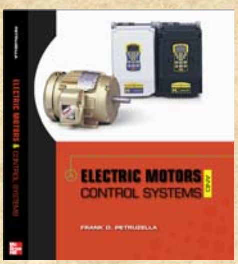


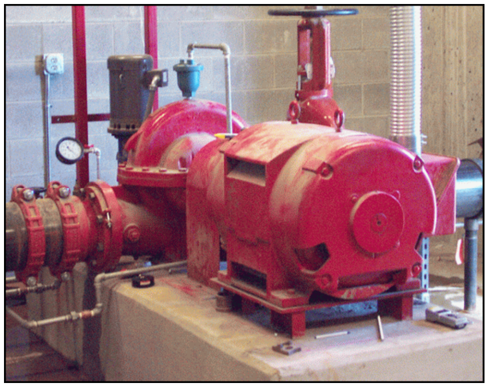
Chapter 5

Electric Motors

PART 7 Motor Installation

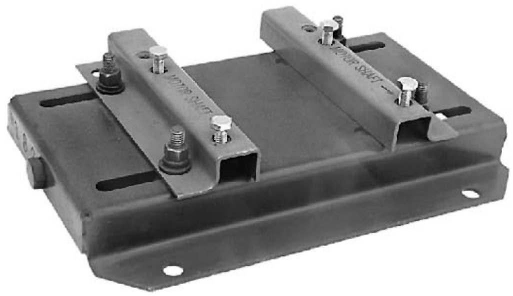
FOUNDATION

FOUNDATION - A rigid foundation is essential for minimum vibration and proper alignment between motor and load. **Concrete** makes the best foundation, particularly for large motors and driven loads.



MOUNTING

MOUNTING – Unless specified otherwise, motors can be mounted in any position or any angle. Mount motors securely to the mounting base of equipment or to a rigid, flat surface, preferably metallic. An **adjustable motor base** makes the installation, tensioning, and replacements of belts easier.



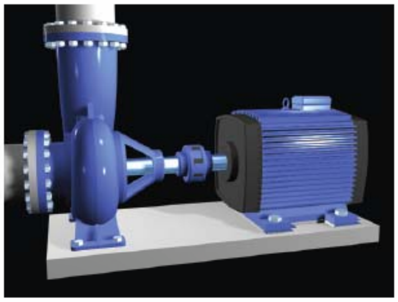
Rigid base, is bolted, welded or cast on main frame and allows motor to rigidly mounted on equipment.

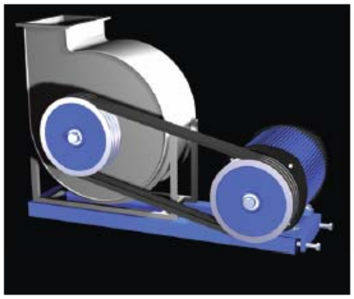
Resilient base, has isolation or resilient rings between motor mounting hubs and base to absorb vibration and noise. A conductor is imbedded in the ring to complete the circuit for grounding purposes.

NEMA C face mount, is a machined face with a pilot on the shaft end which allows direct mounting with a pump or other direct coupled equipment. Bolts pass through mounted part to threaded hole in the motor face.

MOTOR AND LOAD ALIGNMENT

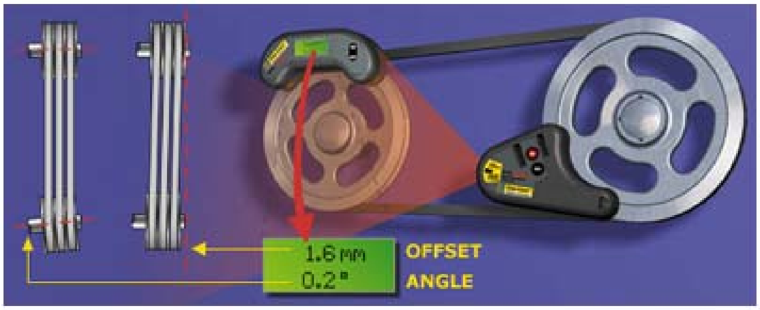
Misalignment **between the motor shaft and the load shaft causes unnecessary vibration and failure do to mechanical problems.**


Shaft alignment

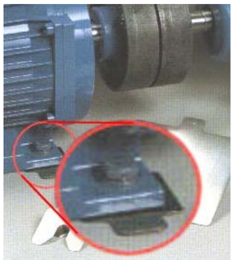

Sheave alignment

Premature bearing failure in the motor and/or the load can result from misalignment.

