COYOTE ELECTRONICS, INC.

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Fort Worth, Texas 76117
817.485.3336
888.557.7873
www.payback.com

V1.1e

Easy-PAYBACK ®

Magnetic-Coupled Variable Speed Belt Drive

"The preferred choice in shaft-mounted drive technology."

Engineering, Technical Data & Specifications

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IMPORTANT

ONLY QUALIFIED PERSONNEL SHOULD PERFORM INSTALLATION AND SERVICE OF THIS PRODUCT.

This PAYBACK® variable speed drive has been certified by Coyote Electronics, Inc. to be constructed with the highest quality components, has been operated under load, and has passed Q.C. and in-house testing. Observe all applicable national and local electrical codes and safety precautions for rotating equipment, including those stated below.

- **READ ALL INSTALLATION INSTRUCTIONS THOROUGHLY BEFORE BEGINNING INSTALLATION OF THE DRIVE.**
- **OBSERVE ALL SAFETY PRECAUTIONS FOR THIS VARIABLE SPEED DRIVE AS YOU WOULD FOR ALL MOTORS AND OTHER ROTATING EQUIPMENT.**
- **CAUTION! WHEN INSTALLING OR REMOVING THE PAYBACK DRIVE, BE AWARE OF THE DRIVE'S WEIGHT (REFER TO THE SECTION TITLED "EASY PAYBACK® TECHNICAL DATA" IN THIS MANUAL TO DETERMINE THE WEIGHT OF THE SPECIFIC DRIVE MODEL). USE PROPER LIFTING EQUIPMENT AND PROCEDURES TO AVOID INJURY.**
- **IF THIS UNIT IS TO BE USED OUTDOORS, THE PROTECTIVE COVER SHOULD ALSO BE RAIN PROOF. THE COVER SHOULD BE CONSTRUCTED TO PROTECT BOTH THE DRIVE *AND* MOTOR.**
- **IF YOU HAVE ANY QUESTIONS CONCERNING THE INSTALLATION, OPERATION OR SAFETY PRECAUTIONS CONCERNING THIS PRODUCT, CALL THE FACTORY BEFORE USING THE PRODUCT.**

817.485.3336 or Toll Free: 888.557.7873

DRIVE SIZES IN THIS MANUAL ARE GENERALLY APPLICABLE FOR VARIABLE TORQUE LOADS.

FOR SIZING CONSTANT TORQUE LOADS, IT IS STRONGLY ADVISABLE TO CONTACT FACTORY FOR ASSISTANCE TO ENSURE SATISFACTORY OPERATION OF THE DRIVE.

TO AID IN PROPER SIZING OF YOUR DRIVE, IT IS RECOMMENDED THAT YOU COMPLETE AND FAX THE SITE SURVEY FORM AT THE END OF THIS MANUAL.

CAUTION

TO PREVENT INJURY, ALWAYS BE SURE PROTECTIVE COVER IS INSTALLED BEFORE STARTING MOTOR.

FORWARD

This reference manual provides the necessary user information for the referenced product(s) manufactured or distributed by Coyote Electronics, Inc. for the user to install and operate the product properly.

Notice:

Engineering Manual V1.1e – DOC # OM-000-006-00-RE EASY PAYBACK ENG MAN

ABSTRACT: ALTERNATIVE METHOD OF VARYING THE SPEED OF THE DRIVEN LOAD

Solves Premature Motor Failure and Power Quality Problems

Paul "Dewey" Boggs III, CEO

Coyote Electronics, Inc.

Introduction

Variable Frequency Drives (VFD's), or Inverters, have become the universally accepted method of variable speed control of AC motors and their respective loads.

The most common type of VFD used today is the PWM (pulse width modulated) Inverter. It is the popular choice because of its excellent operating efficiency and lower front end costs compared to other types of variable frequency speed control methods.

The PWM drive however, has proven to be one of the leading sources of noise and motor related problems in variable speed drive applications. Many technical papers have been recently written identifying the reasons for the problems and offering solutions, yet the same concerns that are directly associated with PWM drives continue and to this day have not been totally resolved.

The leading issues with PWM drives today are:

- Motor winding failure
- Motor bearing currents (premature bearing failure)
- Current harmonics and voltage distortion (affect of facilities power quality)
- Additional motor heating (shortened motor life)
- Low end operating speed range limitation
- Distance limits between motor and drive
- Nuisance dropouts
- Retrofits: cannot reliably use existing motors
- When to use line filters, isolation transformers, bypass disconnects, and special inverter rated wiring or cable
- Highly skilled service level requirements

This paper addresses an alternative method of reliable, efficient, and economical variable speed control of the load where none of the above listed issues are applicable.

Also provided is a sample explanation of the basic principle of operation, a look at the developmental history of the magnetic coupled variable speed drive, the latest advances and improvements in the technology, the benefits, and the successful use of this technology in numerous and diverse applications.

Basic Principle of Operation

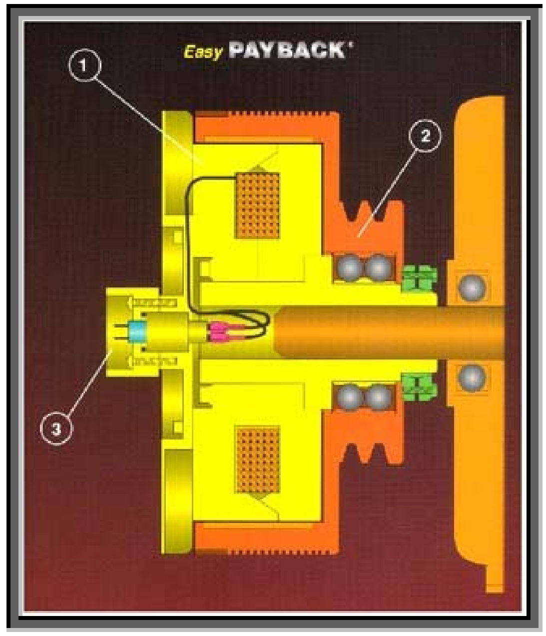
The magnetic coupled concept differs vastly from variable frequency drives in that there is no electrical power interruption to the motor. The motor is allowed to safely operate at its continuous designed speed, while precise, infinitely variable speed control of the load is accomplished by varying the magnet coupling between the motor's output shaft and the load. The ideal configuration shown below comprises two primary elements.

1. electromagnet (multi pole rotor)
2. Armature (steel drum/pulley)

The electromagnet **(1)** is affixed to the motor's shaft with a shaft-locking device so that it runs continuously at motor speed.

The armature / pulley portion **(2)** connects to the driven load. The electromagnet **(1)** and armature **(2)** are separated by ball bearings, which maintain a constant air gap between the two elements.

When current is applied to the coil of the electromagnet via the brushless rotary coupling **(3)**, a polarized field is produced, magnetically coupling both components and causing the output portion to turn in the same direction as the motor. Output speed or torque is dependent on the strength of the magnetic field, which is controlled by varying the amount of current applied to the electromagnet.



EASY-PAYBACK® DRIVE

This proven patented design, which places the output sheaves and bearings close to the motor face and directly over the shaft, allows for maximum belt tensioning without causing stress to the motor's shaft and bearings.

Evolution Of The Magnetic Coupled Drive

Foot Mounted Style

In the 1940's and 50's, magnetic coupled devices known as eddy current clutches were used with AC motors and were a popular method of varying the speed of many industrial loads. Although bulky and inefficient, these workhorses were relatively reliable and were used in applications such as wastewater pumping, punch presses, conveyors, winders and other machine tool situations. These were oversized foot mounted units that initially were designed as a separately housed clutch assembly with an input shaft and an output shaft to be coupled in line between the motor and the load. Also offered were motor and clutch combination (one piece) packaged units. In those days, the primary focus was in functionality, performance and maintainability, as energy efficiency was not as important a factor as it is today.

Shaft Mounted Styles

In the 1960's some of the first commercially available motor shaft-mounted magnetically coupled drives were offered to the industry. This new design was originally intended for small horsepower applications, and was novel in that the drive was totally supported by the motor shaft. The product did have some drawbacks, namely oversized slip rings and problems with brush alignment. It was the end users responsibility to align the brush holder to the existing motor bolts. Unfortunately, motors supplied by different manufacturers varied significantly and alignment became difficult. Additionally the slip rings were provided on the drive at the motor shaft entry side, fabricated on a circuit board type material with copper rings facing the motor. Since the diameter of the outer ring was larger than the inner ring, the outer brush would wear faster. In addition to the uneven and rapid brush wear, the integrity of the circuit board and copper rings were compromised by the heat, causing separation of the rings from the base material. This design was abandoned soon after initial production.

In the 1980's the problem with brush alignment had been somewhat resolved by a new shaft-mounted design that incorporated a bracket supported by an additional bearing on the drive which maintained reasonable alignment between the brush holder and the slip rings. This design enjoyed some success in the machine tool and industrial market where reduced total running hours was somewhat forgiving to the drive. The basic design was still flawed however, as the slip rings were still located on the motor shaft entry side, causing them to be oversized and progressively larger to accommodate the larger horsepower motor shafts. This design created a major headache in the HVAC Air Handler marketplace, as it was soon discovered that 24-hour duty meant frequent brush changes, in some cases as often as every two to three months on the larger drives. Although an improvement over previous efforts, the location of the bearings, being cantilevered to the pulley grooves, caused premature drive bearing failure in many instances. The extra bearing required to accommodate the brush holder had an unacceptably high failure rate as well. This high maintenance drive design has become virtually obsolete in the air handler industry and has been routinely replaced by the more efficient and reliable new brushless designs.

Another design consideration placed the pulley grooves out on the outboard side of the drive, a distance away from the motor face. This, by far is the poorest of all approaches because it directly jeopardizes the motor bearings' life expectancy. Since the pulley grooves are not located over the NEMA shaft extension, applying full rated belt tension may exceed the overhung load rating of the motor in some instances. This outboard pulley design has many documented failures in the field, again compounded by drive bearing failure due to cantilevering effect and motor bearing damage as well.

Preferred Design

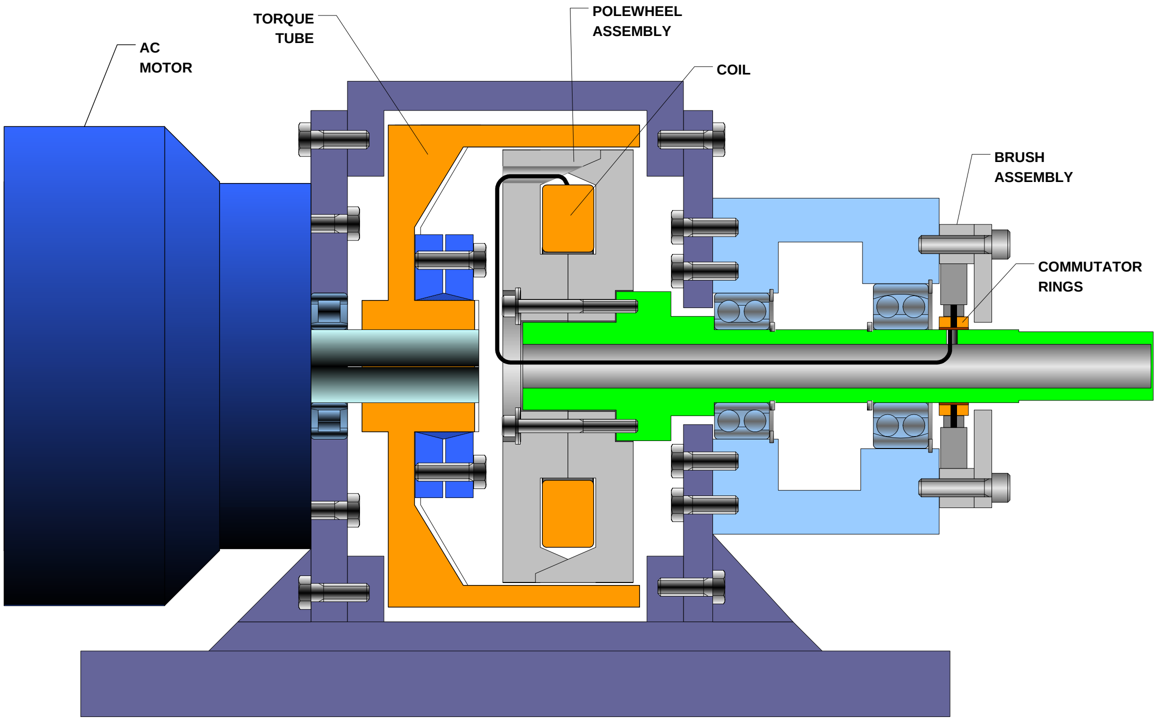
The most reliable design distinguishes itself in many ways from other versions. The rotor/coil assembly rotates constantly with the motor shaft. A one-piece drum/pulley portion is the output-driving member. The pulley grooves are located inboard, closer to the motor face than any other design. The drive's bearings are located directly under the pulley grooves so that maximum belt tension can be applied continuously on all models without harming the drive bearings and yet remains well under the overhung load capacity of the motor. Because the drum is copper lined, the brushless drive runs cooler and is more efficient than other magnetic coupled drives. The drive's coil only requires one-third to one-fourth the wattage of other models. It has the fewest parts, weighs less and has the best operating performance of all previous designs. The proven eleven-year track record allows for the longest drive warranty available in the industry.

1950's Technology

Foot Mounted Eddy-Current Drive

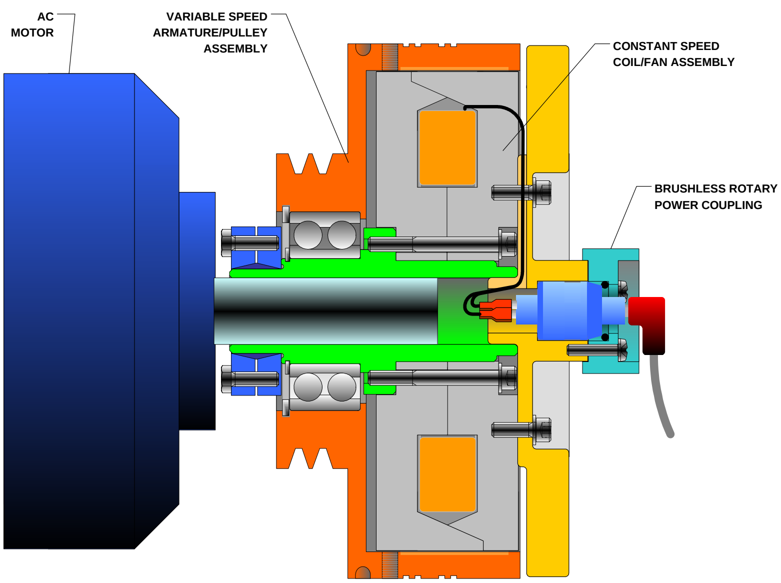
Disadvantages

- **Size**
- **Alignment Difficulty**
- **High Cost**
- **Inefficient**



5 YEAR WARRANTY

Motor/Drive COMBO Winning Design



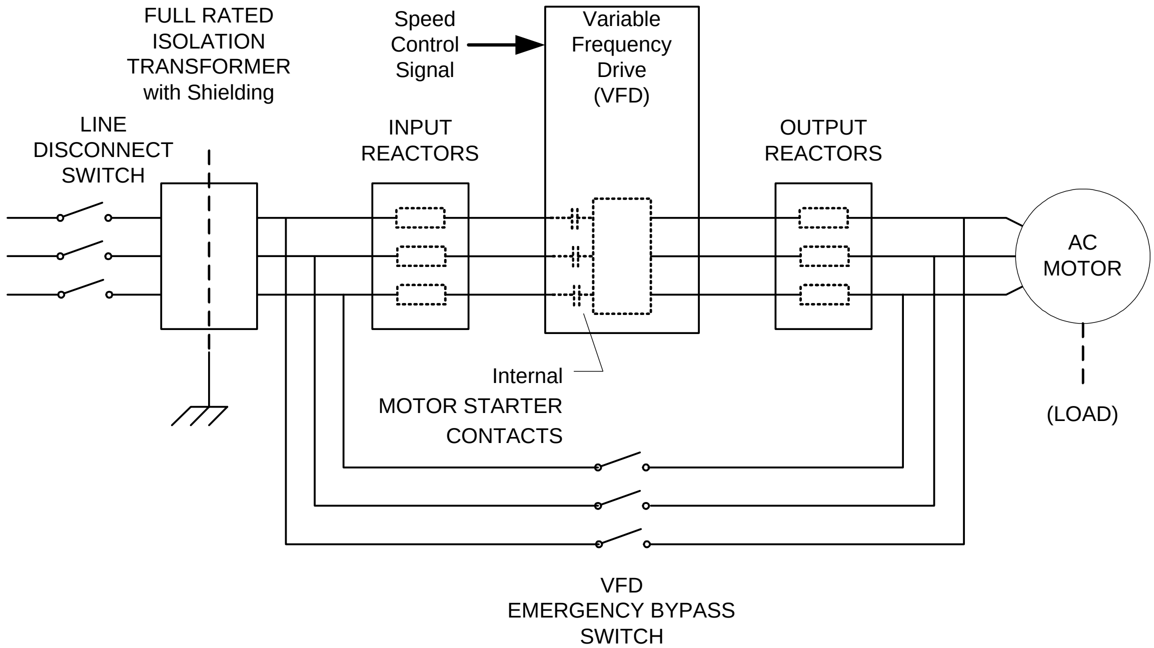
Advantages

- **All Brushless Technology**
- **Copper Plated Drum for Increased Efficiency**
- **Pulley Grooves Closer to Motor (Lowest O.H.L.)**
- **Heavy Duty Bearings are Directly Under Pulley (Allows Maximum Belt Tension)**
- **Fewest Components**
- **Lightest Weight**

COMPARISON – Variable Frequency –vs– Magnetic Coupled

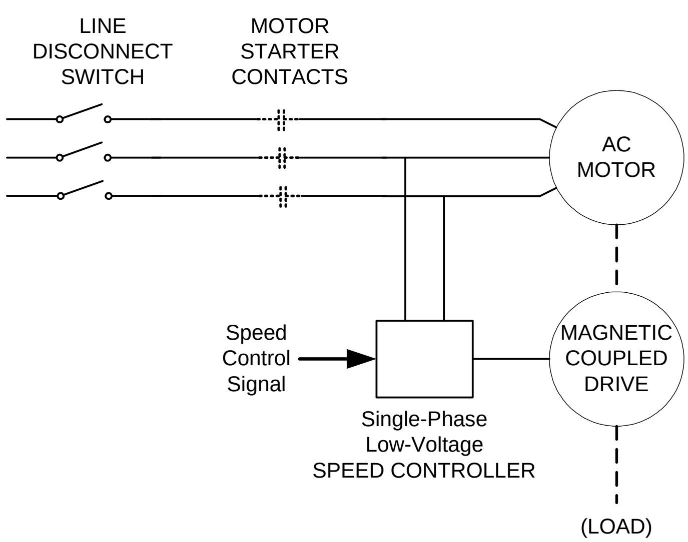
BLOCK DIAGRAM – Variable Frequency Drive (VFD)

Typical required configuration for reduction of harmonic distortion levels induced by Variable Frequency Drives in variable speed applications.



