

Warner Electric

Boston Gear

TB Wood's

Formsprag Clutch

Wichita Clutch

Marland Clutch

Industrial Clutch

Nuttall Gear

Warner Linear

Delroyd Worm Gear

Stieber Clutch

Ameridrives Couplings

Inertia Dynamics

Matrix International

Huco Dynatork

Bibby Transmissions

Twiflex Limited

Kilian Manufacturing

Ameridrives Power  
Transmission

# Electromagnetic vs. Pneumatic Clutches



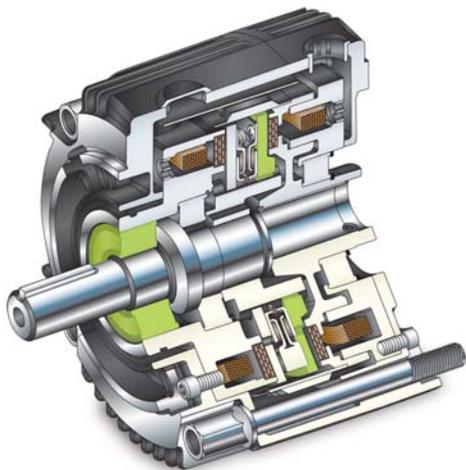
An Altra Industrial Motion Company

# Electromagnetic vs. Pneumatic Clutches

Po-tay-to, Po-tah-to, To-may-to, To-mah-to. A clutch is a clutch is a clutch; a brake is a brake is a brake... actuating medium does not matter. When designers are developing machine functions that include friction clutches and brakes, too many make the incorrect assumption that they can get pretty much the same performance and have the same cost from an electric clutch/brake as from an air unit.

For the majority of applications this simply is not true, there are differences and in some cases they are significant. These differences can be broken down into several categories: unit performance, total system installation cost, system operating cost and maintenance. There will be applications where unit performance is very similar between a pneumatic clutch/brake and an electromagnetic clutch/brake, but we will find that in many of these cases the operating and maintenance costs of the system are quite different. Or we may find that when installation costs are similar that performance will be rather different.

As a starting point, let's review the basic engagement method for the pneumatic clutch and the electromagnetic clutch. In the pneumatic design an actuator is used to apply pressure on the friction faces. When air pressure is applied the two friction faces are compressed together causing a clutch to drive or brake to stop. Generally these units are designed for full torque at 80PSI of air pressure. In an electromagnetic design, the pressure that clamps the two friction faces together is electro-magnetism. The most common voltage used for an electromagnetic unit is 90 volts DC, although other DC voltages are used routinely.



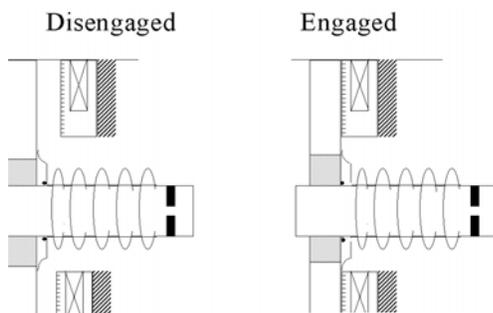
Warner Electric Heavy Duty Gen2 UniModule clutch/brake.

## Performance in Applications

For the average load in a common conveying application, an electromagnetic and a pneumatic clutch will perform quite similarly. At a cycle rate of 10-15 cycles per minute, presuming that air pressure and quality are constant, a pneumatic unit and an electric unit will have similar engagement and disengagement times.

For an indexing application where the load needs to be started and stopped at the same position on every cycle the performance will also be quite similar – for a while. The performance issue that comes into play on applications where cycling accuracy is important is adjustment for wear. All friction devices wear; this is a simple fact of life. How a unit adjusts for that wear is the key to long term performance, efficiency and perhaps profitability.

In pneumatic designs, as the friction faces wear, the air actuator requires a greater volume of air to achieve the same clamping force for the friction faces. Therefore the time from when the engagement switch closes to when the unit is fully engaged will increase as the unit wears. For one common manufacturer of pneumatic clutch/brakes the volume of air in the actuator will rise by 200-300% as the unit wears. In an electric design, an adjusting mechanism can be built into the design of the unit. This Autogap™ mechanism automatically adjusts for wear as it occurs. Thus, as wear occurs the engagement time remains constant.



Warner Electric patented Autogap™ automatically adjusts for wear.

For a wide number of applications consistency of engagement time over the life of a clutch/brake can be a key to protecting profitability. For example, a bag filling operation that is designed to meter out 12 ounces of product into a bag can be affected by variations of engagement time. If engagement time remains constant from cycle to cycle to cycle, then the amount metered into the bag will remain constant from cycle to cycle to cycle. However, if engagement time in the clutch/brake increases as wear occurs, the amount metered into the bag will increase as well. After a million cycles we may find 12.2 ounces, after two million cycles 12.4 ounces, etc. A 3% growth in product loss may be a significant factor in long term profitability.

### System Costs

The Department of Energy states

*“Compressed air is probably the most expensive form of energy in a plant”*

*“Compressed air energy can cost seven to ten times more than electrical energy when it comes to mechanical or process related work”*

(source: DOE [www.compressedairchallenge.org](http://www.compressedairchallenge.org))

A given system when new and used specifically as designed will be less efficient than an electrical system for the same work, but an air system can be efficient within itself when compared to other air systems. However, the vast majority of systems in industrial facilities have been modified and adapted to meet the changing needs of the factory. As a result, they lose their efficiency as complexity is added.