Different types of alignment devices, such as laser alignment kits, are used for motor and load alignment.

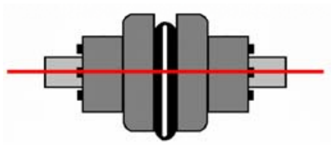


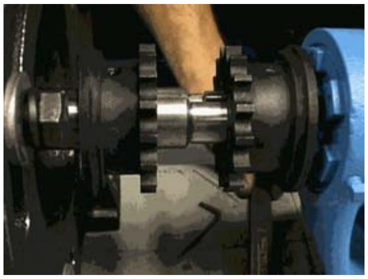
Moving the position of the motor by placing a shim (thin piece of metal) under the feet is sometimes used as part of the alignment process.



***Direct drive motors*, as the name implies, supply torque and speed to the load directly. A motor coupling is used to mechanically connect axially located motor shafts with equipment shafts.**

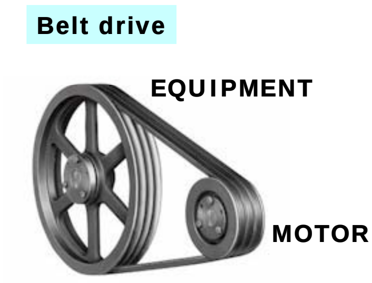
***Direct coupling* of the motor shaft to the driven load results in a 1:1 speed ratio. For direct-coupled motors, the motor shaft must be centered with the load shaft to optimize operating efficiency.**



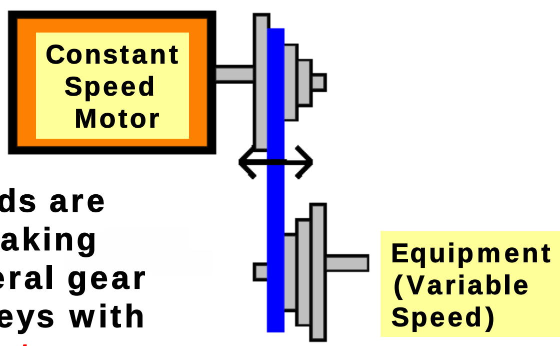


A flexible coupling permits the motor to operate the driven load while allowing for slight misalignments.

Coupling by means of **gears or pulleys/belts** may be used in cases where the application requires other than standard available speed.



Variable speeds are possible by making available several gear ratios, or pulleys with **variable diameters**.



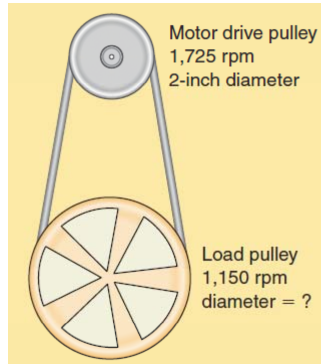
Variable speeds are possible by making available several gear ratios, or pulleys with **variable diameters**.

The follow can be used to calculate speed and pulley sizes for belt-drive systems.

$$\frac{\text{Motor rpm}}{\text{Equipment rpm}} = \frac{\text{Equipment pulley diameter}}{\text{Motor pulley diameter}}$$

EXAMPLE 5-5

Problem: You have a motor to drive a load. The motor operates at 1,725 rpm and has a pulley with a 2-inch diameter; the load must operate at 1,150 rpm. What size of pulley is needed for the load?