BLOCK DIAGRAM – Magnetic Coupled Drive

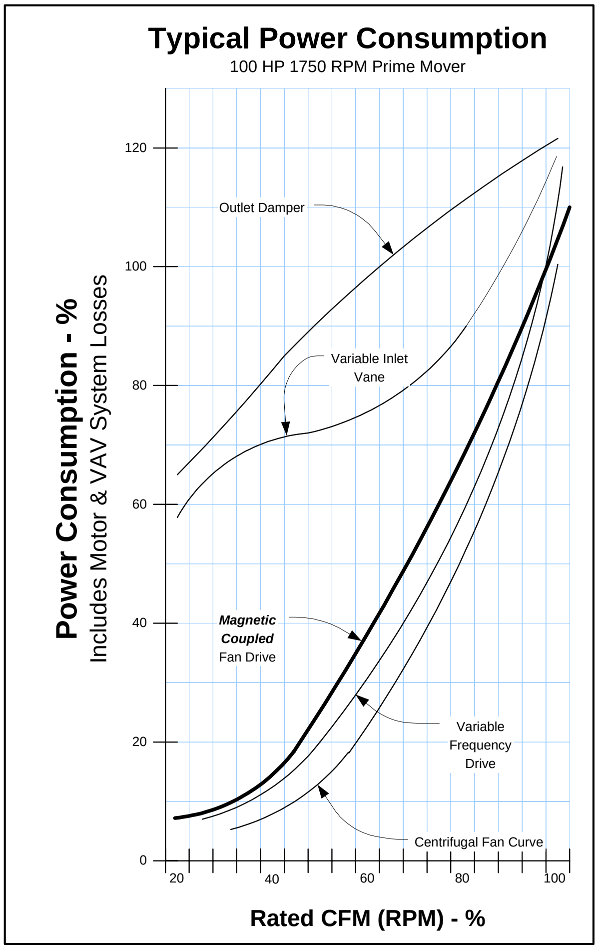
Typical configuration for magnetic coupled variable speed drives application. (True Zero Harmonic Distortion).



Energy Savings

Because of the nature of the descending torque load itself and directly attributed to the affinity laws on variable torque loads such as centrifugal fan or pumps, the magnetic coupled drive provides substantial energy savings with variable speed of the driven load.

As can be seen in the typical power curve comparison graph below, the power curves are similar to VFD's on variable torque loads and the KW savings are significant as well. As a general rule, magnetic coupled drives are more efficient at the very top end of the curve and VFD's are more efficient further down the curve.



A typical magnetic coupled variable speed drive system is capable of energy savings up to 60% over dampers and 30 to 40% over inlet guide vans.

Harmonics

Only the fundamental frequency (60 hertz), produces positive torque on the AC motor shaft. Since harmonic currents generate heat losses in the motor, transformer, and distribution wiring, it is highly desirable that all harmonic currents be as small as possible.

Unlike VFD's, magnetic coupled drives do not interrupt the motor power source. Therefore they do not produce harmonic currents, nor do they cause any voltage distortion.

Consequently, there is no requirement for the added expense of applying costly filtering devices such as line chokes (reactors), and full rated, three phase isolation transformers.

Motor Life

The magnetic coupling is electrically isolated from the motor and in effect operates as an infinitely variable, frictionless clutch, allowing the motor to operate as originally designed, at full speed continuously, and with pure uninterrupted AC power. Regardless of the drives operating speed, the motor never sees any additional heating contributed by the drive. In fact, any additional heat is effectively dissipated by the drive itself, via slip, and not the motor. Unlike VFD's, there are no low end speed restrictions with these types of loads, since the motor always runs COOLER with magnetic coupled variable speed technology. (VFD's typically are limited at the low end of the speed range to prevent the motor from overheating.) With a magnetic coupled drive, the motor fan is always operating at optimum efficiency and there are no unwanted harmonics produced by the drive. The fact that the Magnetic coupled drive allows the load to operate at ANY speed without degradation to the motor provides additional advantages over variable frequency drives.

Besides prolonging the motor life cycle by reducing the heat generated in the motor, additional up front savings can be realized with a magnetic coupled drive because there is no longer a requirement for the extra expense of constructing a pressure relief bypass duct system. This is sometimes necessitated by the direct result of the speed restrictions of the variable frequency drive itself.

Another common concern with VFD's that can affect the life of the motor relates to the distance of the drive from the motor. Known as "reflected wave" or "voltage ring up", the end result is damaging peak voltages at the motor cause by the impedance mismatch that is created by the long connection of the wires between the drive and motor. Higher operating frequencies of the VFD's and faster rise times on the output waveform provide for increased efficiency of the drive, but at the expense of the overall motor life expectancy. Filter reactors on the output side of the drive are generally required in these cases to minimize the rise times of the pulses and lower the peak voltage transients. However, it should be noted that some of the energy savings originally intended by the VFD would be negated by the installation of the filters.

The magnetic coupled drive has no real distance limitations between the drive and the controller. The separation distance has been used successfully up to 2,000 feet. The only requirement is that the two wires that provide DC power to the coil be sized large enough to allow for any voltage drop (say 14 ga. as example). No filters or any other devices are required. There is never any concern about causing damage to the motor or drive.

Lightning and Nuisance Dropouts

Since magnetic coupled drives are isolated from the power source, they provide the highest level of immunity to the effects of lightning.

By virtue of the inherently simple design, the drive is always active as long as the motor starter is energized. Transient over voltages, voltage sags, swells and harmonic distortion from other sources generally do not affect magnetic coupled drives unless the duration of power interruption is significant or long enough to actually drop out the motor starter circuit.

True Retrofit Capability

Magnetic coupled drives can be used safely with all standard AC motors. Since the technology cannot cause electrically induced winding or bearing damage to any motor, there is never any need for inverter duty motors.

Bypass

Another cost saving feature of magnetic coupled drives are built in mechanical lockup bypass. Electrical full speed bypass is accomplished by only one low current diode, and infinitely controllable variable speed bypass is also standard.

Power Factor Correction

Some utility companies in certain locations may charge a penalty if the facility's total measured power factor is below an acceptable pre-determined level.

Power Factor is generally not an issue with magnetic coupled variable speed drives. However, in the event that the power factor may require attention, low cost power factor correction capacitors can always be safely used with magnetic coupled technology.

(Power factor correction capacitors cannot be used with PWM variable frequency drives.)

Maintainability

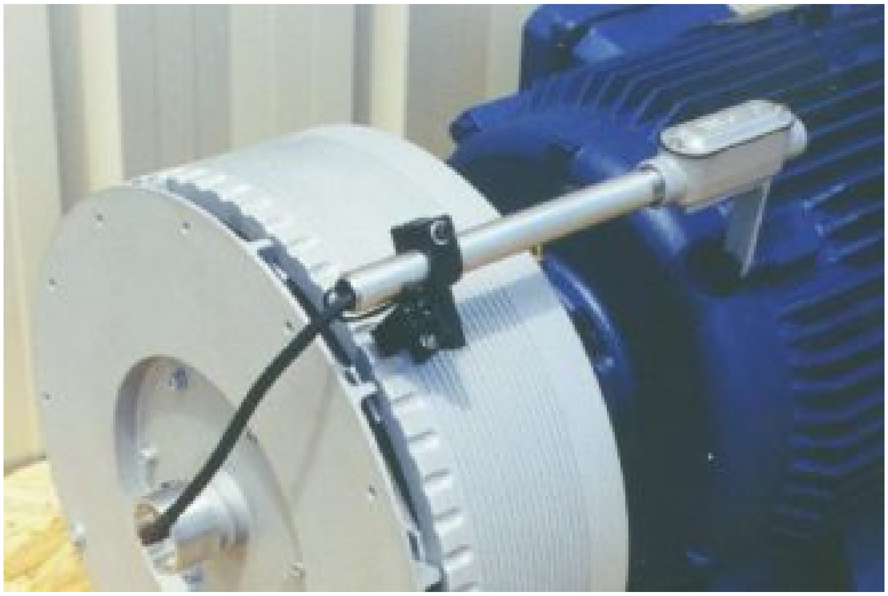
This simple technology does not require highly skilled personnel to maintain. The drive's bearings are permanently lubricated and do not require re-greasing.

Typically the same small footprint, single phase, low wattage, plug-in controller is used on all drives, regardless of horsepower.

Unlike the high maintenance brushes and slip rings of the past, the rotary brushless plug-in coupling cartridge can be swapped in a matter of seconds.

Shown here is a typical brushless, motor mounted magnetic-coupled variable speed drive.

Below is a close up view of the connection to the rotary coupling and optional speed sensor for sensing the holes on the surface of the output drum. The speed sensor is used for providing a feedback loop in closed loop applications and also for speed indication.



Summary of Benefits and Advantages with Magnetic Coupled Drives

- Simple and economical to install
- Substantial energy savings with all variable torque loads
- Does not require highly skilled personnel to maintain or service
- Low cost of ownership, fast payback
- Allows motor to operate more efficiently
- No power quality issues, zero harmonics
- No special filters, reactors, or expensive three phase isolation transformers
- No expensive bypass circuitry
- No nuisance dropouts
- Highest level of immunity to the effects of lightning
- Does not cause additional motor heating, even at continuous low speed requirements (No speed range limitations)
- Does not cause across-the-line shorts, power surges, or voltage spikes
- Does not cause motor frequency noise
- Does not harm motor windings
- Does not cause electrically induced pitting of the motor bearings
- Does not require expensive inverter duty motors
- Controller can be located any reasonable distance from the motor/drive without fear of motor damage
- True retrofit capability, works with existing motors and existing wiring

- Same compact, low wattage controllers for all horsepower drives
- Longer warranties for motors and drives

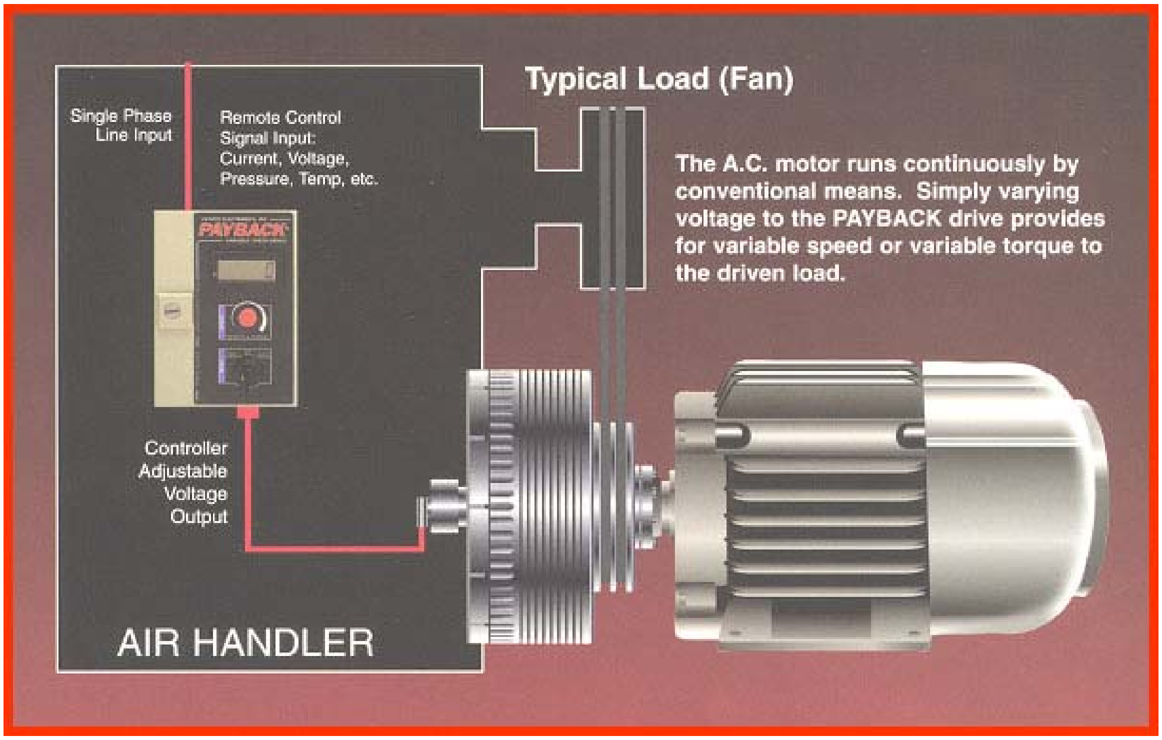
Summary

Not long after man discovered electricity, he found many useful ways of reaping the benefits of this controllable energy source. One of the most significant byproducts of this discovery has been the AC induction motor. Most other inventions pale in comparison to its overall effect on our daily lives. For years, the AC motor has been the primary component in thousands and thousands of many varied motion applications, and the rugged dependability of this prime mover has earned a well-deserved reputation of consistency and reliability.

These motors were originally designed and intended for continuous speed operation that performed very well for the task at hand. It was later discovered, that if the frequency and waveform to the motor is altered within certain “safe” limitations, variable speed could be accomplished, and so you know the rest of the story, eventually the variable frequency drive was born.

The variable frequency drive is a non-linear load since it produces a non-sinusoidal waveform to control the speed of the motor and is the most commonly recognized three phase device that crates substantial harmonics.

BELT DRIVEN AIR HANDLER & PUMP APPLICATIONS:



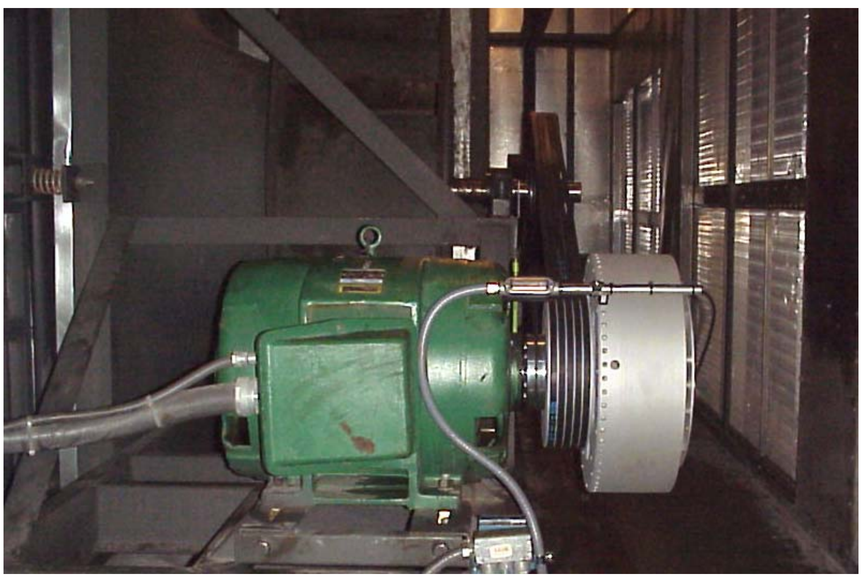
Centrifugal Fan Application

Galleria – Dallas, Texas

New Construction, Twin Towers, Galleria, Dallas, Texas (31 drives, 20 – 50 HP)

MD Anderson Cancer Center – Houston, Texas

17 Drives installed from 100 hp to 200 hp



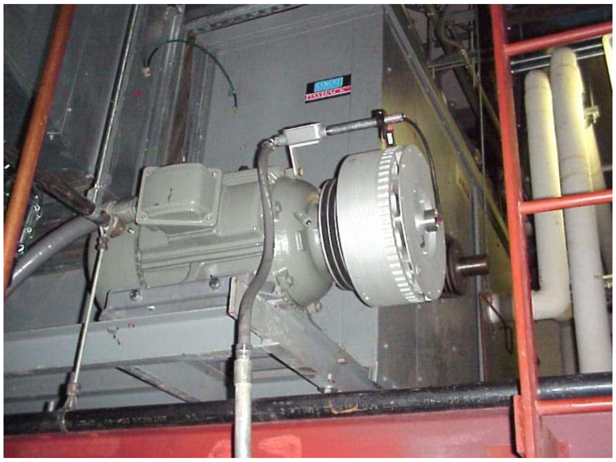
Key Benefits:

Up front savings: Approximately $250,000 over VFD's (Variable Frequency Drives).
Easier to maintain with in-house personnel.
True "ZERO" HARMONICS
Motors run cooler, Last longer

FAA – Houston and Dallas, Texas

FAA – Houston and Dallas, Texas

Magnetic-Coupled Variable Speed Drives installed on York A.H.U. meets stringent harmonics and power quality standards.



75 HP shown above. 30 HP on right. (Covers removed for illustration purposes.)

Southern Methodist University – Dallas, Texas

Southern Methodist University – Dallas, Texas

Paul R. Loyd All Sports Center

Project completed Summer 2000

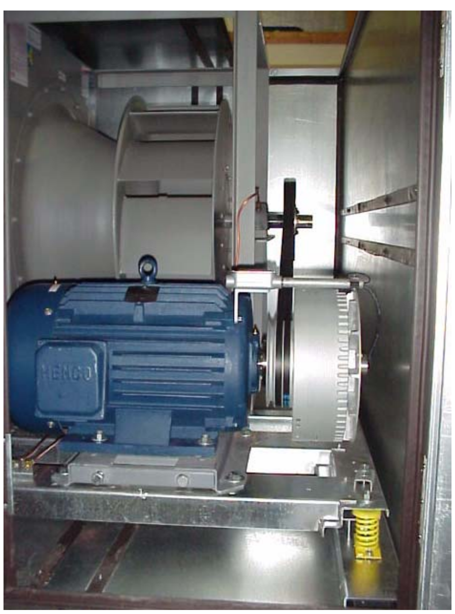
Factory installed Magnetic-Coupled Variable Speed Motor & Drive System in a Trane custom Air Handler

Hospital – Richland Hills, Texas

Factory Installed Rooftop Units

Multiple Air Handling Units installed at a Hospital in Richland Hills, Texas

Retirement Community – Fort Myers, Florida



Multiple magnetic-coupled Drives installed since 1996.

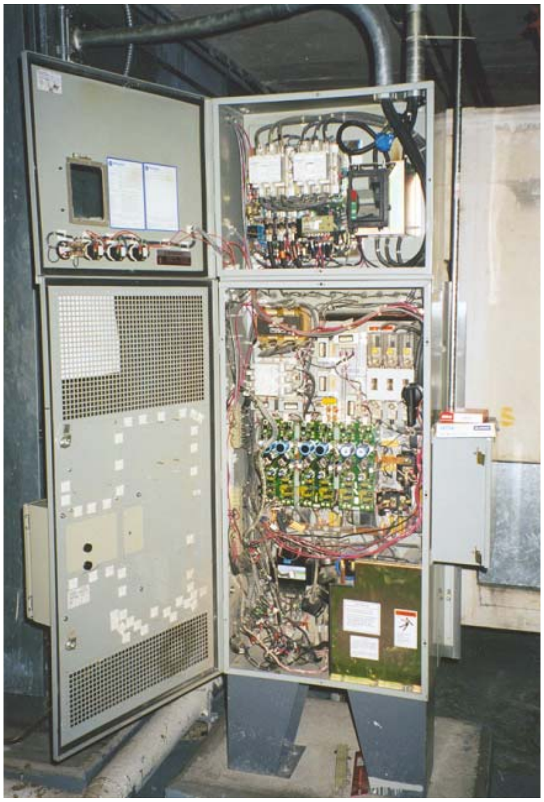
Requires extremely high reliability in outdoors environments on pump drives without the nuisance dropouts and high service costs that are typically associated with VFD's.

McQuay air handler with 25 HP Magnetic-Coupled motor/drive "combo" shown.

University of Alabama – Birmingham, Alabama

Typical 75 hp Variable Frequency Drive

A Good Candidate to Upgrade to a Magnetic-Coupled Variable Speed Drive



Pure & Simple Retrofit

Step #1:

Replace motor pulley with Magnetic-Coupled Drive

Step #2:

Mount new controller on the door of the old VFD and connect two single-phase wires.

