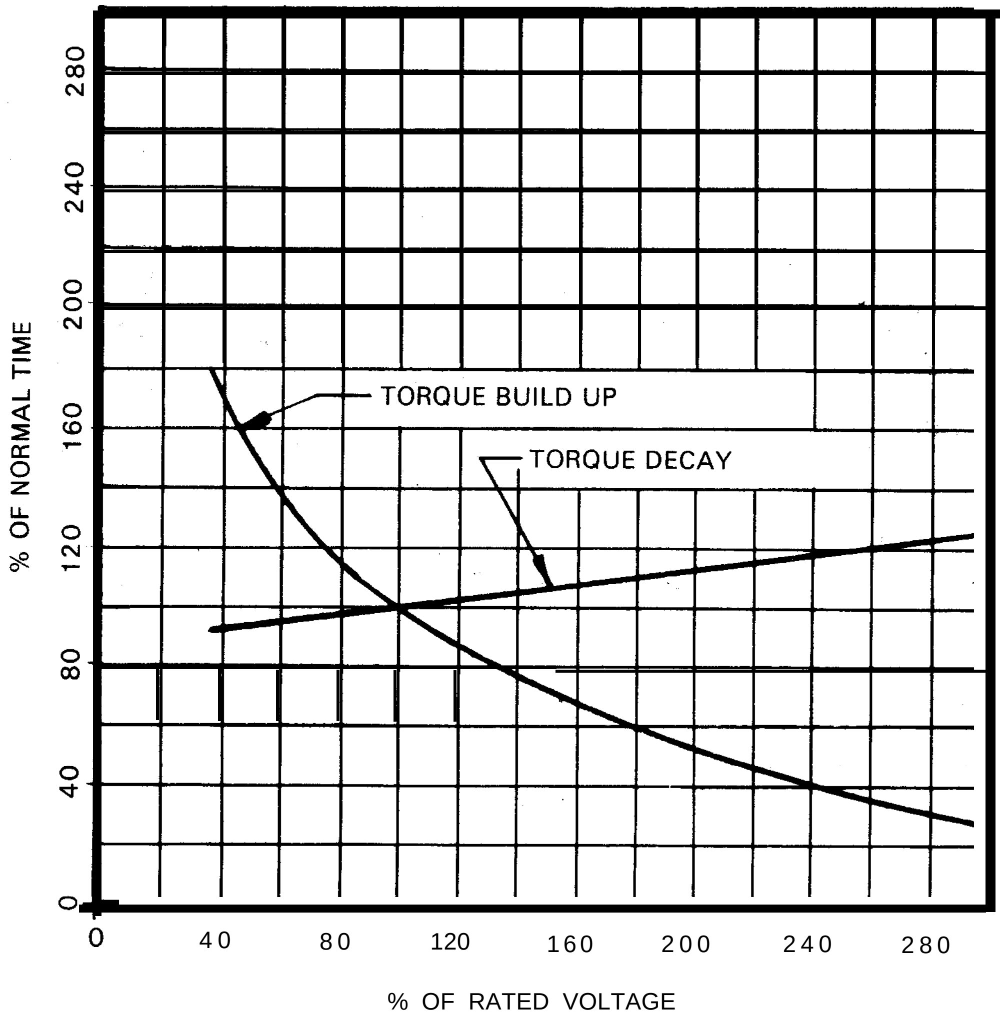


Figure 1G-Typical Response Time vs. Applied Voltage

Figure 1G shows response time up to 300% voltage. In some very special applications involving total cycle times of less than one second, the clutch coil can be wound for rather a low voltage and then as much as ten times rated voltage can be applied. Special applications such as these should be referred to the Airflex Magnetic Engineering Department for specific recommendations.

The setting of the operating air gap does have some effect upon the clutch characteristics. Figure 1H shows how torque varies with air gap. It can be seen that (with the clutch current held constant) the torque increases as the operating air gap is reduced and decreases as the operating air gap is increased. Note that at any setting of the air gap, the torque will vary with current as shown in Figure 1E.