Solution:

$$\frac{\text{Motor rpm}}{\text{Equipment rpm}} = \frac{\text{Equipment pulley diameter}}{\text{Motor pulley diameter}}$$

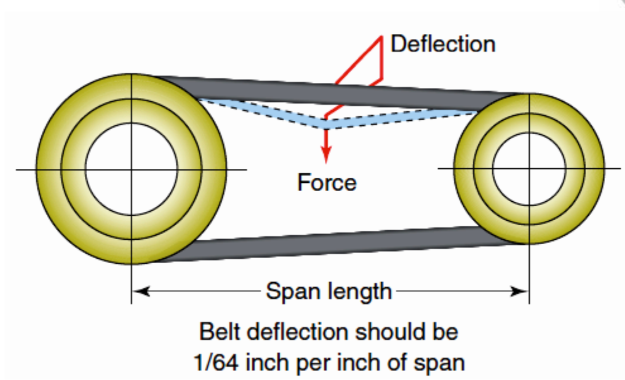
$$\frac{1{,}725}{1{,}150} = \frac{\text{Equipment pulley diameter}}{2}$$

$$\frac{1{,}725 \times 2}{1{,}150} = \text{3-inch pulley}$$

V- belts have a flat bottom and tapered sides that transmits motion between two sheaves.

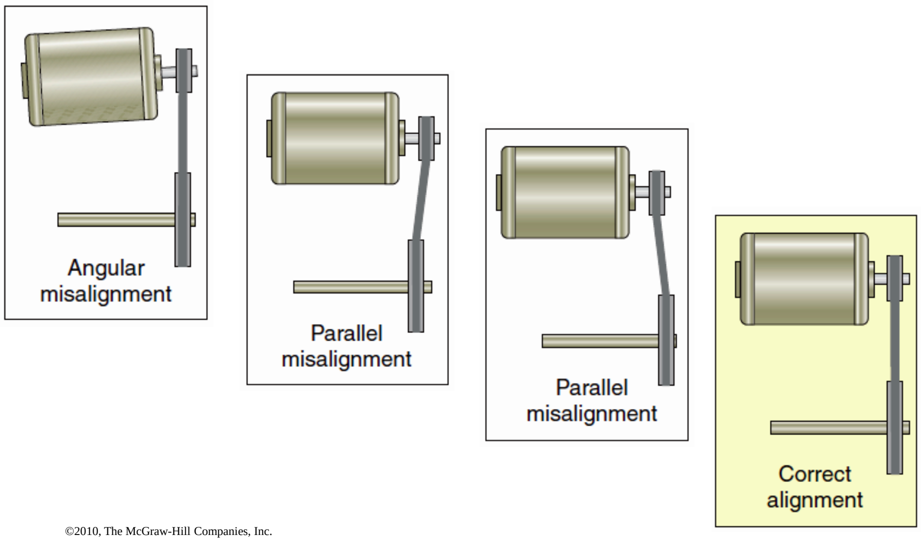
V-Belt

Sheave



The belt must be tight enough not to slip, but not so tight as to overload motor bearings. A belt tension gauge should be used to ensure proper specified belt tension.

Misalignment is one of the most common causes of premature belt failure.



MOTOR BEARINGS

The rotating shaft of a motor is suspended in the end bells by bearings that provide a relatively rigid support for the output shaft.

Motors come equipped with different types of bearings properly lubricated to prevent metal-to-metal contact of the motor shaft.

The lubricant used is usually either grease or oil.

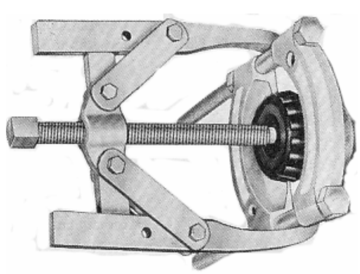
***Sleeve bearings* used on smaller light duty motors consist of a bronze or brass cylinder, a wick, and a oil filled reservoir.**

Large motors (200 HP and over) are often equipped with a large split sleeve bearings that mount on the top and bottom half of the motor endshield.