Step #3:

Plug DC cable into Magnetic-Coupled Drive

Installation upgrade performed by the cheerful maintenances team at the University of Alabama-Birmingham.

Landfill Application: Methane Gas Powered Engine Generators

Problems:

Excessive starts / stops
Reduced equipment life
High inrush fan motor current
High motor loading during cycle on time
High audible noise levels

Solution:

Eliminates starts / stops
Extends equipment life
Motor runs cooler
Noise abatement
Tighter engine temperature control by improved fan speed regulation

Belt Driven Variable Speed Pumps

Benefits:

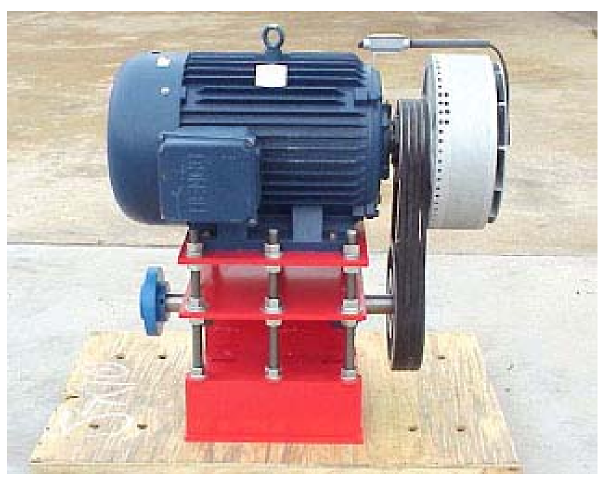
- *Saves Energy*
- *Low maintenance*
- *Reduces vibration*
- *Reduces alignment problems*
- *Belts last longer due to controlled soft start*
- *Easy to change pulley during commissioning for correcting for full load rpm*
- *Zero harmonics*

75 HP Belt Driven Magnetic-Coupled Drive with Jackshaft Assembly

for Waste Water Utilities – Dallas, Texas

Upgrade RETROFIT of existing pump drive.

Older style foot mounted eddy current drive is removed and replaced with this pre-assembled package resulting in higher efficiency and performance.



Side view showing jack shaft and pump coupling connection. Cover is removed for photographic purposes.

Punch Press Magnetic-Coupled Variable Speed Drive Retrofit

Benefits:

- *Economical conversion to variable speed*
- *Easy to install*
- *Ability to adjust stroke when length of input product is changed*
- *Soft starting*
- *Reduced clutch-brake maintenance*
- *Driven equipment life is extended*
- *Improved process efficiency*
- *Drive maintenance is virtually zero*

Pump Jack Applications

Benefits:

- *Simple field retrofit*
- *Can use original motors*
- *Does not require 3 phase power in rural areas*

Progressive Cavity Pump Applications

**Field retrofit shown with cover removed for illustration purposes.
The drive simply replaces the original motor pulley**

HARMONIC DISTORTION COMPARISONS

VFD –vs – PAYBACK®

The new IEEE 519 standards now include limits for total harmonic current distortion. Variable Frequency Drive Inverters (VFD's) are connected through high voltage, high current, 60 Hz three phase AC power lines to the electric motor.

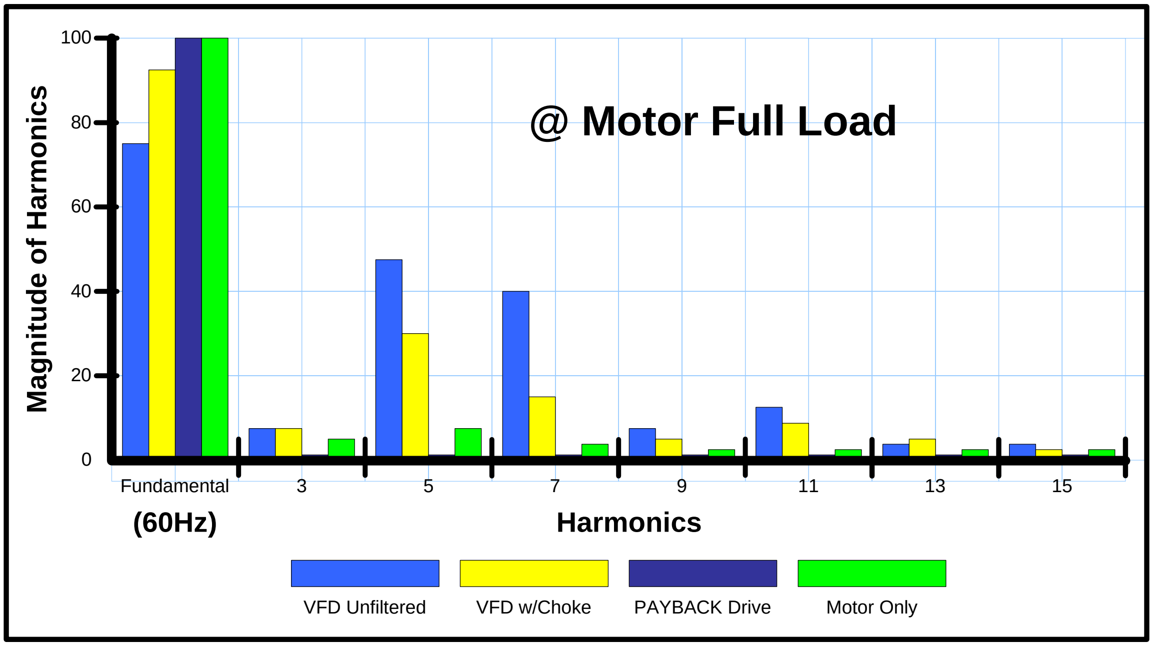
All Variable Frequency Drives create current distortion since they are connected directly to the AC power line. This distortion of the actual AC current waveform produces additional disturbances such as noise (both audible and electrical), line voltage distortion, harmonic distortion, RFI/EMI frequency generation, and causes heat in the distribution system.

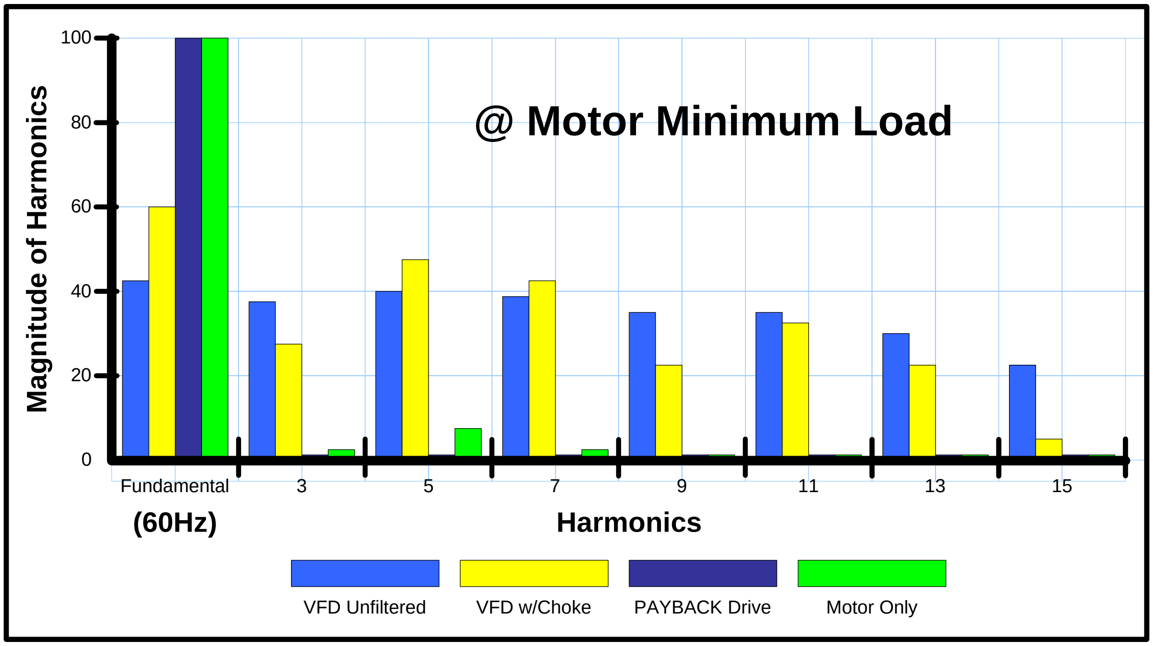
Unlike VFD's, **PAYBACK® magnetic coupled drives do not interrupt the power source to the AC motor and therefore do not produce any current harmonics, nor is there any resultant voltage distortion.**

All PAYBACK® variable speed drives mount directly to the shaft of a standard constant speed AC motor that is typically connected to the AC power line through a conventional motor starter. The fan or pump rotates at a speed that is proportional to the voltage applied to the drive's control coil by the PAYBACK® speed controller, which connects to a 120 volt, 3 amp single phase power source. Since PAYBACK® drives work with standard motors, there is no additional expenditure for special rated motors, as is the case with VFD's.

The PAYBACK® drive meets all IEEE 519 standards and complies with FCC part 15 subpart J specification on RFI/EMI disturbances.

HARMONICS





- Only the fundamental frequency produces torque on the motor shaft
- Harmonic currents generate heat losses in the motor, transformer and distribution wiring
- Excessive harmonic currents shorten motor life expectancy because of unwanted heating
- Magnetic coupled drives do not create harmonic currents nor do they cause voltage distortion

% THD Comparison

(% Total Harmonic Distortion)

PAYBACK® Magnetic-Coupled Drive – vs – Variable Frequency Drive

Fan Speed	PAYBACK® Drive [1]	VFD Only [2]	VFD W/Chokes [3]	VFD W/XFRMR [4]
755/779*	3	83	41	38
717	3	88	45	43
653	3	96	51	48
589	3	103	60	53
525	3	111	72	53
460	3	121	81	50
395	4	133	97	41
330	5	145	103	34
262	4	153	114	28
199	4	158	127	23
132	5	147	132	23

Tested @ 230V/3 phase/60 Hz, LINCOLN 7-1/2 HP 1760 rpm motor, 17.8 FLA, 90.3% EFF.

NOTE: Motor operating independently at FULL LOAD on same line conditions measured 3% THD.

Motor operating independently at ZERO LOAD measured 5% THD.

CONCLUSION: PAYBACK® Drive THD readings are no different than the AC motor used alone.

Products used for test:

1. PAYBACK® model Easy-2 magnetic-coupled shaft mounted belt drive.
2. Baldor VFD model ID15H207 Variable Frequency Drive.
3. Baldor recommended 3% line reactors rated for 7-1/2HP/230V VFD use.
4. VFD Drive Isolation Transformer with shielding, ACME#DTFA-011-TS, Delta-Wye, 11.0 KVA.

Instruments used: POWERSITE model PS3000 Energy Analyzer.

Test performed: March 1, 1998, Fort Worth, TX. Dayton Blower.

1. PAYBACK® Model Easy-2 with EL-FAN-1 Speed Control.
2. VFD only connected directly to motor
3. VFD with input and output line reactors
4. VFD with Drive Isolation Transformer and input/output line reactors

*Fan operating speed of 755 rpm measured with PAYBACK® Drive, 779 rpm is Fan operating speed measured with VFD running at 60 Hz.

The following is information obtained from the Electric Variable Speed Reference Guide originally printed by Ontario Hydro. Listed are some of the effects and problems relating to harmonics regarding the use of Variable Frequency Drives (VFD's, Inverters, Converters) with motors.

10.2 HARMONIC DISTORTION

WHAT IT CAN DO

* As with many other forms of pollution, the generation of harmonic distortion affects the whole electrical environment. It propagates through the power system, and may even show up at distant points outside the plant, thus causing problems for other equipment connected to the power supply.

* Typical effects of harmonics on the motor/drive system include:

  * reduced motor efficiency due to increased losses
  * increased heating of motors, cables and transformers
  * excessive voltage stress on insulation of motor windings
  * torque pulsations

*General problems caused by harmonics are:

  * general degradation of power quality
  * voltage dips or voltage ripple
  * premature equipment failure
  * mal-operation of important control and protection equipment
  * interference with telecommunications or computer systems
  * amplification of harmonic levels resulting from resonance
  * incorrect readings on mechanical timing relays and watt-hour meters
  * blown fuses

* All capacitors, including those used for power factor correction, tend to be very susceptible to harmonics damage. Disastrous consequences can occur if capacitors are exposed to excessive harmonic voltages or currents.

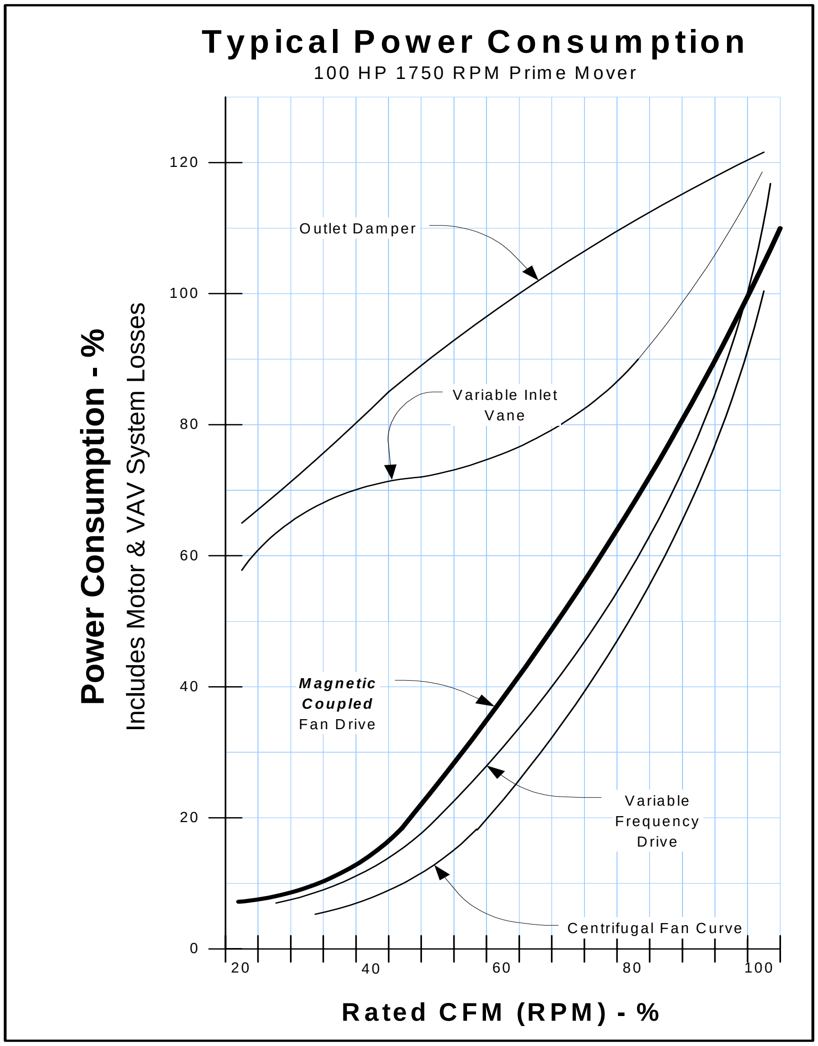
<u>*The harmonics produced by a converter may increase motor losses by 5-10%.</u>

Electric Variable Speed Drive Reference Guide originally printed by Ontario Hydro.

The Canadian Electrical Association expresses its appreciation to Ontario Hydro for use of this material.

This Reference Guide is published in cooperation with Energy, Mines and Resources Canada

POWER CURVES for Variable Torque FAN Load



By varying the speed of a centrifugal Fan, the magnetic coupled drive can provide energy savings of up to 60% over dampers and 30% to 40% over inlet guide vanes.

NOTES ON SAVINGS TABLES & GRAPHS

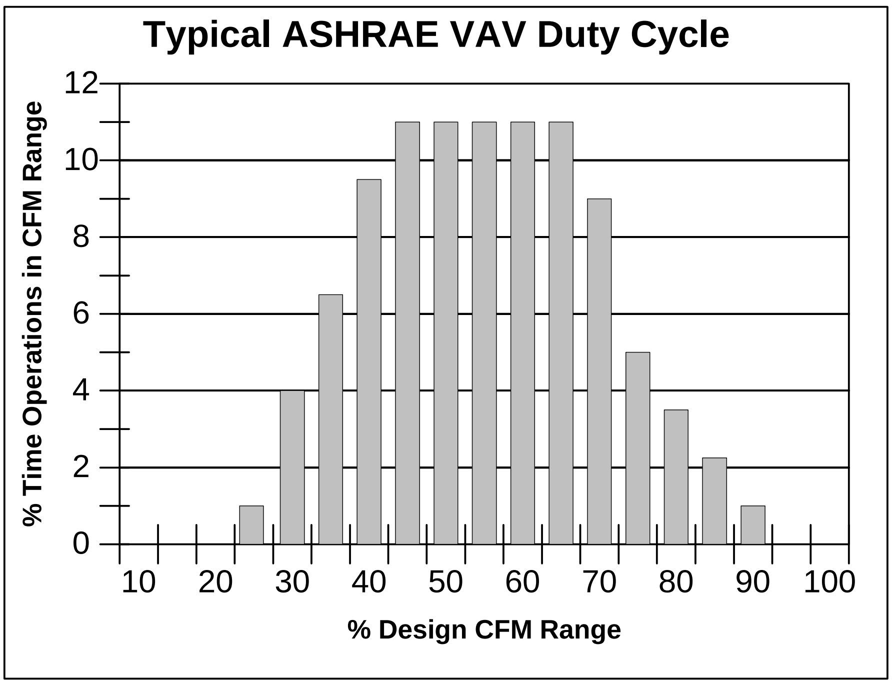
Following are graphs, tables, formulas useful for understanding centrifugal applications and the effect which centrifugal loads have on electrical energy consumption.

Projections are based upon the following assumptions:

1. 365 days/year x 24 hours/day = 8,760 hrs/year

2. Cost per hp/year = $\frac{\text{8,760 hours x hp x 746 watts/hp x \_\_\_\_\_ cents/kw. Hr.}}{\text{1,000 w/kw}}$

3. Calculations are based upon average duty cycle of 55% cfm (charted below)



COST SAVINGS

The following tables show savings in dollars per year. Calculations are based upon a 24-hour, 7-day/week operations and variable speed operation over a typical bell shaped curve duty cycle.