A compressed air system consists of:

- Air compressor
- Compressor motor
- Compressed air system controls (motor controls and load sharing controls between multiple compressors)
- Air inlet filters
- Compressor cooling
- After coolers
- Separators
- Dryers
- Piping
- Valves

These systems are complex. They take in plain factory air, compress it, clean contaminants out of it through filters, dry it to remove humidity, and move it through the piping. However, as air is compressed it heats up, which requires cooling. Cooling causes humidity condensation, which requires drying. Drying it heats it again, etc.

All of these devices are electrically powered. All of these devices are connected with pipes and hoses.

All of this complexity and the interaction between stages creates opportunities for pressure changes as filters fill up, as dryers collect humidity and so forth. Hoses and pipes are under pressure, which can lead to leaks. Leaks in air systems are cited as the source of loss of efficiency that will be at least 10% and more likely over 20% in the typical factory.

The effect of pressure changes and leaks is to create maintenance costs within a factory. Filters must be cleaned routinely. Lubrication systems must be maintained. Leaks must be addressed. Dryers and separators must be maintained.

Compared to an electrical system, moving air around a factory is a complex and difficult challenge. Electricity does not need to be dried or cooled. Power must be regulated through transformers but there is no maintenance to this process. Once installed, the system requires little active maintenance.

There are very few factories that do not have existing compressed air systems. If they do not have compressed air, adding it to use a pneumatic clutch/brake quickly becomes prohibitive. To add a pneumatic clutch into a factory where a compressed air system already exists requires:

- Filter/Regulator/Lubricator
- Piping
- Control valve
- Wire
- Switch
- Clutch/brake

By comparison, installation time for an electric system is generally simpler and less expensive than air. Simply running wire to an application is simpler and easier than doing the plumbing to install piping for an air system. A switch controls both the electric and pneumatic units. In the electric unit, the switch directly controls the DC power going to the clutch/brake. In a pneumatic system, the switch actuates the valve, which controls the air flow to the clutch/brake. So, in addition to the switch being a potential point of installation problem, the pneumatic system also needs to have the valve installed properly. More complexity, more installation time, more cost.

The electrical power coming into most facilities in North America is relatively clean and consistent. Even when machine installation is relatively poorly done, electrical power in a factory does not vary widely. Further, electric clutch/brakes are fairly simple devices and are not prone to performance problems due to spikes

or noise in the electrical lines. While these kinds of power problems can impact variable speed drives or PLCs, clutch/brakes are much simpler and are not affected.

To run an electro-magnetic clutch the system requires AC power input. From that point the components are:

- Wire
- Power supply to convert AC to DC power
- Wire
- Switch
- Clutch/brake

### Effect of System Variation on Unit performance

Electrical power in a facility will generally not vary by more than a few percent on any given power grid. If this does occur, the effect on clutch/brake performance is generally low. A change in input voltage from 90 volts to 81 volts does not have significant impact on unit performance.

When evaluating pneumatic units, we see that variations can impact air pressure dramatically. As filters and dryers do their work they accumulate contaminants and humidity. This accumulation will impact air pressure. As noted earlier, variations of 10% or more are common in North American factories. Returning to our indexing or metering applications, we see that as variations take place, engagement time will change. As engagement time changes, product quality or scrap or both will be impacted.

### Wear Life and Unit Performance

As noted earlier, the ability of an electromagnetic clutch/brake to incorporate the Autogap™ will ensure the same performance and engagement time through the life of a unit. A pneumatic unit will not include this function.

In general the claim that friction material life in a pneumatic unit is longer than for an electromagnetic unit is a true claim. However, the first failure in pneumatic units is typically not the friction facing, it is in the seals and gaskets within the unit. While inexpensive to repair, the down time caused by the failures can be an expensive cost. Further, as the seals and gaskets deteriorate, they will cause pressure drop within the unit, causing negative changes in unit performance.

### Cycle Rates

A key factor in cycle rates for clutches and brakes is the maximum cycles per minute. As noted earlier, a switch actuates both the electromagnetic and the pneumatic units. The switch will control the flow of electricity to the electric clutch/brake and the actuation of the valve that controls the pneumatic clutch/brake.

Response time in an electromagnetic clutch/brake can be impacted by the level of power applied. For a 90 volt unit, there will be variation when lesser voltage is applied. A variation of more than 10% is normally required to see a variation in performance. From the time the unit receives power until the unit achieves 90% of rated torque is a value called build up time. It is possible to use a control called an Over-excitation (OEX) control to reduce build up time. This control provides a short pulse of power that typically will reduce build up time by 2/3s. This allows for cycle rates in common applications using 1 HP and less to achieve up to 250 cycles per minute, and sometimes more depending on inertia.

In a pneumatic unit, response time on the valve can add from 5 to 70 milliseconds to the engagement time of the system. To further slow a pneumatic unit, if the unit is more than 8 inches from the valve the engagement time can be impacted negatively even further.

### Conclusion

For common industrial applications both electromagnetic and pneumatic clutches and brakes are used widely. For applications where accuracy, consistency and downtime are not issues affecting selection, either will work well. However, where it is important to control engagement time electro-magnetic units will have greater consistency over the life of a unit than a pneumatic. While pneumatic units may have longer friction facing life, their initial failures occur earlier at the seals and gaskets, resulting in repair costs and downtime. Unit costs for an electric and pneumatic unit are quite similar. Depending on unit size and configuration either may be 5-10% more or less than its competitor. However, when complete system costs, maintenance and downtime are considered, the electro-magnetic units excel at providing cycling performance for a long life with less downtime and greater consistency.



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