Ball bearings **are the most common type of bearing. The load is transmitted from the outer race to the ball, and from the ball to the inner race. Ball bearings come in three different styles: permanently lubricated, hand packed, and bearings that require lubrication through fitting.**

Both not lubricating and overlubricating bearings can damage a motor. Too much grease can cause them to run hot, shortening their life. Excessive lubricant can find its way inside the motor where it collects dirt and causes insulation deterioration.

Roller bearings **are used in large motors for belted loads. The roller is a cylinder, so this spreads the load out over a larger area, allowing the bearing to handle much greater loads.**



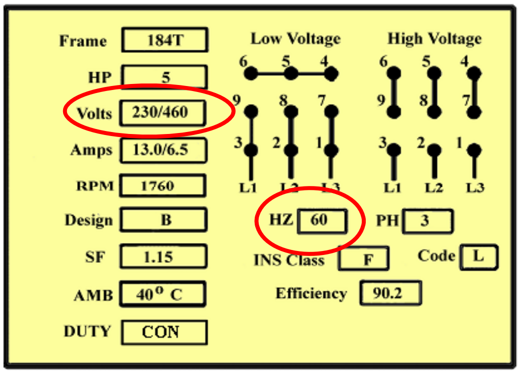
Different types of pullers are available, with various types and sizes of adapters for removal of bearings.

Thrust bearings are designed to handle higher than normal axial forces exerted on the shaft of the motors, as is the case with some fan and pump blade applications.

Motors for vertical mounted motors typically use thrust bearings.

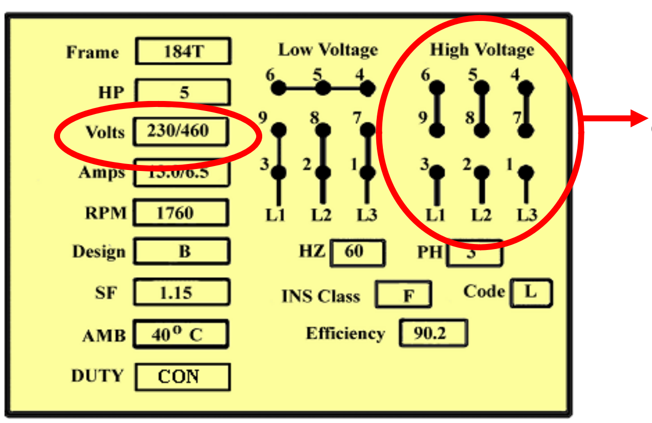
ELECTRICAL CONNECTIONS

NEMA standards and Art. 430 of the NEC as well as state and local codes provide specific electrical and mechanical installation requirements and recommendations covering motors and motor controls.

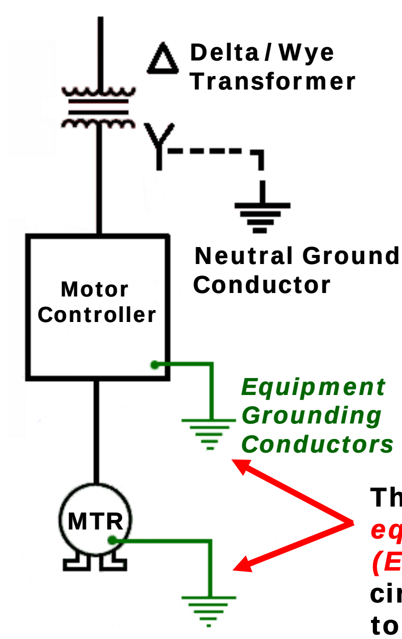


The motor must be connected to a power source corresponding to the voltage and frequency rating shown on the motor nameplate.