PAYBACK® - vs – Inlet Guide Vanes							
Rated HP	Cost Of Electricity **(/ KWH)**						
	$.04	**$.05**	**$.06**	**$.07**	**$.08**	**$.09**	**$.10**
5	492	615	737	860	984	1107	1229
7.5	738	923	1,107	1,291	1,475	1,660	1,844
10	984	1,229	1,475	1,721	1,967	2,213	2,459
15	1,475	1,844	2,213	2,582	2,951	3,319	3,688
20	1,967	2,459	2,951	3,443	3,934	4,425	4,918
25	2,459	3,074	3,688	4,303	4,918	5,533	6,147
30	2,951	3,688	4,426	5,163	5,902	6,639	7,377
40	3,934	4,918	5,902	6,885	7,869	8,852	9,836
50	4,918	6,147	7,377	8,606	9,836	11,065	12,295
60	5,902	7,377	8,852	10,328	11,803	13,279	14,754
75	7,377	9,221	11,065	12,,909	14,754	16,598	18,442
100	9,836	12,295	14,754	17,212	19,672	22,130	24,589
150	14,754	18,442	22,131	25,818	29,508	33,195	36,884

PAYBACK® - vs – Outlet Dampers							
Rated HP	Cost Of Electricity **(/ KWH)**						
	$.04	**$.05**	**$.06**	**$.07**	**$.08**	**$.09**	**$.10**
5	857	1,072	1,284	1,499	1,715	1,929	2,142
7.5	1,286	1,609	1,929	2,250	2,571	2,893	3,214
10	1,715	2,142	2,571	2,999	3,428	3,857	4,285
15	2,571	3,214	3,857	4,450	5,143	5,784	6,427
20	3,428	4,285	5,143	6,000	6,856	7,713	8,571
25	4,285	5,357	6,427	7,499	8,571	9,643	10,713
30	5,143	6,427	7,713	8,998	10,286	11,570	12,856
40	6,856	8,571	10,286	11,999	13,714	15,427	17,142
50	8,571	10,713	12,856	14,998	17,142	19,283	21,427
60	10,286	12,856	15,427	17,999	20,470	23,142	25,712
75	12,856	16,070	19,283	22,497	25,712	28,926	32,140
100	17,142	21,427	25,712	29,997	34,282	38,567	42,852
150	25,713	32,140	38,568	44,995	51,426	57,850	64,279

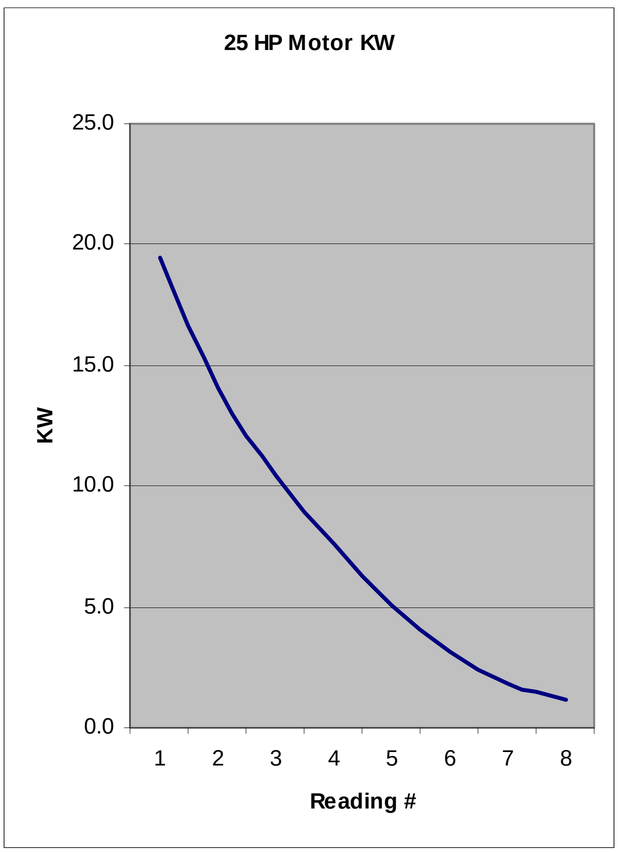
	Measured						
Reading #	Coyote VSD (RPM)	AHU Fan (RPM)	Motor (RPM)	Amps	KW	Equivalent HP	Motor Casing Temp
1	1,705	1,511	1,769	28.7	19.5	26.1	118
2	1,457	1,286	1,778	22.0	14.1	18.9	117
3	1,240	1,092	1,786	18.4	10.4	14.0	114
4	1,027	907	1,788	15.7	7.6	10.2	109
5	788	698	1,793	13.8	5.0	6.7	107
6	569	507	1,795	13.0	3.2	4.3	101
7	321	295	1,798	12.3	1.9	2.5	102
8	238	214	1,799	12.2	1.2	1.6	101

1. Date of test was 06/30/1999.
2. Equivalent horsepower was calculated by multiplying the Measured KW by 1.341.

Motor Data / used with PAYBACK® model Easy-4 (25 HP Shaft Mounted Magnetic Coupled Drive)

PAYBACK® Drive pulley diameter 8.0”

Fan pulley diameter 9.0”



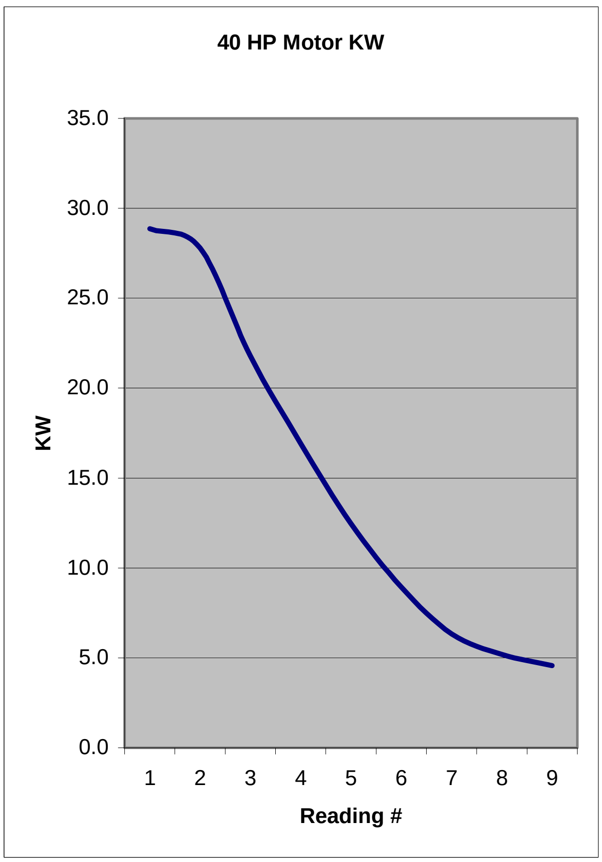
Brand	Baldor
Serial #	09810-39L031W790H1
Cat #	M2531T
Frame	284T
Amps	59/29.5
Volts	230/460
HP	25
RPM	1760
Ph	3
Hz	60
Class	B
NEMA Nom Eff	91.70%
Power Factor	86%

	Measured						
Reading #	Coyote VSD (RPM)	AHU Fan (RPM)	Motor (RPM)	Amps	KW	Equivalent HP	Motor Casing Temp
1	1,732	1,944	1,777	43.0	28.9	38.7	98
2	1,702	1,909	1,778	41.9	27.8	37.3	98
3	1,500	1,683	1,783	35.2	21.8	29.2	100
4	1,301	1,461	1,787	29.4	16.9	22.7	101
5	1,102	1,234	1,791	24.9	12.5	16.7	101
6	902	1,013	1,795	22.1	9.0	12.0	100
7	701	784	1,795	20.7	6.3	8.5	99
8	505	567	1,797	19.3	5.2	7.0	99
9	302	339	1,799	18.7	4.6	6.2	98

NOTE: Reading #1: Drive coil voltage set at maximum of 50 VDC for full speed output measurement

1. Date of test was 08/21/1999.
2. Equivalent horsepower was calculated by multiplying the Measured KW by 1.341.

Motor Data / used with PAYBACK® model Easy-5 (40 HP Shaft Mounted Magnetic Coupled Drive)



Brand	Magnetek
Serial #	390798
Cat #	997009-13
Frame	324T
Amps	96.4/48.2
Volts	230/460
HP	40
RPM	1760
Ph	3
Hz	60
Class	
NEMA Nom Eff	93.00%
Power Factor	

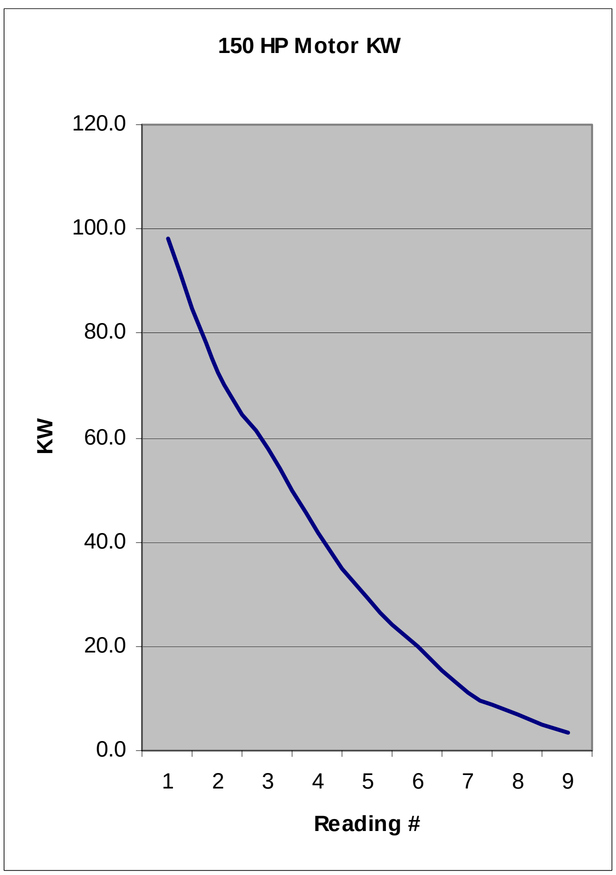
PAYBACK® Drive pulley diameter 9.0”

Fan pulley diameter 8.0”

	Measured							
Reading #	**Coyote VSD (RPM)**	**AHU Fan (RPM)**	**Motor (RPM)**	**Amps**	**KW**	**Equivalent HP**	**Motor Casing Temp**	**Coyote Bearing Temp**
1	1,712	727	1,794	133.7	98.0	131.4	105	100
2	1,475	631	1,797	104.1	72.4	97.1	110	105
3	1,291	548	1,797	87.9	57.9	77.6	105	100
4	1,095	466	1,798	73.8	41.9	56.2	102	97
5	902	382	1,798	64.7	29.2	39.2	100	95
6	730	310	1,799	58.9	20.0	26.8	100	95
7	510	221	1,799	53.8	11.2	15.0	100	95
8	359	146	1,799	53.5	6.8	9.1	100	95
9	156	67	1,799	53.0	3.5	4.7	102	97

1. Date of test was 05/28/1999.
2. Equivalent horsepower was calculated by multiplying the Measured KW by 1.341.

Motor Data / used with PAYBACK® model Easy-8 (150 HP Shaft Mounted Magnetic Coupled Drive)



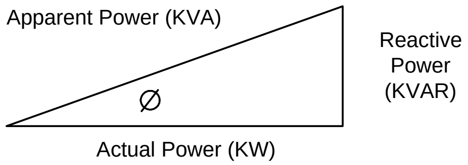
Brand	HEMCO Global High Efficiency Motor
Serial #	HB1504FBCT1
Cat #	HB1504FBC, DESB
Frame	445T
Amps	166
Volts	460
HP	150
RPM	1780
Ph	3
Hz	60
Class	F
NEMA Nom Eff	95.0%
NEMA Min Eff	94.1%

PAYBACK® Drive pulley diameter 16.0”

Fan pulley diameter 37.5”

The Power Factor

Power factor alone does not really describe what the power company is penalizing: KVAR does!



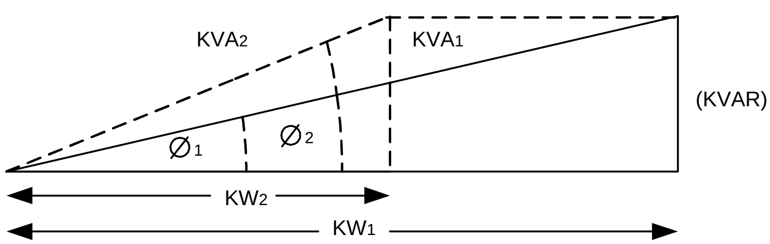
$$\text{Power Factor} = \frac{\text{Actual Power}}{\text{Apparent Power}} = \text{Cosine } \varnothing$$

Actual Power (KW) is the electrical power consumed by the motor to do work.

Reactive Power (KVAR) is the power that is wasted due to the inductive load. In some areas of the country, Power companies will penalty bill if it becomes excessive.

Apparent Power (KVA) is what transformers and power generating equipment must be sized for, and determines the investment the utility company must make in generating and distribution equipment. If KVAR is minimized, apparent power approaches actual power. This is what the power company tries to achieve and is the reason you are penalized for reactive power.

Power Factor is merely an easy way to describe KVAR given a fixed KW consumption. It can easily be seen from the power triangle, however, that if KW use is decreased while KVAR remains fixed, the angle between the two must increase.



The cosine of this angle is the Power Factor, which will decrease as the angle increases.

Angle (Degrees)	Power Factor
0	1.000
5	0.996
10	0.985
20	0.939
30	0.886
45	0.707

But the power penalty is only assessed at full load because this is where extra generating capacity must be provided for the wasted energy. At anything below full load the capacity of the system is already above that point.

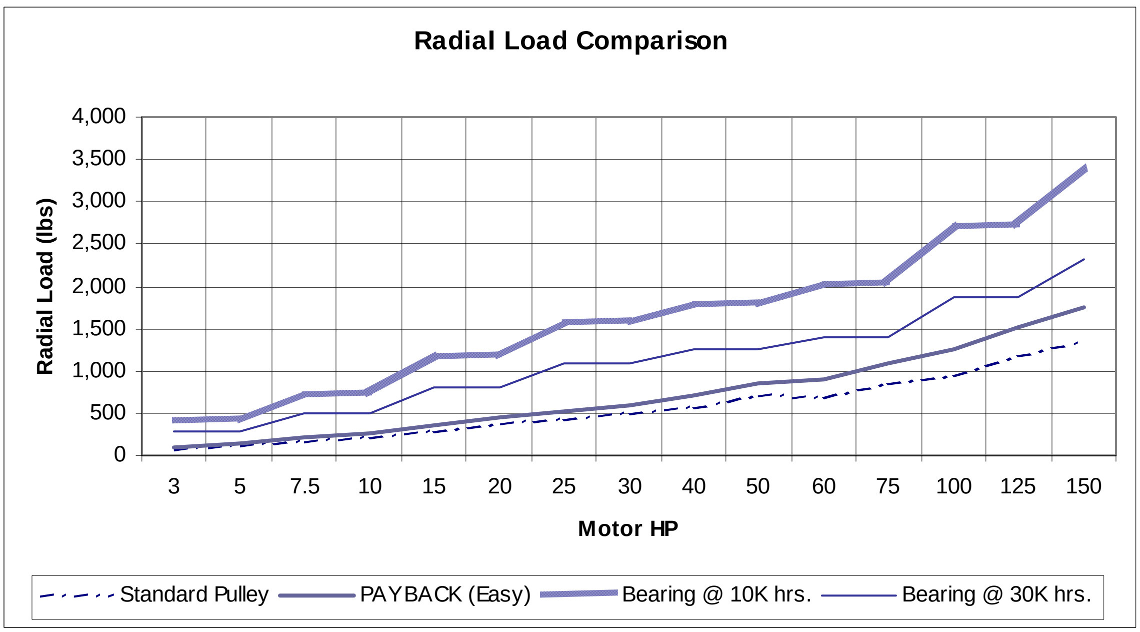
This is the reason that KVAR is the issue and not Power Factor. Power Factor will vary with the load as a result of the change in KW and KVAR.

Building power factor is a vector summation of all building power users power triangles. As the load drops off for an individual motor its power factor lowers, but since it is less and less of the total building power consumption, it influences building power factor less and less.

In the rare case where building power factor may be affected (such as multiple inductive loads that are inappropriately oversized in proportion the actual required loads), the addition of power factor correction capacitors can be installed to bring the building power factor back to a satisfactory level.

Radial Load Comparison

Motor HP	Standard Pulley	PAYBACK (Easy)	Bearing @ 10K hrs.	Bearing @ 30K hrs.
3	75	100	430	295
5	124	153	430	295
7.5	166	208	730	500
10	220	266	730	500
15	289	358	1,175	800
20	383	459	1,175	800
25	418	515	1,585	1,100
30	500	601	1,585	1,100
40	573	710	1,800	1,250
50	713	858	1,800	1,250
60	680	907	2,025	1,405
75	847	1,079	2,025	1,405
100	956	1,265	2,725	1,880
125	1,189	1,508	2,725	1,880
150	1,360	1,757	3,400	2,325



EASY PAYBACK® SPECIFICATION GUIDE FOR:

Variable Speed FAN and PUMP Drives & Controls (BELT DRIVEN, Variable Torque Load Applications)

Furnish magnetic coupled variable speed drives, controllers, and/or motors of the type and size shown. Coyote Electronics, Inc. or an approved equal shall manufacture drives and controllers.

Drive Unit Description

The drive unit shall be self-contained and include the following; first a constant speed input drive member that is directly mounted to the motor shaft with a shrink disc shaft locking device; second a variable speed driven output member htat rotates freely without any mechanical connection (other than its own support bearings). Output speed is accomplished by varying the amount of current applied to the drive's rotating coil, which changes the strength of the magnetic field across an air gap, controlling the amount of coupling between the two elements.

1. The AC motor shall be wired to operate continuously at full speed when the motor contactor is energized.
2. Torque shall be transmitted from the electric motor to the drive's output member via magnetic force across a single air gap. (Oversized, inefficient stationary coil designs with multiple air gaps will not be acceptable).
3. Only brushless electrical coupling to the rotating coil is permissible (brushes will not be acceptable).
4. The pulley/sheaves shall be located on the motor shaft-entry side of the drive nearest the motor face so as not to cause undue stress on the motor shaft and motor bearings.
5. All drive bearings must be located directly under the pulley grooves for uniform loading of the bearings.
6. All drives shall incorporate manual mechanical bypass for full speed emergency lockup capability.
7. The internal surface of the drive drum shall be copper lined for maximum energy efficiency.
8. Unit shall be capable of operating continuously at any output speed from 0 to 100% without causing any increase in motor heating.
9. The manufacturer prior to shipment shall test all units at full rated load and speed.
10. When both the Variable Speed Drive AND a new Motor are required, the Drive AND Motor shall be supplied by the same drive manufacturer, dynamically balanced and tested as a complete motor/drive unit assembly.

Speed Controller Description

The speed controller in conjunction with the drive shall meet or exceed FCC Part 15 Subpart J specifications on RFI/EMI disturbances with IEEE-519 standards for total harmonic current distortion. The speed controller shall not create objectionable PWM, six-step or other audible acoustical noise when operating throughout the entire speed range regardless of full-load or part-load conditions. The controller shall be immune to line noise generated by other electrical equipment.

Each speed controller shall operate on 115 volts AC, 50/60 Hz @ 3 amps, single phase power and provide adjustable voltage output to the drive. The controller shall accept current, voltage, or pressure transducer signal input and shall interface with any energy management system.

The controller shall be housed in a NEMA 1 enclosure, pre-wired with "Man-Off-Auto" selector switch, manual operator speed potentiometer on the front cover, and optional Speed Meter, if required. The controller shall also provide independent adjustable soft-start for preset ramp-up of the drive. In the event of power failure or momentary interrupt, the unit shall automatically restart with preset ramp-up when power is restored to the motor.

Qualifications

1. The magnetic coupled, variable speed drive shall be equal to Coyote Electronics, Inc.'s: Model Easy-PAYBACK® series brushless belt drives.
2. The enclosed, prewired controller shall accept any grounded or ungrounded current, voltage, or pressure to analog signal input and shall be equal to Coyote Electronics, Inc.'s:
    a. ET-DC1 (Includes control transducer & primary fuses), or;
    b. ETL-DC1 (Same as above and includes LCD RPM/Speed Meter option).