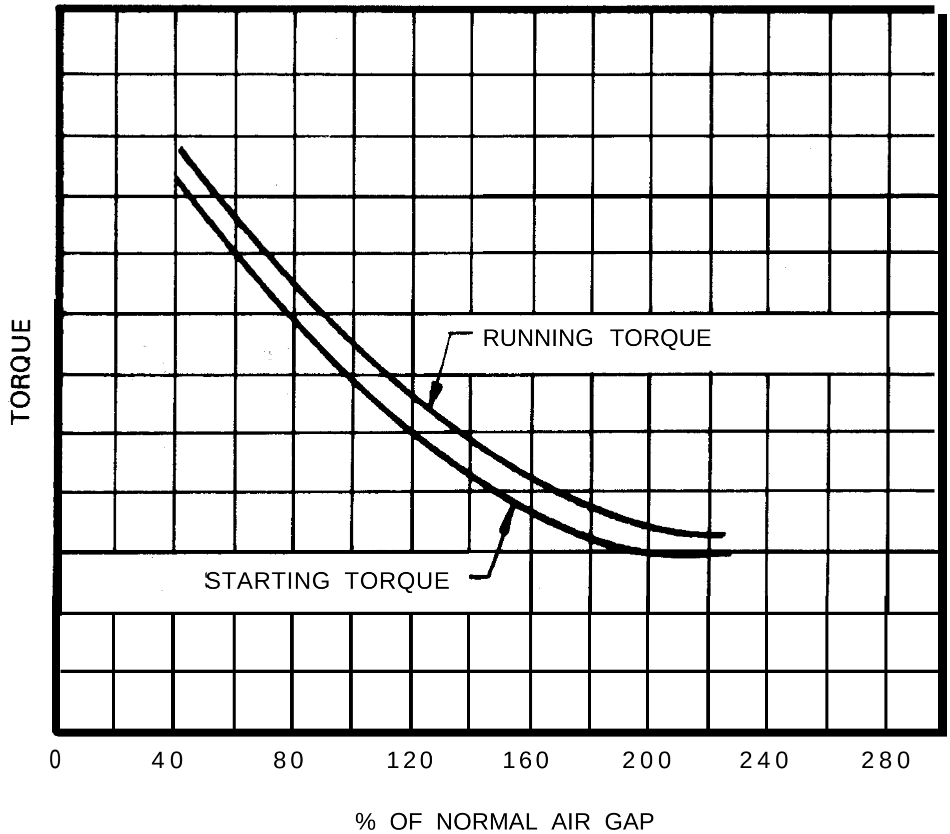


Figure 1H-Typical Curve of Clutch Torque vs. Air Gap

Clutch response time is only slightly influenced by the setting of the air gap. Torque build-up time increases slightly when the operating air gap is larger than normal and decreases slightly when the operating air gap is smaller than normal. Torque decay time does not change.

Because of the superior characteristics of the friction discs and steel discs, the torque that the clutch can transmit is not a function of speed; that is, the torque does not vary as the relative or slip speed of the friction discs and drive discs changes. Hence, in selecting a clutch to provide a certain amount of torque, the speed (within normal limits) need not be considered. In addition, the characteristics of the friction discs are such that the torque does not "fade". The friction discs are run in at the factory prior to shipment and the torque characteristics of the discs change negligibly during the life of the friction discs.

High operating temperatures will, of course, shorten the life of any clutch, hence adequate cooling by air or oil should be provided. Because the clutch coil is encapsulated in a high temperature epoxy resin, it can tolerate temperatures up to 120°C (248°F) without shortening coil life. The disc pack can also tolerate temperatures up to 200°C (392°F) without damaging the friction or steel plates. The clutches are also designed so that they can be energized continuously without exceeding allowable coil temperatures. Further information for calculating clutch heating is to be found in Bulletin M-l03-E Technical Data on Airflex Magnetic Clutches.

Call or write for additional information Eaton Corporation, Industrial Drives Division, 9919 Clinton Road, Cleveland, Ohio 44144.

Airflex®

Form ML-318
Revised September 3, 1997

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