Stator winding connections **should be made as shown on the nameplate connection diagram or in accordance with the wiring diagram attached to the inside of the conduit box cover.**



GROUNDING

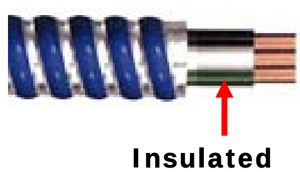


Both your motor and the equipment or apparatus to which it is connected must be *grounded* as a precaution against the hazards of electrical shock and electrostatic discharge.

This is done by using an *equipment-grounding conductor (EGC)* that establishes a path or circuit for ground-fault current to facilitate overcurrent device operation.

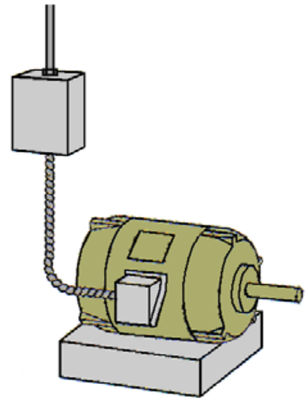
Grounding of an electronic motor drive also helps to reduce unwanted electrical noise that can interfere with the proper operation of the electronic motor drive circuits.

The EGC may be a conductor (bare or insulated) run with the circuit conductors, or where metal raceways are used, the raceway may be the equipment-grounding conductor.



Where flexibility is required the final connection to the motor is made with a short length of flexible conduit or cable with an equipment-grounding conductor installed.

Flexible Conduit



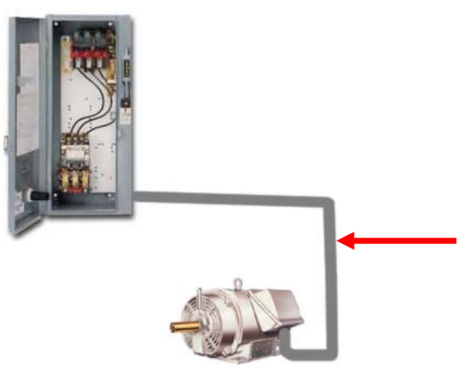
The color *green* is reserved for an insulated grounding conductor.

Grounding the motor shaft by installing a grounding device prevents bearing damage by dissipating shaft currents to ground.

Electrical currents are induced onto the motor's rotor shaft and seek the least resistant path to ground – usually the motor bearings. This occurs more often in AC motors controlled by variable frequency drives. The random and frequent discharging causes pitting of the bearing's rolling elements. For this reason, proper grounding is especially critical on the motor frame, between the motor and drive, and from the drive to earth.

CONDUCTOR SIZE

The size of the branch circuit conductors is normally determined in accordance with the NEC based on the motor full-load current and increased where required to limit voltage drop.



Undersized wire will limit stating abilities and cause overheating of the motor.

EXAMPLE 5-6

Problem: What size THW CU conductors are required for a single 15-hp, three-phase, 230-V squirrel-cage motor?

Solution:

Step 1 Determine the full-load current (FLC) rating of the motor to be used in determining the conductor size. NEC 430.6 requires that tables 430.247 through 430.250 be used to determine the FLC *and not* the nameplate rating. Table 430.250 deals with three-phase alternating current motors, and using this table, we find that for a 10-hp, 208-V, three-phase motor the FLC is 42 amperes.

Step 2 NEC 430.22 requires branch circuit conductors supplying a single motor to have an ampacity not less than 125 percent of the motor FLC. Therefore,

$$\text{Rated ampacity} = 42\text{ A} \times 125\%$$
$$= 52.5\text{ A}$$

Step 3 According to Table 310.16, the conductor size required would be:

6 AWG THW CU

VOLTAGE LEVELS AND BALANCE

Motor parameters **should be kept as close to the nameplate value as possible, with a maximum deviation of 5%.**