(Retrofit) Installation Specifications:

1. Mount the drive unit on the existing motor shaft in accordance with the manufacturer's instructions.
2. On existing (retrofit) belt-drive applications, remove the exiting fan sheaves on the fan shaft and install the new sheaves correctly sized so the maximum fan rpm will match the original fan rpm. The new fan sheaves should always be sized large enough so that in full speed emergency lock-up and at maximum running load, the motor's full load amps are never exceeded.
3. Align the new fan sheaves with the Motor/Drive sheaves and then properly tension the belts.
4. Mount the drive controllers at the location required by the engineer, observing all applicable codes.
5. Make all electrical and control signal connections to the drive and controller.
6. The complete drive and controller installation shall comply fully with the manufacturer's instructions.

(New) Installation Specifications

FANS / Air Handlers

The Drive Manufacturer shall provide the **motor *and* drive** as a complete, tested and dynamically balanced variable speed unit assembly, and ship the unit to the FAN / Air Handler O.E.M. for installation in the equipment.

PUMPS

The Drive Manufacturer shall provide the motor, drive, base, pump, covers and all other pertinent components as a complete variable speed pump unit assembly. The assembled, aligned, dynamically balanced and tested unit will then be shipped directly to the site.

Safety First

WHEN SERVICING, INSTALLING, OR REMOVING THE DRIVE:

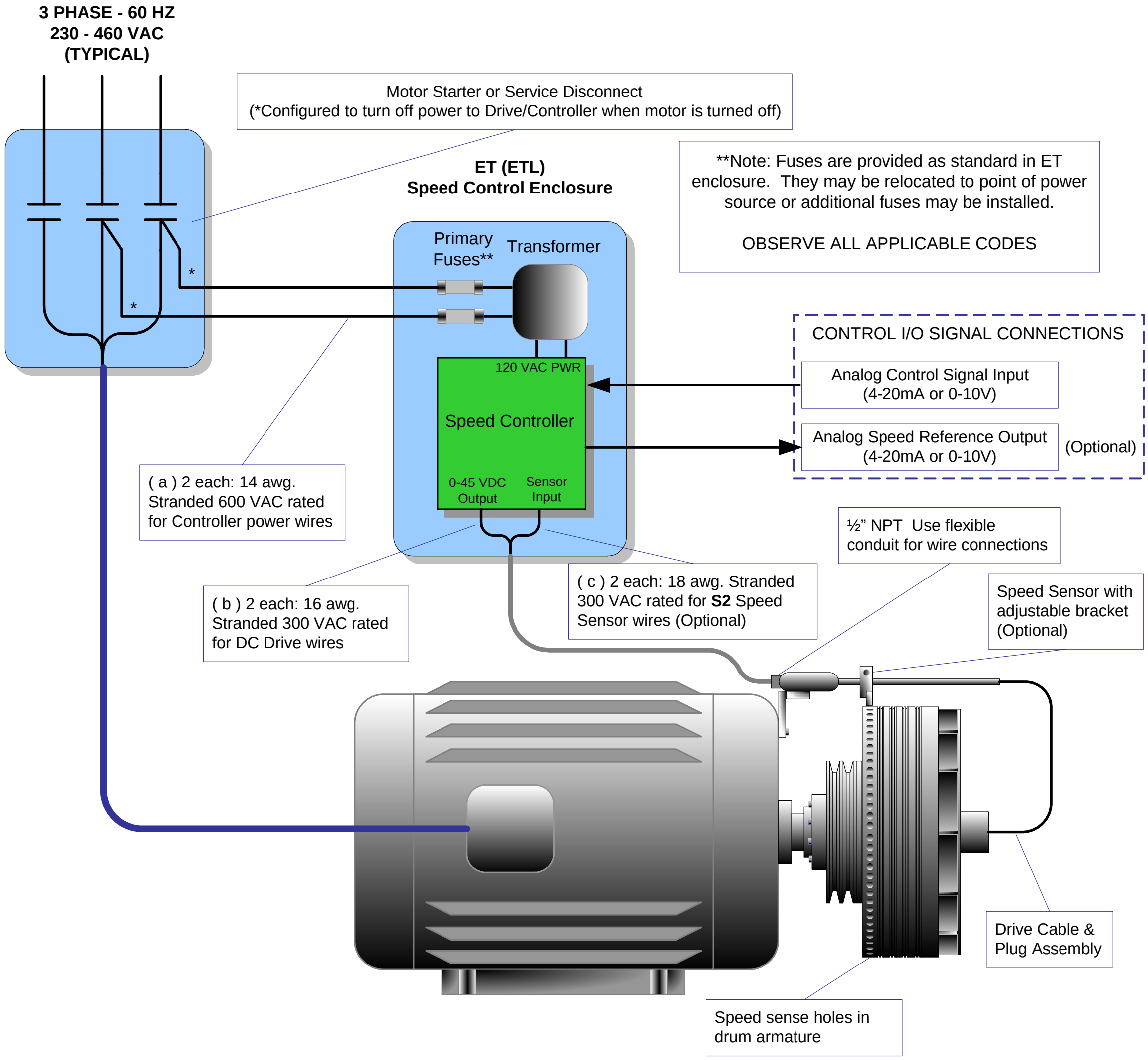
- **ALL SERVICE SHOULD BE PERFORMED BY QUALIFIED PERSONNEL.**
- **ALWAYS TURN OFF (LOCKOUT/TAG-OUT) ALL POWER TO THE MOTOR AND CONTROLS.**
- **BE AWARE OF THE DRIVE'S WEIGHT AND USE PROPER LIFTING EQUIPMENT AND PROCEDURES TO AVOID INJURY. (REFER TO THE SECTION TITLED "EASY PAYBACK® TECHNICAL DATA" IN THIS MANUAL TO DETERMINE THE WEIGHT OF THE SPECIFIC DRIVE MODEL).**
- **OBSERVE ALL SAFETY PRECAUTIONS FOR THIS VARIABLE SPEED DRIVE AS YOU WOULD FOR ALL MOTORS AND OTHER ROTATING EQUIPMENT.**

SYSTEM WIRING LAYOUT W/CABLE SUPPORT ASSEMBLY

The motor bracket-mounted cable support assembly allows for cable support and a convenient wire termination point for the two dc wire connections from the drive to the controller. It also provides support for the optional **S2** two-wire speed sensor and sensor bracket.

For field installation retrofit, the angle bracket and cable support assembly attaches easily to the motor with one of the four motor bolts on the front face of the motor. Be sure to inspect the bolt before installing to make sure there are enough threads to support the bracket. Replace with a longer bolt if necessary.

Once installed, the belts may be tensioned without disconnecting the wires since the cable assembly will move along with the motor as belt tension adjustments are made. For belt replacement, the cable can be easily unplugged and the belts replaced.



1. Use flexible seal-tite steel conduit for running the wires from the junction box to the speed controller enclosure. Keep all High Voltage Power Wires separate from any Control or Signal wires. Observe all applicable electrical & safety codes, and all local code requirements. For OUTDOOR applications, use the enclosure manufacturers' recommended conduit fittings deemed suitable for such situations.

2. Use UL/CSA Listed stranded wire only! **Recommended wire sizes:**

   a. 14 awg. Stranded @ 600 VAC rating for the two single phase line input power wires to the ET controller control transformer (primary fuses).

   b. 16 awg. Stranded @ 300 VAC rating for the two DC wires from the controller to the drive that will be joined in the motor mounted junction box to the factory supplied drive plug-in cable shown on the "Drive Cutaway" page.

   c. 18 awg. Stranded @ 300 VAC rating for the two **S2** speed sensor wires, if used.

3. Allow adequate clearance at the front end of the drive to insure that the cable can plug into the rotary electrical coupling without contacting any rotating components of the drive system. (Typically 1-½" minimum clearance).

INSTALLATION

Drive (read "Safety First" section on next page before working on equipment)

1. **IMPORTANT!** Be sure that the motor shaft conforms to the NEMA standard tolerances. (If the motor shaft is undersized, non-uniform in diameter across the length, or has excessive run-out, this can be problematic to the performance, installation or removal of the drive). **See "Motor Shaft Tolerance Table" in this manual.**
2. Inspect the inside bore of the drive and the motor shaft to be sure they are clean and smooth. Remove any scratches or burrs with sandpaper if necessary so that all surfaces are smooth.
3. Once both surfaces are very clean, spray white lithium grease on both the inside of the drive bore and onto the entire motor shaft. (The objective here is to provide a light film onto the mating surfaces. This will help prevent galling or scratching the motor shaft when positioning the drive on the motor shaft). Carefully wipe off any excess grease on the motor shaft area where the shrink disc will be tightening the drive hub to the motor shaft.
4. Place the shrink-disk on the drive hub with the bolts facing towards the motor. **(NEVER TIGHTEN THE SHRINK-DISC LOCKING BOLTS BEFORE MOUNTING ON THE MOTOR, SINCE THE HUB BORE OF THE DRIVE CAN BE PERMANENTLY CONTRACTED, THUS PREVENTING THE DRIVE FROM FITTING PROPERLY ON THE MOTOR SHAFT).**
5. Lift the drive via the eyebolt and align the Hub Location Mark (Orange Dot) with the center of the motor's shaft keyway slot. Guide the drive onto the motor shaft while keeping the hub mark in alignment with the keyway slot to insure best balance. With the drive properly prepared, the drive should slide onto the shaft smoothly.

   DO NOT FORCE THE DRIVE ON THE MOTOR SHAFT AND NEVER HAMMER ON THE DRIVE OR ALUMINUM FAN.
6. If the fit seems tight or if there is difficulty sliding the drive on the motor shaft, repeat steps 2 through 5.
7. Mount the drive all of the way on the motor shaft, as close to the motor face as possible for optimal balance and to minimize overhung load. With the shrink-disc positioned all the way onto the drive hub, tighten the shrink-disc bolts per the following instructions:
   A. Alternately hand-tighten the shrink-disc locking bolts, making sure that the two collars of the shrink-disc are maintained in an even (parallel) position.
   B. Now tighten all of the bolts one after another with an open-end metric wrench in sequence by approximately ½ turns even if at the beginning some of the bolts require very little effort. Use an 8MM wrench for drive frame sizes Pup and Jr, a 10MM wrench for drive frame sizes 1, 2, 3 & 4, a 13MM for drive frame sizes 5, 6 & 7, and a 17MM wrench for drive frame sizes 8 & 9.
   C. Continue tightening until all of the bolts on the shrink-disc are tight. Since in this application, use of a torque wrench is not practical, Coyote recommends that all shrink-disc bolts be tightened very thoroughly before starting the motor. This is always required to prevent any possibility of slippage between the motor shaft and the drive hub, which could cause galling of the shaft or hub, making removal of the drive from the motor shaft difficult.
8. Once the drive is mounted correctly, align the driven pulley to precisely line up with the drive's sheaves.
9. Install the belts. Be sure to remove the lift eyebolt (if used) from the drum.

Electrical Cable Connections

1. Attach the motor mounted CSA (Cable Support Arm assembly) to the motor.
2. Connect the supplied cable with the **female** plug terminals to the RPCU-2 (rotary power coupling unit) **male** plug terminals. Feed the cable through the pipe of the CSA assembly and make the wire connections to the wires from the controller in the CSA junction box. The purpose of the CSA assembly is for holding the cable wires securely, preventing any rotation of the wires and at the same time not causing any undue pressure on the rotary power coupling. The terminal cable wires may be routed and secured to the rotary power coupling from any direction as long as it does not interfere or come into contact with any of the drive system's rotating parts.
3. Additionally, the optional speed sensor and plastic clamp (if used) can be installed on the same CSA ½" pipe and aligned with the holes/notches on the drum outer diameter. (Follow the appropriate speed sensor mounting instructions and wire connections). The cable can now "float" with the motor to accommodate belt tensioning or belt replacement without damaging the wires or affecting the gap distance between the speed sensor and the speed sensing holes on the drum.
4. The belt guards should be made to clear the drive by 3 to 4 inches with adequate provision for air flow. Additionally, all guards should be constructed with a solid top to prevent any debris from falling onto the drive. ***For safety, the belt guards should always be installed before turning on the motor.**

SAFETY FIRST

WHEN SERVICING, INSTALLING, OR REMOVING THE DRIVE:

- ALL SERVICE SHOULD BE PERFORMED BY QUALIFIED PERSONNEL.
- ALWAYS TURN OFF (LOCKOUT/TAG-OUT) ALL POWER TO THE MOTOR AND CONTROLS.
- BE AWARE OF THE DRIVE'S WEIGHT AND USE PROPER LIFTING EQUIPMENT AND PROCEDURES TO AVOID INJURY. (REFER TO THE SECTION TITLED "EASY PAYBACK® TECHNICAL DATA" IN THIS MANUAL TO DETERMINE THE WEIGHT OF THE SPECIFIC DRIVE MODEL).
- OBSERVE ALL SAFETY PRECAUTIONS FOR THIS VARIABLE SPEED DRIVE AS YOU WOULD FOR ALL MOTORS AND OTHER ROTATING EQUIPMENT.

DRIVE REMOVAL

Drive (read "Safety First" section on previous page before working on equipment)

Alternately loosen each shrink-disc locking bolt by ½ turn at a time until all three elements of the shrink disc are loose on the hub and the drive can be removed from the motor shaft. It is not necessary to remove the locking bolts completely.

Slide the drive off of the motor shaft. In most instances, the drive will easily separate from the motor shaft. However, **in the event the drive is seized on the motor shaft even after the shrink-disc is loose on the hub, Coyote recommends the following method for correct removal:**

1. Unplug the cable wires to the rotary coupling located on the center of the fan.
2. Remove the main fan mounting bolts (6 each).
3. Carefully remove the fan from the drive and then unplug the internal wires that connect the drive coil to the rotary electrical coupling. (Set the Fan aside).
4. After the fan is removed from the drive, the drive's hub mounting bolts will be accessible and you can see the end of the motor shaft down the center of the drive hub bore.
5. Remove two of the hub mounting bolts, install a BAR PULLER** using the same bolts or longer bolts if necessary to secure the puller to the hub. **CAUTION!!! If longer bolts are required, be sure to first carefully check that the longer bolts DO NOT BOTTOM OUT AGAINST THE BEARING on the inside of the drive to avoid damage of the bearing shields.** (The bolts selected to use with the puller should be just long enough to adequately thread into the hub the same distance as the original bolts).
6. Adjust the center adjustment bolt of the puller against the end of the motor shaft until the drive is removed from the motor. (You may also insert a short steel spacer into the hub opening that is slightly smaller in diameter of the hub bore / motor shaft diameter to prevent wear on the end of the motor shaft face when pushing off with the puller bolt. This is recommended if removal is more difficult than normal).

**(Alternatively, a custom puller plate can be fabricated with a welded nut and adjustment bolt instead of using a bar type puller. Coyote recommends using a grade 8 nut and bolt as a minimum requirement).

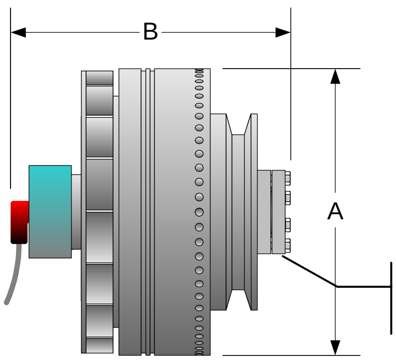
<u>DO NOT use a puller type that wraps around the drum, and DO NOT apply excess pressure to, or strike the drive drum as the drum can be distorted</u>. Only attach the puller to the center hub or the spider assembly and push off against the end of the motor shaft after completely loosening the shrink disc.

Easy PAYBACK® Technical Data (Pup and Jr)

Easy PAYBACK® Brushless v-belt style, shaft-mounted variable speed drives

For use with 4 Pole, 60 Hz, 1750 RPM Motors.

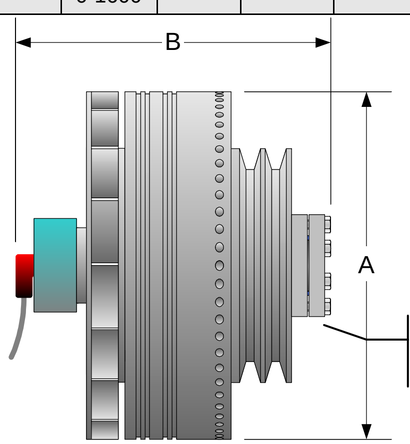
					PUP DRIVE MODEL SELECTION							
Motor HP	Output Speed Range (RPM)	Motor Frame	Motor Shaft Dia.	Number of Belts & (Type)	PUP-1A42*		PUP-1A40		PUP-1A38		PUP-1A36*	
1/3	0-1700	56, 56H	0.625 (5/8")	1 (A, AX)	4.45	4.20	4.25	4.00	4.05	3.80	3.85	3.60
1/2	0-1650											
3/4	0-1600											
					OUTSIDE (O.D.)	DATUM "A"	OUTSIDE (O.D.)	DATUM "A"	OUTSIDE (O.D.)	DATUM "A"	OUTSIDE (O.D.)	DATUM "A"
					PUP DRIVE PULLEY DIAMETERS**							



Model Size	A	B	Weight (lbs.)
PUP-1A**	6.50	6.10	19.5

"Size 24 shrink disc assembly"
(6 ea.) 8mm locking bolts.

					JR DRIVE MODEL SELECTION							
Motor HP	Output Speed Range (RPM)	Motor Frame	Motor Shaft Dia.	Number of Belts & (Type)	JR-2A50*		JR-2A48		JR-2A46		JR-2A44*	
1	0-1700	143T	0.875 (7/8")	2 (A, AX)	5.25	5.00	5.05	4.80	4.85	4.60	4.65	4.40
1-1/2	0-1650	145T										
2	0-1600											
					OUTSIDE (O.D.)	DATUM "A"	OUTSIDE (O.D.)	DATUM "A"	OUTSIDE (O.D.)	DATUM "A"	OUTSIDE (O.D.)	DATUM "A"
					JR DRIVE PULLEY DIAMETERS**							



Model Size	A	B	Weight (lbs.)
JR-2A**	7.80	6.90	29.5

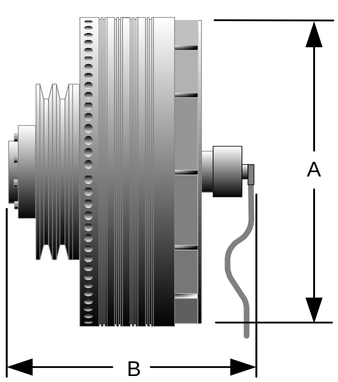
"Size 30 shrink disc assembly"
(7 ea.) 8mm locking bolts.

*** Normally stocked sizes. ** Contact factory for custom drive pulley sizes.**

Data subject to change without notice.

EASY PAYBACK® TECHNICAL DATA

AC Motor Data (4 Pole, 60 Hz, 1750 RPM)				Easy-PAYBACK® Brushless v-belt style, shaft-mounted variable speed drive. PAYBACK® RELIABILITY…"PURE & SIMPLE" ™		
MOTOR HP	MOTOR FRAME ODP (TEFC)	MOTOR SHAFT DIAMETER	PAYBACK® Drive Model	Output Speed Range (RPM)	Number of Belts & (Type)	Pulley OD (Inches)
3	182T	1.125	EASY-1	0-1700	2 (3VX)	5.30
5	184T			0-1600		
7.5	213T	1.375	EASY-2	0-1700	2 (3VX)	6.00
10	215T			0-1600		
15	254T	1.625	EASY-3	0-1700	2 (5VX)	7.10
20	256T			0-1600		
25	284T	1.875	EASY-4	0-1700	3 (5VX)	8.00
30	286T			0-1650		
40	324T	2.125	EASY-5	0-1700	3 (5VX)	9.00
50	326T			0-1650		
60	364T	2.375	EASY-6	0-1700	4 (5VX)	9.25
75	365T			0-1650		
100	404T (405T)	2.875 (**3.375)	EASY-7	0-1700	5 (5VX)	11.30
125	405T (444T**)			0-1650		
150	444T (445T)	3.375	EASY-8	0-1700	6 (5VX)	13.20
200	445T (447T)	3.375	EASY-9	0-1700	6 (5VX)	13.20

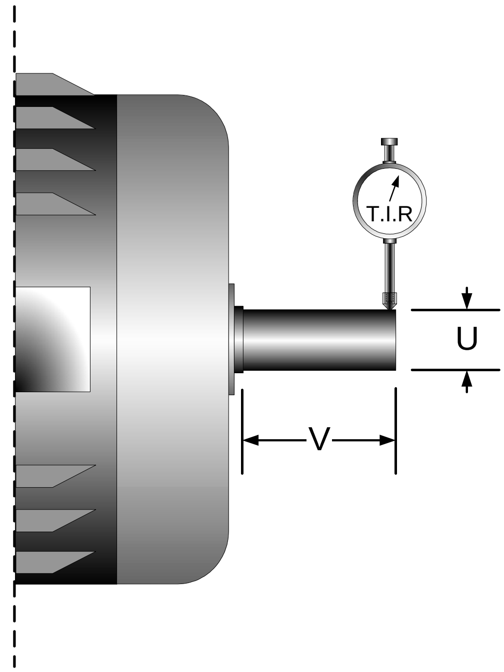


DATA SUBJECT TO CHANGE WITHOUT NOTICE.			
Model Size	**A**	**B**	**Weight (lbs.)**
Easy-1	9.00	7.50	43
Easy-2	10.50	8.25	69
Easy-3	12.30	9.50	113
Easy-4	14.00	10.50	176
Easy-5	16.30	11.50	266
Easy-6	17.30	12.50	315
Easy-7	21.00	15.00	564
Easy-8	24.00	16.00	698
Easy-9	26.00	17.00	937

MOTOR SHAFT TOLERANCE TABLE (NEMA T)

Coyote's PAYBACK® variable speed drives are designed to be used with any typical 4-pole, 50 or 60HZ NEMA T frame motor.

Before installing the drive however, always verify that the motor meets the standard shaft diameter and T.I.R. (total indicator reading) tolerances of (MG1-4.9.7) in the chart below.



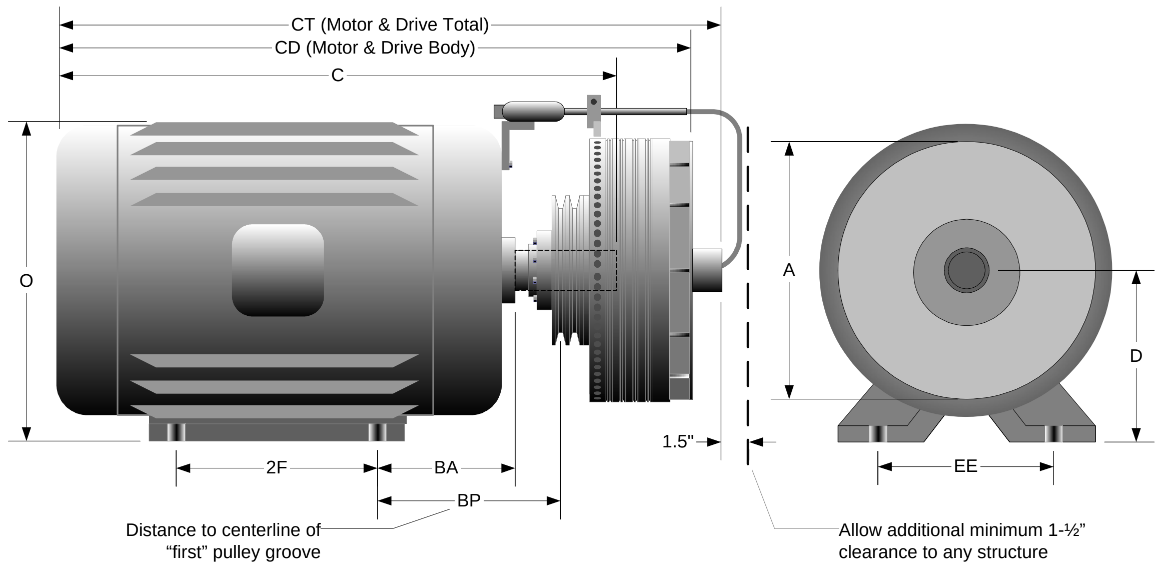
ALL DIMENSIONS IN INCHES

MOTOR FRAME	**SHAFT LENGTH** (Typical) **V**	**SHAFT DIAMETER** TOLERANCE **U**	**T.I.R.** (Total Indicator Reading) Shaft Runout Tolerance
182T/184T	2.750	1.1250 1.1245	(.002) +-.0010
213T/215T	3.375	1.3750 1.3745	(.002) +-.0010
254T/256T	4.000	1.6250 1.6240	(.002) +-.0010
284T/286T	4.625	1.8750 1.8740	(.003) +-.0015
324T/326T	5.250	2.1250 2.1240	(.003) +-.0015
364T/365T	5.875	2.3750 2.3740	(.003) +-.0015
404T/405T	7.250	2.8750 2.8740	(.003) +-.0015
444T/445T/447T	8.500	3.3750 3.3740	(.003) +-.0015

NOTE: For new applications, drive may be purchased complete with new motor. See ***Easy PAYBACK® Motor & Drive "COMBO" Dimensions***.

Easy PAYBACK® Motor & Drive “COMBO” Dimensions

TEFC (Cast Iron) Nema-T Frame Epact-2 High Efficiency Motor
with Easy-PAYBACK® Magnetic-Coupled Adjustable Speed Drive



Sized for 1750 RPM (4 Pole) TEFC ONLY								All Dimensions are in “INCHES”					
COMBO Model													
Drive	**(HP)**	TEFC Frame	2F	C	CD	CT	BA	BP	O	A	EE	D	# Grooves (STYLE) Diameter
EASY-1	**M3**	182T	4.50	15.6	19.0	21.0	2.75	4.0	9.1	9.0	7.5	4.50	2(3V)
	M5	184T	5.50	16.8	20.2	22.2							5.30”
EASY-2	**M7.5**	213T	5.50	17.7	21.0	23.0	3.50	5.0	10.9	10.5	8.5	5.25	2(3V)
	M10	215T	7.00	19.2	22.5	24.5							6.00”
EASY-3	**M15**	254T	8.25	22.0	25.5	27.5	4.25	5.7	13.2	12.3	10.0	6.25	2(5V)
	M20	256T	10.00	29.8	27.3	29.3							7.10”
EASY-4	**M25**	284T	9.50	28.8	32.4	34.4	4.75	5.7	14.6	14.0	11.0	7.00	3(5V)
	M30	286T	11.00	28.8	32.4	34.4							8.00”
EASY-5	**M40**	324T	10.50	29.9	34.5	36.5	5.25	7.0	16.0	16.3	12.5	8.00	3(5V)
	M50	326T	12.00	31.1	35.7	37.7							9.00”
EASY-6	**M60**	364T	11.25	32.2	37.0	39.0	5.88	7.2	18.2	17.3	14.0	9.00	4(5V)
	M75	365T	12.25	33.6	38.4	40.4							9.25”
EASY-7	**M100**	405T	13.75	39.8	45.7	47.7	6.62	9.1	19.9	21.0	16.0	10.00	5(5V)
	M125	444T	14.50	46.2	50.9	52.9	7.50	10.0	22.1		18.0	11.00	11.30”
EASY-8	**M150**	445T	16.50	48.6	54.3	56.3	7.50	9.3	22.1	24.0	18.0	11.00	6(5V)
													13.2”
EASY-9	**M200**	447T	20.00	49.1	55.8	57.8	7.50	9.3	23.0	26.0	18,0	11.0	6(5V)
													13.2

Pulley Selection

IMPORTANT: *The new driven pulley should always be sized large enough so that when the system is operating at its absolute maximum required rpm, the PAYBACK® Drive should also be operating at its maximum speed.*

By correctly sizing the driven pulley in this manner, the system will be more efficient.

> *Selecting too small of a driven pulley will waste energy.*

Always take an amp reading of the existing motor at full load and continue to monitor the motor amps after the retrofit.

> *With the proper sized pulley, the system will never exceed the full load amp rating of the motor (including service factor), even in full speed lock-up mode.*

See Manual Lock-Up Instructions for Full Speed Bypass.

Selecting the belts & driven pulley to match the PAYBACK® Drive's sheaves is easy.

Step 1: First, measure the existing driven shaft diameter for the new bushing replacement. Next, measure the center-to-center distance between the existing motor shaft and driven shaft. Observe the belt take-up adjustment on the motor base and ALLOW for a midrange take-up measurement to start with for calculating the new belt sizes.

Step 2: Determine the RATIO of the existing motor pulley and driven pulley by dividing the (DRIVEN) pulley diameter by the motor pulley diameter.

$$\frac{\text{(DRIVEN) Pulley DIAMETER}}{\text{Motor Pulley DIAMETER}} = \text{(WORKING RATIO)}$$

Step 3: Multiply the new PAYBACK® Drive's pulley diameter by the working ratio to determine the calculated new (DRIVEN) pulley diameter.

PAYBACK® Pulley DIA. X (WORKING RATIO) = **Calculated* DRIVEN Pulley DIA

Step 4: Select the nearest size pulley from a sheaves selection book, matched with the correct bushing to fit the DRIVEN shaft. *Always try the LARGER sheave first whenever possible. Using the new selected DRIVEN pulley diameter in conjunction with the new drive pulley diameter and the center-to-center measurement, size the new belts from a belt selection guide. Use notched "VX" style belts for best efficiency.

> *If you need assistance in correctly sizing your pulley and belts, or have any other questions about your application, please contact us at:*
>
> ***Phone:** 817.485.3336 or toll free at: 888.557.7873*
>
> ***Fax:** 817.485.9437*
>
> ***E-mail:** info@payback.com*

EASY PAYBACK® ORDERING INFORMATION

IMPORTANT: Always verify motor frame and shaft sizes.

Easy PAYBACK® Drive Selection

To select the correct size drive, simply locate the horsepower and frame size of you're AC motor in the "Technical Data" chart on the previous page.

> *EXAMPLE: A 50 HP motor with a 326T frame would require an Easy-5 PAYBACK® Drive.*

If your particular requirements are not listed, please contact the factory.

Pulley Selection

For optimum efficiency, the driven pulley should be selected so that when the system is at the maximum designed speed (RPM), the PAYBACK® Drive is also operating as closely as possible to its maximum output speed.

> *The driven pulley should always be sized large enough so the motor does not exceed its full load amp rating when the system is at the maximum operating load/RPM.*

CONSULT FACTORY FOR AVAILABLE ALTERNATIVE PULLEY STYLES AND DIAMETERS

Belt Selection

For maximum belt efficiency, use notched (VX) style V-Belts.

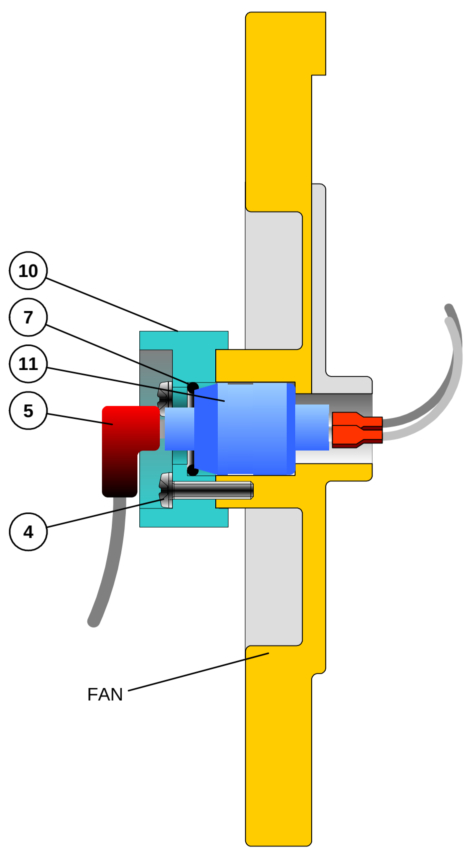
RPCU-2 INSTALLATION

After verifying that the controller is supplying adjustable DC voltage to the RPCU-2 (Rotary Power Coupling Unit) drive terminals, but the drive is not engaging (turning), or varying the load rpm correctly, then replace the RPCU-2.

> *Replacement time: 5 minutes, typical.*
> *Tools required: Phillips Screw Driver, Needle-Nose Pliers.*

1. **SAFETY FIRST!** Be sure to TURN OFF ALL POWER to the motor and drive unit.
2. Disconnect the drive power cable (5) from the RPCU-2 (11) on the Drive.
3. Carefully unscrew the three Phillips screws (4a) with lock-washers (4b), while holding the end-cap assembly in place.
4. Remove the end-cap (10), note the rubber O-Ring washer (7) in place against the RPCU-2 (11).
5. Gently pull out the RPCU-2 (11) to the full extension and disconnect (un-plug) the inner terminals with the Needle-Nose pliers.
6. Connect the new RPCU-2 (11) to the inner terminals on the fixed (NON-BEARING) side of the coupler.
7. Put the RPCU-2 (11) back in place, re-assemble with end-cap (10) and O-Ring washer (7) against the RPCU-2 (11), insert and tighten the three Phillips screws (4a) with lock-washers (4b).
8. Connect the drive power cable (5) to the bearing side of the new RPCU-2 on the drive, being careful not to bend or twist the prongs.

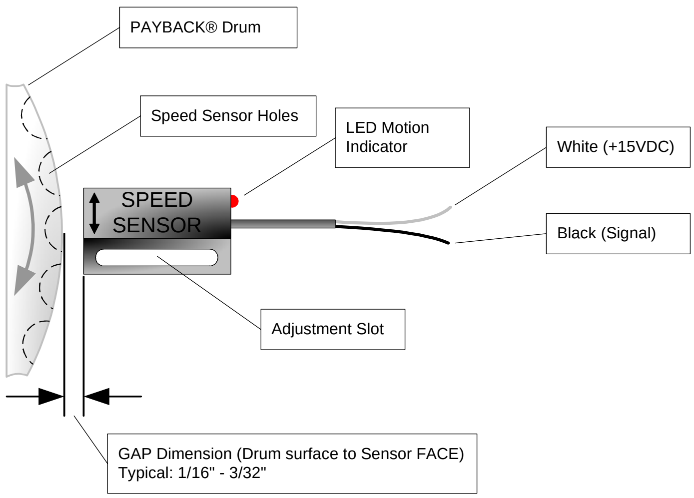
   BEFORE STARTING MOTOR, CHECK TO BE SURE RPCU-2 IS CORRECTLY INSTALLED. YOU SHOULD BE ABLE TO HOLD THE POWER CORD STATIONARY WHILE ROTATING THE FAN BY HAND. VERIFY THAT THE CORD DOES NOT RUB ANY ROTATING SURFACE OF THE DRIVE.
9. Turn power on and start up system. Any questions, call Service Department toll free at 1.888.557.7873.



Item	Description	QTY
5	DRIVE POWER CABLE	1
4a	PBX-BOLT 10-24X7/8	3
4b	PBX-LWASHER-10	3
7	PBX-O-RING	1
10	PBX-ENDCAP-2	1
11	PBX-RPCU-2	1

SPEED SENSOR ORIENTATION & INSTALLATION

To be installed by trained, qualified service personnel only. Always observe all safety precautions regarding rotating machinery and all applicable electrical codes.



1: The Coyote 2-wire Speed Sensor MUST BE ORIENTED as shown above with respect to the direction of travel of the rotating speed sensor holes to be detected on the drum.

Mounting the sensor in any plane other than as shown above will cause erratic operation.

2: Always adjust the gap between the drum surface and sensor face to the maximum safe operating distance, typically 1/16 – 3/32 inch.

Note: *Setting the gap too close may not allow for the natural expansion of the drum when operating normally and may damage the sensor.*

Manual Lockup Instructions

For Emergency Full-Speed By-Pass

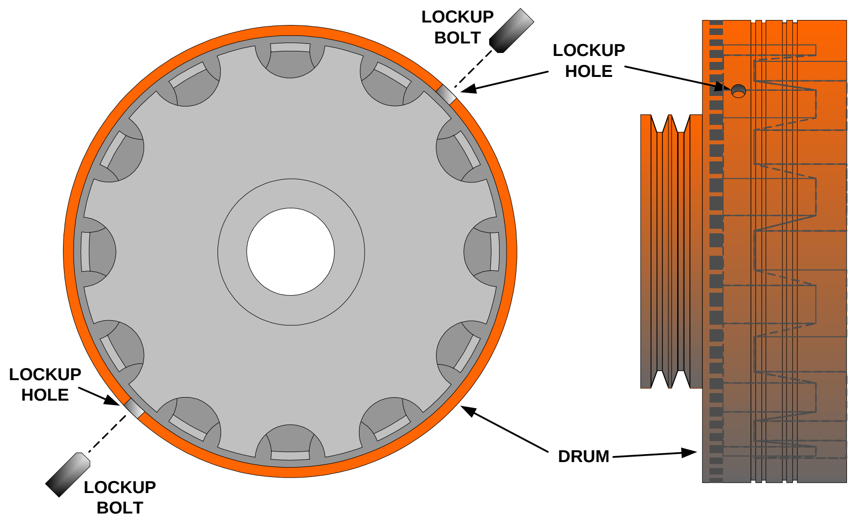
WARNING

BEFORE BEGINNING THE MANUAL LOCKUP PROCEDURE, ALWAYS REMOVE POWER FROM BOTH THE CONTROL AND MOTOR WHEN INSTALLING OR REMOVING LOCKUP BOLTS, AND/OR WHEN SERVICING THE DRIVE. ALWAYS LOCK OUT THE POWER TO THE MOTOR TO PREVENT ACCIDENTAL STARTUP WHILE PERFORMING THIS PROCEDURE.

1. Select the appropriate size lockup bolt for your drive from the chart below.

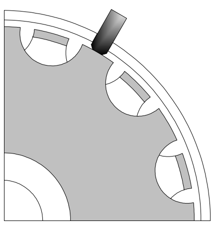
DRIVE MODEL SIZE	(QTY EA) LOCKUP BOLT SIZE
SIZE 1, 2, 3	(2 EA) 3/8 x 3/4L x 16TPI
SIZE 4, 5, 6	(2 EA) 1/2 x 1L x 13TPI
SIZE 7, 8, 9	(4 EA) 3/4 x 1-1/2L x 10TPI

2. Locate the threaded lockup holes on opposite sides of the drum's circumference.

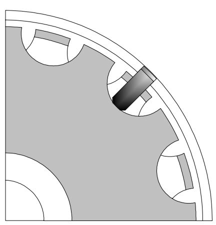


3. Screw the lockup bolts into the holes and **ALTERNATELY HAND TIGHTEN** until they each make contact with the finger peaks of the inner portion of the drive as shown below.

   IMPORTANT: If your drive incorporates the speed sensor option, be sure that the lockup bolts do not interfere or come in contact with the speed sensor. The speed sensor can be temporarily pivoted out of the way and securely repositioned on the support arm to assure adequate clearance from the rotating lockup bolts. After the lockup bolts are removed, the speed sensor gap can be properly re-adjusted. Follow the "Speed Sensor Orientation and Installation" instructions in this manual.