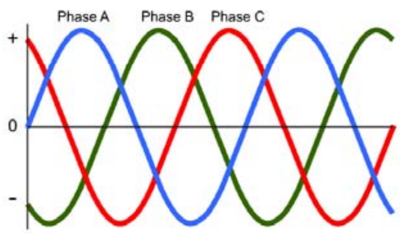
ELECTRIC MOTOR NAMEPLATE					
MODEL 500		SPLIT PHASE		TOTALLY ENCLOSED	
FRAME		TYPE	INS. CLASS	IDENTIFICATION NO.	
145		KC	J	2538094990298209	
HP	RPM	VOLTS		AMPS	CYC	S.F.
1 ½	1725	115/230		15/7.5	60	1.25
DESIGN CODE: B				PHASE	EFF	p.f.
DRIVE END BEARING BBD 116				1	62%	75%
OPP. END BEARING B0B 117				DUTY: CONTINUOUS		
AMB 40 C		NO THERMAL PROTECTION				

Although designed to operate within 10% of nameplate voltage, large voltage variations can have negative effects on torque, slip, current, efficiency, power factor, temperature and service life.

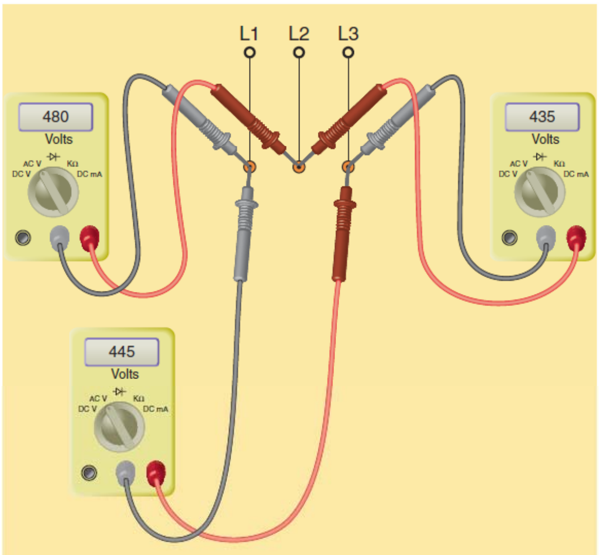
Motor Characteristic	Voltage Variation	
	90% of Nameplate	110% of Nameplate
Starting and Maximum Running Torque	-19%	+21%
Percent Slip	+22%	-19%
Full-Load Slip	-0.2% to -1.0%	+2.0% to +1.0%
Starting Current	-10%	+10%
Full-Load Current	+5% to +10%	-5% to -10%
No-Load Current	-10% to -30%	+10% to +30%
Temperature Rise	+10% to +15%	-10% to -15%
Full-Load Efficiency	-1% to -3%	+1% to +3%
Full-Load Power Factor	+3% to +7%	-2% to -7%

When 3-phase line voltages are not equal in magnitude, they are said to be unbalanced.

Unbalanced voltages may cause unbalanced currents resulting in overheating of the motor's stator windings and rotor bars, shorter insulation life, and wasted energy in the form of heat.



A voltage unbalance can magnify the percent current unbalance in the stator windings of a motor by as much as 6 to 10 times the percent voltage unbalance.



The voltage unbalance is calculated as follows:

$$\text{Percent voltage unbalance} = \frac{\text{Maximum voltage deviation from the voltage average}}{\text{Average voltage}} \times 100$$

Acceptable voltage unbalance is typically not more than 1%. Where there is a 2% or greater voltage unbalance steps must be taken to determine and rectify the source of the unbalance. In cases where the voltage unbalance exceeds 5%, it is not advisable to operate the motor at all.

EXAMPLE 5-7

Problem: What is the percent voltage unbalance for a three-phase supply voltage of 480 V, 435 V, and 445 V ?