CORRECT ALIGNMENT



INCORRECT ALIGNMENT

4. **NOW TIGHTEN LOCKUP BOLTS SECURELY** with a wrench, and then you may restore power to the motor. The drive will now run at motor speed.

MAINTENANCE GUIDE

PAYBACK® patented drives are less complex and contain fewer critical parts, as compared to all other VSD technologies, thereby minimizing routine maintenance requirements.

Lubrication

Drives:

All PAYBACK® variable speed drives use high quality, permanently lubricated-for-life ball bearings. There is no need for re-lubrication. Ultra long bearing life expectancy is attributed to the unique patented design.

Motors:

LINCOLN models (1 – 200 HP) 1800 RPM, ODP & TEFC, PREMIUM EFFICIENCY

56 through 145T Permanently lubricated ball bearings. No re-lubrication necessary

182T through 449T Recommended Greases (Lithium based NLGI No. 2 consistency):

Chevron SRI #2

Shell-Alvania #2

Mobile-Movilux #2

Re-lubrication Period

Based on 1750 RPM, 24hrs per day (Severe) Duty:

Lubricate every 4 months (1 oz.)

Based on 1750 RPM, 8hrs per day (Standard) Duty:

Lubricate every 12 months (1 oz.)

DO NOT OVER GREASE

Excessive lubrication can cause premature bearing failure.

All Other Motor Brands:

Refer to the specific motor manufacturer's recommended lubrication instructions.

Field Replaceable Coupler (See RPCU-2 Installation Instructions):

The RPCU-2 (Rotary Power Coupling Unit) is a simple, field replaceable plug-in cartridge that is an economical alternative to conventional solid brushes and slip rings for transferring the low power current output of the stationary dc controller to the PAYBACK® Drive's rotating coil.

Typical life expectancy (varying conditions) – Replacement Period

Based on 1750 RPM, 24hrs per day Duty: (2 – 4 Years)

Based on 1750 RPM, 8hrs per day Duty: (5 – 6 Years)

START UP PROCEDURE

“Easy-PAYBACK®” Magnetic Coupled Variable Speed Drives with “ET” series Speed Controls

Before starting, check and make sure the two emergency bypass lock-up bolts located on the outside diameter of the drive’s drum, have been removed from the drive. **See manual lockup instructions.**

The controls may or may not be installed on the equipment when it arrives at the job site. Please read the following instructions and verify that all of the following steps are completed for the initial field set up.

“ET” Control Enclosure Installation:

Mount the “ET” PAYBACK® control enclosure in close proximity to the motor starter or motor service disconnect (whichever is the final device feeding power to the motor). Optionally, at customer preference, the controller can also be remotely mounted a distance away from the equipment. The controller typically is to be connected to two of the high voltage power wires going to the motor to insure that when the motor is switched off, all power to the controller and drive is also turned off. (The purpose for the transformer in the “ET” controller enclosure is to conveniently provide isolated, 115 VAC single phase power to the controller circuitry when the motor is running.)

The panel with associated components may be easily removed from the enclosure by removing the four panel mounting screws and unplugging TB1 and TB2 plug terminals from the speed controller circuit board. This will allow you to drill the necessary holes for the wires to be connected from the power source, drive and control signal without damage to the controller components. (See appropriate controller connection diagram for terminal connections.) Be sure to comply with all local electrical codes and observe safe wiring practices.

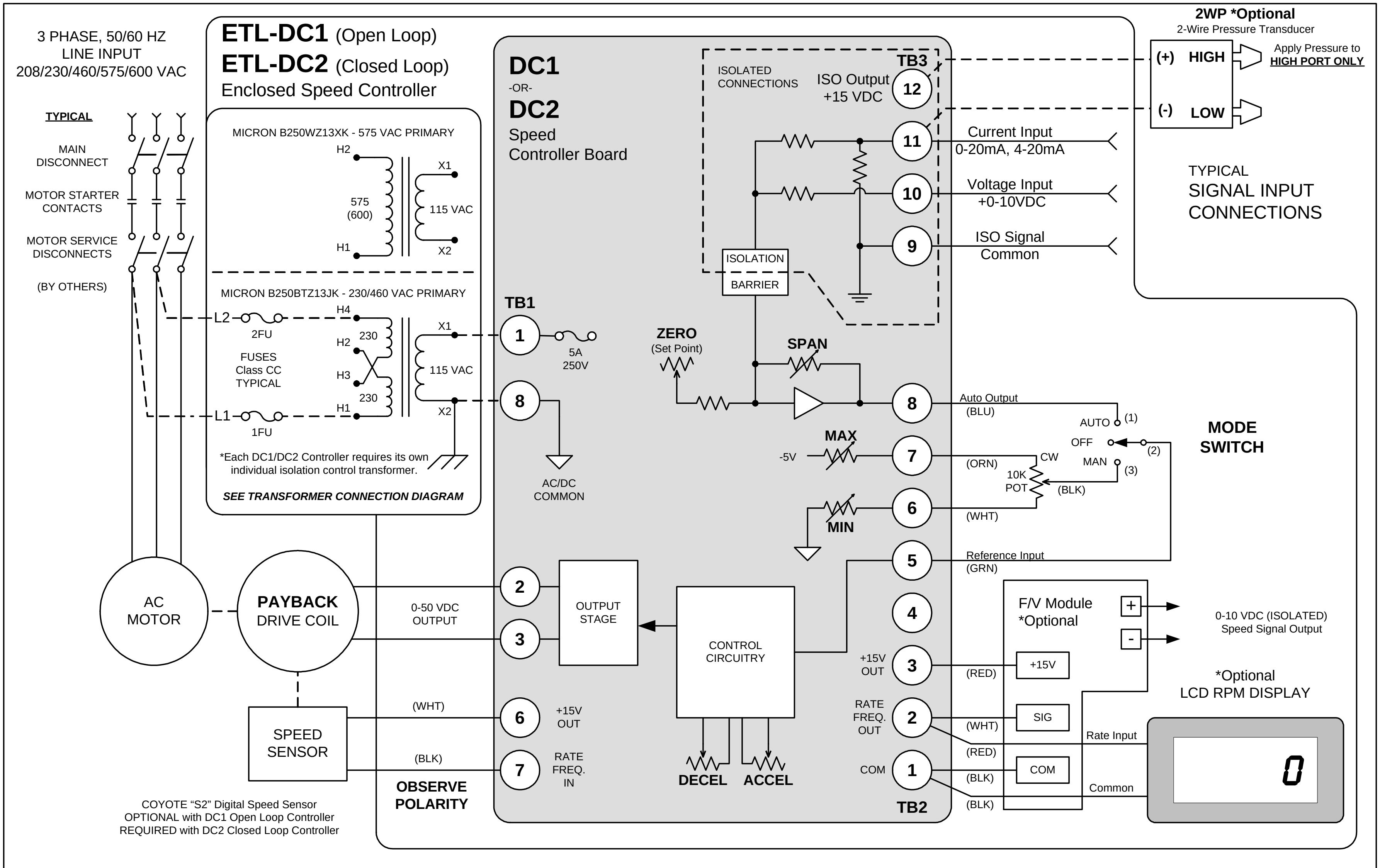
The minimum wire requirements are as follows:

> The two high voltage power wires that will connect to the line input fuse block assembly in the control enclosure should be at least 14-gauge/stranded/600 volt insulation rating. (A 2-conductor stranded, 300 volt rated, cable and plug assembly is provided by Coyote for connecting to the drive end for powering the drive’s DC coil.) See also: PAYBACK® Drive System Wiring Layout Diagram and all relevant electrical drawings.

Attention Electrician/Installer, Before Applying Power:

1. Turn OFF ALL POWER to the “ET” enclosure.
2. Turn the “Man-Off-Auto” switch on the front enclosure cover to the “OFF” position.
3. Open the “ET” control enclosure and check the control transformer primary jumpers in the “ET” enclosure to verify that they are correct for your specific line voltage. Re-jumper correctly, if required.
4. UN-PLUG the TB1 power plug to the speed controller circuit board.
5. Turn the motor on briefly to verify correct rotation of the motor. Correct motor phase wiring if necessary.
6. With an ac voltmeter, check across the unplugged TB1 plug, terminals 1 and 8 to verify that there is 115 VAC when the POWER IS TURNED ON to the control transformer. (The Speed controller circuit voltage input power requirement is 115 VAC +/- 10% typ.)
7. If you DO NOT read 115 VAC across terminals 1 and 8 of the TB1 plug, then repeat steps 1 – 6. If you DO read 115 VAC across terminals 1 and 8 of the TB1 Plug, turn power OFF and then re-install plug TB1 to the controller board.

The PAYBACK® drive system is now ready for manual operation. The system is now ready for check out under remote control conditions. Refer to relevant calibration procedures and complete the WARRANTY registration form.



NOTES

*The control power transformer is configured to assure that single phase 115 VAC power to the controller is available ONLY when the motor is running.
EACH DC1 or DC2 CONTROLLER MUST BE CONNECTED TO ITS OWN INDIVIDUAL POWER ISOLATION TRANSFORMER FOR PROPER OPERATION.
DO NOT CONNECT ADDITIONAL CONTROLLERS TO THE SAME TRANSFORMER. KEEP ALL HIGH VOLTAGE WIRES SEPARATE FROM OTHER WIRES.
***The optional remote mounted pressure sensor, if used, should always be located on the duct a reasonable distance from the blower to avoid turbulence error.
The tubing length to the sensor should be kept as short as possible to reduce the possibility of response delays which could contribute to system “hunting”.
DO NOT RUN POWER WIRES AND SIGNAL WIRES IN THE SAME CONDUIT...KEEP SEPARATE. OBSERVE ALL ELECTRICAL AND SAFETY CODES.

DC1/DC2 variable speed controller with isolated input conditioning circuitry that accepts and follows a standard voltage or current signal, or optionally, the signal from a Coyote 2WP (Two-wire pressure transducer) for stand alone applications to maintain a constant static pressure set point.
See applicable: SIGNAL FOLLOWING or PRESSURE SET POINT MODE calibration instructions
Designed and manufactured in the U.S.A.

COYOTE ELECTRONICS, INC.
4701 Old Denton Road
Fort Worth, Texas 76117
www.payback.com

Phone: 817.485.3336
Fax: 817.485.9437

ETL-DC1/DC2 UNIVERSAL

DC1/DC2 Speed Controller with 115 VAC control transformer and optional LCD display, F/V Feedback & Pressure Sensor

SIZE	FSCM NO	DWG NO	REV
A		BD-000-001-10	D
SCALE NONE		SHEET 1 OF 1	

SIGNAL FOLLOWING MODE SETUP PROCEDURE

The following adjustments apply to DC1/DC2 SIGNAL FOLLOWING applications only!

For Stand-Alone PRESSURE SET POINT adjustment procedure: See "DC1/DC2 Pressure Set Point Mode Setup Procedure".

Your **DC1/DC2** controller has been pre-calibrated for your convenience and some of the settings may be factory sealed to prevent accidental adjustments in the field. Some minor adjustments may be necessary to accommodate your particular application**. VERY IMPORTANT!** We recommend that you monitor the motor current with a clamp-on amp meter while making these adjustments.

IN ALL CORRECTLY SIZED APPLICATIONS, YOU SHOULD ALWAYS BE ABLE TO OPERATE THROUGHOUT THE ENTIRE SPEED RANGE WITHOUT EXCEEDING THE MAXIMUM FULL LOAD AMPS OF THE MOTOR. THIS ALSO APPLIES WHEN IN FULL SPEED LOCKUP MODE.

TO ENSURE THAT YOUR APPLICATION ALWAYS OPERATES AT MAXIMUM EFFICIENCY:

The driven sheaves should always be sized large enough so that when the system is at its maximum required operating RPM/CFM, etc., the PAYBACK® drive is also operating as closely as possible to its maximum obtainable output speed.

Note that the circuit board potentiometers are the 20-turn type allowing for precise control settings.

I. MANUAL MODE ADJUSTMENTS (Be sure to monitor motor current as described above)

1. Turn the 3-way selector switch to the **MANUAL** position.
2. Set the operator speed control knob full counterclockwise (minimum on dial).
3. Adjust the **MIN pot** on the DC1/DC2 circuit board **for desired minimum speed**.

   (USUALLY FACTORY PRESET FOR ZERO OUTPUT, with LED indicator ON.)
4. Now slowly turn the operator speed control knob up to full clockwise (maximum on dial).
5. Adjust the **MAX pot** on the DC1/DC2 circuit board **for maximum desired speed**. OBSERVE actual RPM reading on the meter, if supplied.

   To avoid dead band at the top end of the speed range DO NOT OVER-ADJUST THIS SETTING.

   Note: The LCD speed meter has been factory pre-calibrated. When a speed meter is not supplied, we recommend using a hand held optical tachometer to monitor the output speed of the drive.

   The drive may now be manually operated throughout the entire speed range with the actual speed indicated by the speed meter.
6. It may be necessary to repeat steps 2 through 5 to fine-tune the final adjustments.
7. For smooth acceleration (Soft-Start) during initial startup, turn the **ACCEL pot** clockwise to lengthen the ramp of acceleration.

   This feature virtually eliminates belt squealing during startup of the drive and is typically factory adjusted, although some situations may require further adjustment.

   Note: The **DECEL pot** has been factory set for minimum (full counter clockwise).

II. AUTO MODE ADJUSTMENTS (Be sure to monitor motor current as described above)

1. Turn the 3-way selector switch to the AUTO position.
2. With the external input signal at minimum, i.e.: 4ma for 4-20ma input, adjust for desired **minimum** speed with the **ZERO pot** on the DC1/DC2 circuit board.
3. With the external input signal at maximum, i.e.: 20ma for 4-20ma input, adjust for desired **maximum** speed with the **SPAN pot** on the DC1/DC2 circuit board.

   To avoid dead band at the top end of the speed range DO NOT OVER-ADJUST THIS SETTING.

   Check to make sure minimum adjustment is still correct. Fine tune until desired span is reached.

IF FOR ANY REASON, YOUR DRIVE FAILS TO OPERATE PROPERLY AFTER YOU HAVE PERFORMED THE ABOVE PROCEDURES, PLEASE CALL THE FACTORY FOR FURTHER INSTRUCTIONS AT **817.485.3336**.

PRESSURE SET POINT MODE SETUP PROCEDURE

The following adjustments apply to DC1/DC2 PRESSURE SET POINT applications only!

For SIGNAL FOLLOWING adjustment procedure: See "DC1/DC2 Signal Following Mode Setup Procedure".

Your **DC1/DC2** controller has been pre-calibrated for your convenience and some of the settings may be factory sealed to prevent accidental adjustments in the field. Some minor adjustments may be necessary to accommodate your particular application**. VERY IMPORTANT!** We recommend that you monitor the motor current with a clamp-on amp meter while making these adjustments.

IN ALL CORRECTLY SIZED APPLICATIONS, YOU SHOULD ALWAYS BE ABLE TO OPERATE THROUGHOUT THE ENTIRE SPEED RANGE WITHOUT EXCEEDING THE MAXIMUM FULL LOAD AMPS OF THE MOTOR. THIS ALSO APPLIES WHEN IN FULL SPEED LOCKUP MODE.

TO ENSURE THAT YOUR APPLICATION ALWAYS OPERATES AT MAXIMUM EFFICIENCY:

The driven sheaves should always be sized large enough so that when the system is at its maximum required operating RPM/CFM, etc., the PAYBACK® drive is also operating as closely as possible to its maximum obtainable output speed.

Note that the circuit board potentiometers are the 20-turn type allowing for precise control settings.

I. MANUAL MODE ADJUSTMENTS (Be sure to monitor motor current as described above)

1. Turn the 3-way selector switch to the **MANUAL** position.
2. Set the operator speed control knob full counterclockwise (minimum on dial).
3. Adjust the **MIN pot** on the DC1/DC2 circuit board **for desired minimum speed**.

   (USUALLY FACTORY PRESET FOR ZERO OUTPUT, with LED indicator ON.)
4. Now slowly turn the operator speed control knob up to full clockwise (maximum on dial).
5. Adjust the **MAX pot** on the DC1/DC2 circuit board **for maximum desired speed**. OBSERVE actual RPM reading on the meter, if supplied.

   To avoid dead band at the top end of the speed range DO NOT OVER-ADJUST THIS SETTING.

   Note: The LCD speed meter has been factory pre-calibrated. When a speed meter is not supplied, we recommend using a hand held optical tachometer to monitor the output speed of the drive.

   The drive may now be manually operated throughout the entire speed range with the actual speed indicated by the speed meter.
6. It may be necessary to repeat steps 2 through 5 to fine-tune the final adjustments.
7. For smooth acceleration (Soft-Start) during initial startup, turn the **ACCEL pot** clockwise to lengthen the ramp of acceleration.

   This feature virtually eliminates belt squealing during startup of the drive and is typically factory adjusted, although some situations may require further adjustment.

   Note: The **DECEL pot** has been factory set for minimum (full counter clockwise).

II. AUTO MODE ADJUSTMENTS (Be sure to monitor motor current as described above)

PRESSURE SENSOR SIGNAL USED AS A SET POINT SPEED CONTROL

1. Turn the 3-way selector switch to the **AUTO** position.
2. Adjust for the desired pressure set point via the **ZERO** pot, located on the DC1/DC2 board.

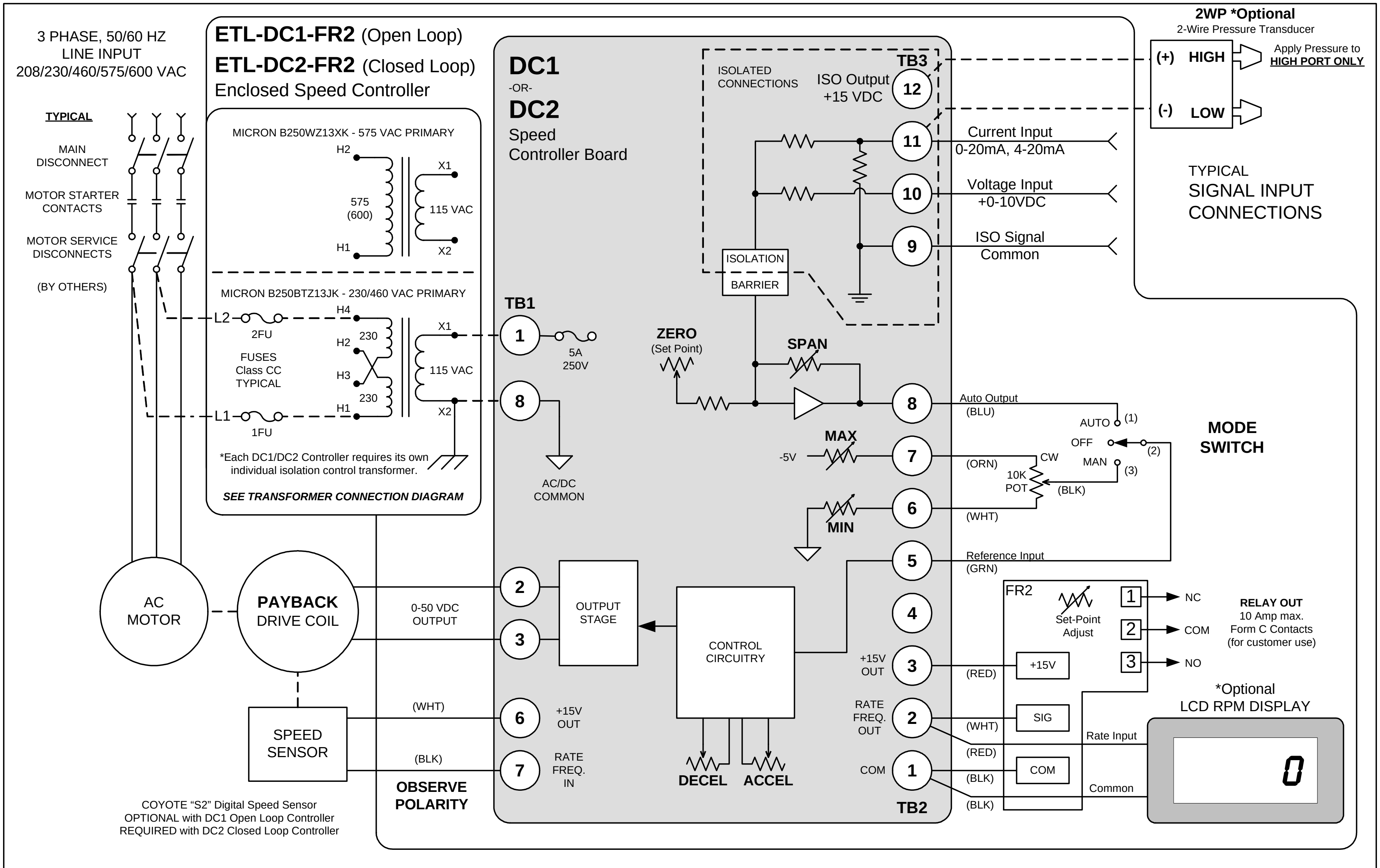
   Note that the **SPAN** potentiometer which is also located on the DC1/DC2 circuit board is factory set, typically 4 to 5 turns from maximum clockwise allowing for higher gain conditioning of the pressure transmitter input signal for proper set point mode operation.

III. 2WP PRESSURE SENSOR/TRANSMITTER

*Your 2WP Pressure Sensor/Transmitter has been factory calibrated to specifications determined at the time the drive system was ordered. NO FIELD ADJUSTMENTS ARE REQUIRED.

IF FOR ANY REASON, YOUR DRIVE FAILS TO OPERATE PROPERLY AFTER YOU HAVE PERFORMED THE ABOVE PROCEDURES, PLEASE CALL THE FACTORY FOR FURTHER INSTRUCTIONS AT **817.485.3336**.

Supplemental Section



NOTES

*The control power transformer is configured to assure that single phase 115 VAC power to the controller is available ONLY when the motor is running.
EACH DC1 or DC2 CONTROLLER MUST BE CONNECTED TO ITS OWN INDIVIDUAL POWER ISOLATION TRANSFORMER FOR PROPER OPERATION.
DO NOT CONNECT ADDITIONAL CONTROLLERS TO THE SAME TRANSFORMER. KEEP ALL HIGH VOLTAGE WIRES SEPARATE FROM OTHER WIRES.
***The optional remote mounted pressure sensor, if used, should always be located on the duct a reasonable distance from the blower to avoid turbulence error.
The tubing length to the sensor should be kept as short as possible to reduce the possibility of response delays which could contribute to system "hunting".
DO NOT RUN POWER WIRES AND SIGNAL WIRES IN THE SAME CONDUIT...KEEP SEPARATE. OBSERVE ALL ELECTRICAL AND SAFETY CODES.

DC1/DC2 variable speed controller with isolated input conditioning circuitry that accepts and follows a standard voltage or current signal, or optionally, the signal from a Coyote 2WP (Two-wire pressure transducer) for stand alone applications to maintain a constant static pressure set point.
See applicable: SIGNAL FOLLOWING or PRESSURE SET POINT MODE calibration instructions
Designed and manufactured in the U.S.A.

COYOTE ELECTRONICS, INC.
4701 Old Denton Road
Fort Worth, Texas 76117
www.payback.com
Phone: 817.485.3336
Fax: 817.485.9437

ETL-DC1/DC2-FR2

DC1/DC2 Speed Controller with 115 VAC control transformer, optional LCD display, and Frequency Adjustable set-point relay

SIZE	FSCM NO	DWG NO	REV
A		BD-000-011-10	C
SCALE: NONE		SHEET: 1 OF 1	

FR2 RELAY MODULE ADJUSTMENT PROCEDURE

(Speed Set-Point Operated Contact)

Note: The speed controller must be calibrated prior to adjusting the FR2 threshold relay module.

MONITOR THE DRIVE RPM AND THE MOTOR AMPS WHILE PERFORMING THESE ADJUSTMENTS.
All adjustment potentiometers on the DC1/DC2 board and the FR2 set-point module are the 20-turn type.
Please follow the adjustment procedures in this manual, or calibrate as follows with the motor turned on:

I. MANUAL MODE (Sets the operating range of the door mounted manual speed potentiometer).

1. Select the MANUAL MODE on the MODE SELECTOR SWITCH located on the enclosure door.
2. Turn the Man Speed Knob on the enclosure door all the way down (counterclockwise to lowest setting).
3. Adjust the MIN SPEED pot on the DC1/DC2 circuit board down (counterclockwise) until the Status LED just turns ON, which indicates that the dc voltage is turned off to the drive coil.
4. Now turn the Man Speed Knob on the enclosure door all the way up (full clockwise to maximum setting).
5. Adjust MAX SPEED pot on the DC1/DC2 circuit board until the drive/equipment just reaches maximum speed. (This is also the same point the motor amps will be at maximum). Do not over adjust, as this will only add additional current to the clutch and create a dead band at the top of the speed range.
6. Repeat steps 1 thru 5 to fine tune if necessary.

II. AUTO MODE (Applies to typical Signal Following Adjustment Mode Only)

Verify signal type supplied to the controller on the TB3 isolated signal terminals. (0-10vdc, 4-20ma, etc).
The auto mode functions similarly to the manual mode adjustments, except the AUTO (SPAN and ZERO) potentiometers are used to set the operating control range of the input signal to the drive.

1. Select the AUTO MODE on the MODE SELECTOR SWITCH located on the enclosure door.
2. With minimum signal input at the TB3 signal terminals (i.e. 4 ma for 4/20ma, 0vdc for 0-10vdc, etc), adjust the ZERO pot until the Status LED just turns ON, which indicates the dc voltage is turned off to the drive coil. Turning the zero pot too far in either direction will cause the LED to go off again. Be sure to set this initial adjustment accurately with the LED ON and dc voltage OFF to the drive.
3. Now apply your maximum input signal, (i.e. 20 ma for 4/20ma, or 10vdc for 0-10vdc, etc).
4. Adjust the SPAN pot on the DC1/DC2 board until the drive/equipment just reaches maximum speed.

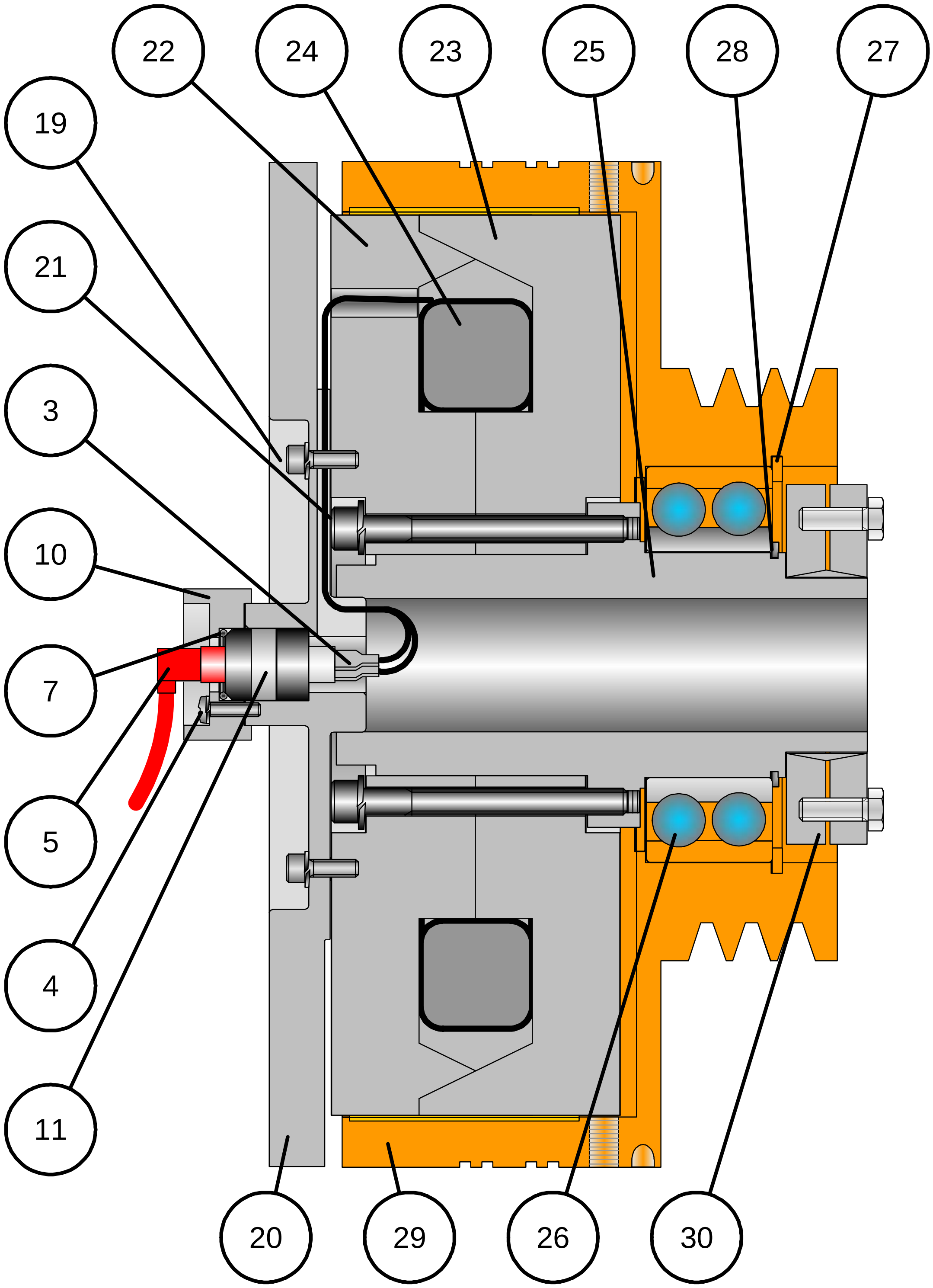
   (This is also the same point the motor amps will be at maximum). Do not over adjust, as this will only add additional current to the clutch and create a dead band at the top of the speed range.
5. Repeat steps 1 thru 4 to fine tune if necessary.

III. FR2 RELAY MODULE ADJUSTMENT (Auxiliary Module that has an adjustment pot that can be set to operate at any point throughout the speed range of the drive system).

Verify all connections to the module and check that the speed sensor is connected and is working properly. The speed sensor has an integrally mounted LED that will illuminate on each alternate cycle of sensing the passing holes on the drive drum. (There are 60 holes per each drive).

1. First, determine at what speed point you would like for FR2 Relay contact to activate.
2. Select MAN MODE on the MODE SELECTOR SWITCH.
3. Adjust the Man Speed KNOB on the enclosure door until the system is operating at the exact speed where you want the FR2 relay to energize.
4. Adjust the FR2 set-point adjust pot until the FR2 LED just turns on. The relay will remain energized at this speed point and higher. When the drive is slowed down below this speed, the relay will deactivate, and then reactivate again every time the speed passes above the set-point.

EASY PAYBACK® DRIVE CUTAWAY



EASY PAYBACK® DRIVE PARTS LIST

ITEM #	BIN#	PART#	QTY	APPLICATION / DESCRIPTION
3		TERMINALS (Straight)	2	2 WIRE CONNECTIONS FOR RPCU-2/PAYBACK COIL (INSIDE TERMINALS)
4a		PBX-BOLT 10-24 X 7/8 PHILLIPS PAN HD	3	#10 HOLDING BOLT FOR ENDCAP ASSY.
4b		PBX-LWASHER-10	3	#10 LOCKWASHERS FOR ENDCAP ASSY.
5		DRIVE POWER CABLE	1	2 WIRE CABLE W/RIGHT-ANGLE TERMINALS
7		PBX-O-RING	1	RPCU-2 O-RING
10		PBX-ENDCAP-2	1	ENDCAP FOR RPCU-2
11		PBX-RPCU-2	1	ROTARY POWER COUPLING UNIT
19a		PB(*)-BOLT-FAN	6	MOUNTING BOLTS FOR FAN ASSY
19b		PB(*)-LWASHER-FAN	6	LOCKWASHERS FOR FAN ASSY
20		PB(*)-FAN	1	ALUMINUM FAN
21a		PB(*)-BOLT-SPIDER	6	MOUNTING BOLTS FOR SPIDER ASSY
21b		PB(*)-LWASHER-SPIDER	6	LOCKWASHERS FOR SPIDER ASSY
22		PB(*)-SPIDER-A	1	SPIDER (A) – FAN-SIDE
23		PB(*)-SPIDER-B	1	SPIDER (B) – SHEAVE-SIDE
24		PB(*)-COIL	1	DRIVE COIL
25		PB(*)-HUB-(Specify bore size)	1	MAIN SUPPORT HUB
26		PB(*)-BEARING	1	MAIN DRIVE BEARING
27		PB(*)-INT SNAPRING	1	INTERNAL SNAP RING FOR DRIVE BEARING
28		PB(*)-EXT SNAPRING	1	EXTERNAL SNAP RING FOR DRIVE BEARING
29		PB(*)-DRUM	1	DRUM AND PULLEY ASSY
30		PB(*)-SHRINKDISC	1	SHRINKDISC ASSY

Notes:

(X) – Indicates parts used on all models

(*) – Specific model # i.e.: PB(1), PB(2), PB(3), etc.

For ordering information and spare parts, call: 817.485.3336

WARRANTY REGISTRATION FORM

FOR FACTORY WARRANTY TO BE VALID, INSTALLER MUST COMPLETE THIS FORM.

Please make copies of this blank form. Fill out the required data for each system.

FAX COMPLETED FORM to Coyote Electronics, Inc. 817-427-4395 or 817-485-9437

INSTALLATION DATE ____________________ PERFORMED BY ____________________

PHONE ____________________ FAX ____________________

JOB/SITE NAME ____________________

ADDRESS ____________________

____

APPLICATION / TYPE OF EQUIPMENT (Be specific) ____________________

EQUIPMENT DESIGNATION, UNIT #, I.D. # ____________________

PAYBACK DRIVE MODEL # ____________________ DRIVE SERIAL # ____________________

DRIVE PULLEY DIA. ____________________ DRIVEN EQUIP. PULLEY DIA. ____________________

MOTOR NAMEPLATE DATA

HP/KW ____________________ RPM ____________________ FRAME # ____________________

☐ ODP ☐ TEFC ☐ OTHER ____________

☐ 50HZ ☐ 60HZ ☐ 1-PHASE ☐ 3-PHASE

FULL LOAD AMPS ____________________ @ AC VOLTS ____________________

RECORD ALL DATA WITH SYSTEM OPERATING AT MAXIMUM (100% FULL LOAD / RPM CONDITION)
VERIFY THAT THE DC CONTROLLER VOLTAGE TO THE DRIVE IS SET TO MAXIMUM (APPROXIMATELY 50VDC)

ACTUAL MEASURED DATA @ FULL LOAD RPM

LINE AC VOLTS ____________________ MOTOR AC AMPS ____________________

DRIVE RPM ____________________ DRIVEN LOAD RPM ____________________

@ CONTROLLER DC VOLTAGE OUTPUT TO PAYBACK DRIVE COIL ____________________ VDC

WARNING: The installation and use of Coyote Electronics, Inc.'s products should be in accordance with the provisions of the U.S. National Electrical Code and/or other local codes or industry standards that are pertinent to the particular end use. Installation or use not in accordance with these codes and standards could be hazardous to personnel and/or equipment.

Coyote Electronics, Inc.• 4701 Old Denton Road • Fort Worth, TX. 76117 • Phone: 817-485-3336

NAME ____ PHONE ____ FAX ____

- Please make copies of this blank form. Fill out as much information as possible.
- Use one (1) form per motor.
- Email all pertinent jpeg digital pictures to: **eng@payback.com**
- If applicable, submit a detailed sketch of the equipment layout, clearance dimensions and all other pertinent information including belt guard requirements.
- Fax completed form to **CEI** at: **(817) 485-9437**

MOTOR NAMEPLATE DATA

HP ____ SF ____

KW ____ PF ____

☐ ODP ☐ TEFC ☐ OTHER

FRAME ____ ____

☐ 50HZ ☐ 1-PHASE

☐ 60HZ ☐ 3-PHASE

☐ 1-SPEED ____ RPM

☐ 2-SPEED — HI ____ RPM

— LO ____ RPM

FL AMPS ____

@ AC VOLTS ____

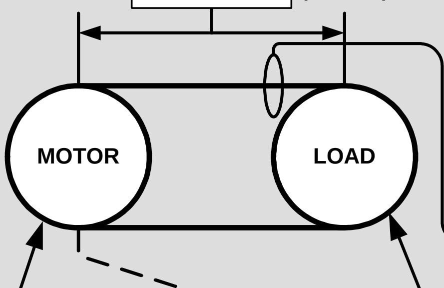
MOTOR PULLEY

DIA. ____

MODEL # ____

EXISTING EQUIPMENT DATA

SHAFT CENTERS ____ (INCHES)



OUT ____ IN ____

MOTOR ADJUSTMENT RANGE (INCHES)

MOTOR ADJUSTMENT BASE TYPE:

☐ THREADED ROD ☐ PIVOT

☐ SLOTTED RAILS ☐ FLAT

☐ OTHER ____

SITE SURVEY

DOC # TR-000-001-01-RF

BELT(S)

MODEL # ____

QTY OF BELTS ____

DRIVEN PULLEY

DIA. ____

MODEL # ____

BUSHING # ____

SHAFT DIA. ____

EQUIPMENT DESCRIPTION

EQUIPMENT DESIGNATION, UNIT #, I.D. # ____

APPLICATION/TYPE OF EQUIPMENT (BE SPECIFIC) ____

AMBIENT OPERATING TEMPERATURE FOR:	(MIN)	(MAX)	INDOORS	OUTDOORS
MOTOR & DRIVE	°F	°F	☐	☐
CONTROLLER	°F	°F	☐	☐

DESIGN OPERATING RPM ____ @ DESIGN BHP/BKW ____

MEASURED DATA @ FULL LOAD RPM (IF AVAILABLE):

LINE AC VOLTS ____ AC AMPS ____ DRIVEN LOAD RPM ____

SPEED CONTROLLER REQUIREMENTS

DISTANCE - MOTOR/DRIVE TO CONTROLLER LOCATION (FEET) ____

SIGNAL FOLLOWING TYPE: ☐ 0-10V DC ☐ 4-20 mA ☐ OTHER ____

☐ SPEED/RPM METER OPTION (LCD DISPLAY & SPEED SENSOR)

☐ PRESSURE SENSOR: SETPOINT/RANGE (SPECIFY) ____

☐ ISOLATED SPEED FEEDBACK SIGNAL FOR 0-1800 RPM (SPECIFY) ☐ 0-10V DC ☐ 4-20 mA

☐ OTHER ____

NOTES:

Coyote Electronics, Inc. 4701 Old Denton Road Fort Worth, TX 76117 Phone: 817.485.3336