Solution:

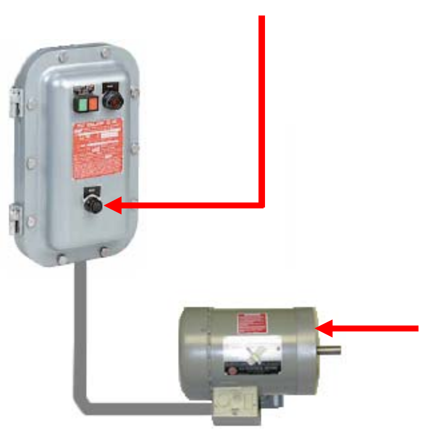
$$\text{Average voltage deviation} = \frac{480 + 435 + 445}{3} = \frac{1{,}360}{3} = 453\ \text{V}$$

Maximum deviation from the average voltage = 480 − 453 = 27 V.

$$\text{Percent voltage unbalance} = \frac{\text{Maximum voltage deviation from the voltage average}}{\text{Average voltage}} \times 100 = \frac{27}{453} \times 100 = 5.96\%$$

BUILT-IN THERMAL PROTECTION

Overload relays mounted on the motor starter enclosure protect the motor by monitoring the motor current and resultant heat it created inside the motor by this current flow.

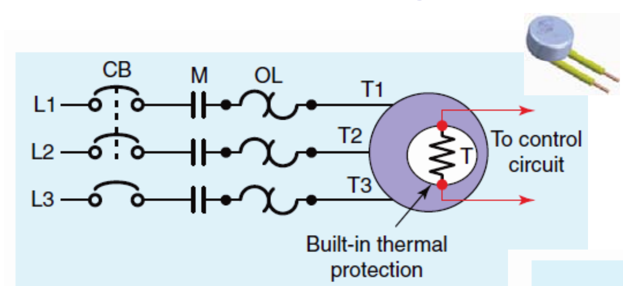


They do not however monitor the actual amount of heat generated within the winding.

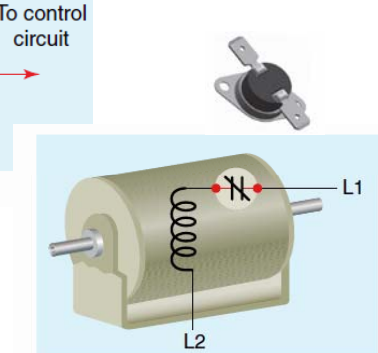
Motor subject to such conditions as excessive starting cycles, high ambient motor temperatures, or inadequate ventilation conditions may experience rapid heat buildup that is not sensed by the current of the overload relay.

To minimize such risks *thermal protectors* located inside the motor that sense motor winding temperature are used.

Thermal protection devices may be integrated into the control circuit or connected in series with the motor windings.



Integrated into the control circuit

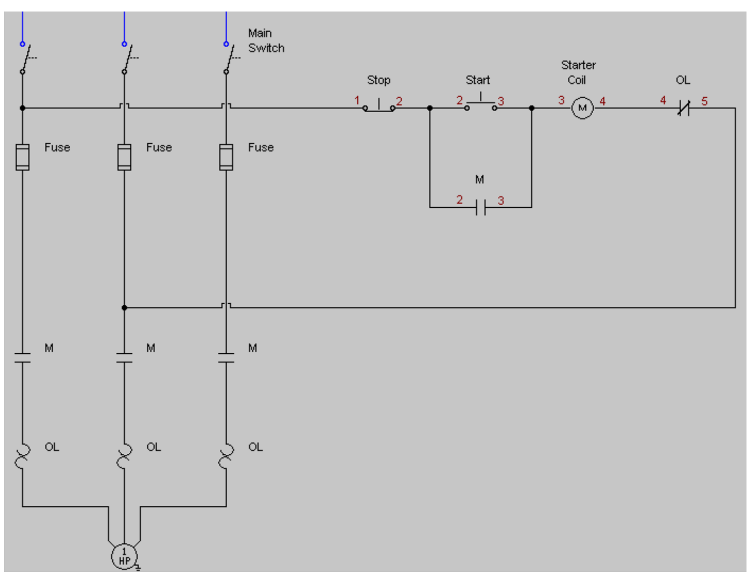


Wired in series

Automatic Reset: **After the motor cools, this line-interrupting protector automatically restores power. It should not be used where unexpected restarting would be hazardous.**

Application:
Surface Water Pump Motor Equipped With Built-In Automatic Thermal Protector

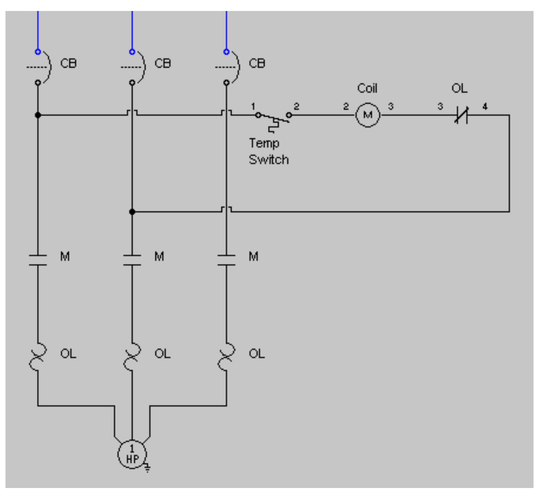
Simulated Automatic Motor Reset

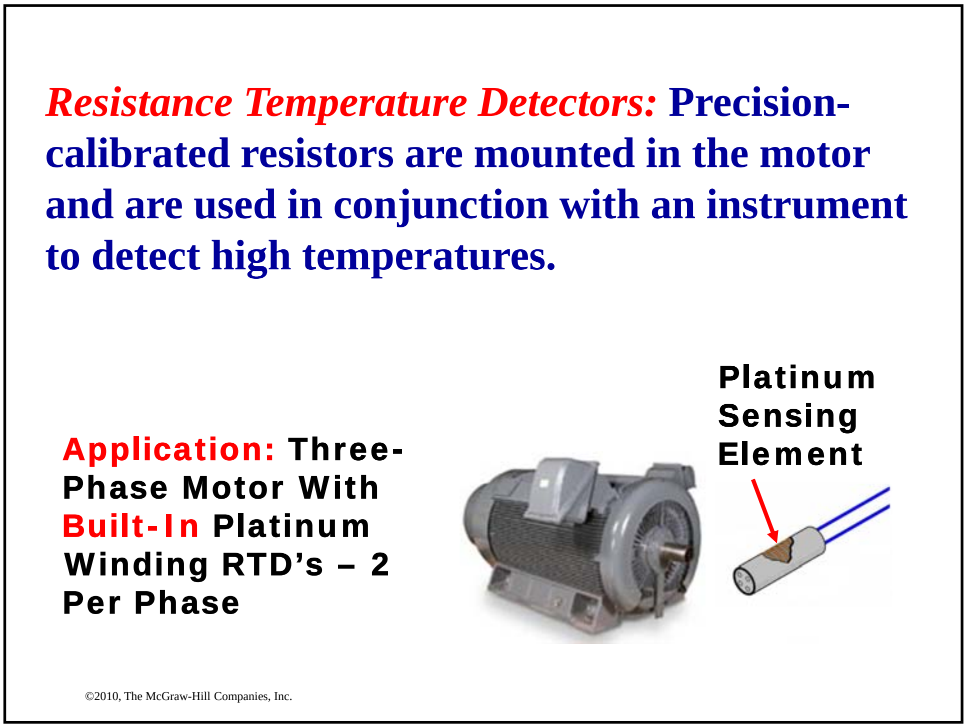


Manual Reset: **This line-interrupting protector has an external button that must be pushed to restore power to the motor. Use where unexpected restarting would be hazardous, as on saws, conveyors, compressors and other machinery.**

Application: **Saw Motor Equipped With Built-In Manual Thermal Protector**

Simulated Manual Motor Reset





Resistance Temperature Detectors: **Precision-calibrated resistors are mounted in the motor and are used in conjunction with an instrument to detect high temperatures.**
Application: Three-Phase Motor With Built-In Platinum Winding RTD's – 2 Per Phase
Platinum Sensing Element
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