ELECTRIC MOTORS

Enclosures for Motors

Types of motor enclosures generally used in farm applications:

(1) Open type; drip proof or splash-proof. A general purpose motor for use in dry locations which are relatively free of splashing liquids and dust particles.

(2) Totally enclosed. For applications where the motor will be subject to dust, moisture, wash water, foreign particles, or for outdoor usage. Recommended for most farm uses.

(3) Explosion proof. Designed to prevent ignition of any explosive gases or dust and dirt which may surround the motor.

Electric Motor Protection

To insure long motor life and freedom from electrical hazards, motors must be protected from short circuits and overload. If the motor is overloaded it will draw excessive current and overheating will result. Overheating will cause the insulation on the windings to breakdown and may cause the bearings to seize. As a general rule, a general purpose motor is overheating if you cannot hold your hand on it for a few seconds.

A thermal overload switch built into the motor affords the best protection against motor overloading. Built-in thermal protective devices may be of either the automatic-reset type or manual-reset type. A manual-reset type is recommended for general purpose use. An automatic-reset type protective device should not be used on any motor where automatic restarting of the motor could cause a personal injury or cause damage to the machinery being operated.

Motors may draw 3 to 12 times their normal running current when starting, thus ordinary single-element fuses are not satisfactory for protecting motors.

The fuse in the circuit to which a motor is connected is designed to protect the wiring and not the motor. Thus, unless complete fusing protection (short and overload) is provided in the motor a separate delay-type fuse or breaker for each motor is necessary.

Time-delay fuses provide both short circuit and overload protection, and allows the motor to draw a large current for a short time while starting. Time-delay fuse sizes are listed in Table C2.4 for some appliances and in Table C2.7 for electric motors.

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Table C2.6: General Purpose Single-Phase Motor Types and Their Characteristic

Type	Horsepower ranges	Load-starting ability	Starting Current	Characteristics	Electrically reversible	Typical Uses
Split Phase	1/20 to 1/3	Easy starting loads. Develop 150% full-load torque.	High, 5 to 7 times full-load current.	Inexpensive, simple construction; small for a given motor power; nearly constant speed with varying load.	yes	Fan, centrifugal pump; a load that increases as speed increases.
Capacitor *start induction run*	1/8 to 10	Hard starting loads. Develop 300% of full-load torque.	Medium, 3 to 6 times full-load current.	Simple construction; long service; good general-purpose motor suitable for most appliances; nearly constant speed with varying loads.	yes	Reciprocating compressor, auger conveyor, vacuum pump, (specially designed capacitor motors are suitable for silo unloaders and barn cleaners.)
Capacitor *start capacitor run*	1/2 to 20	Hard starting loads. Develop 250% of full-load torque.	Medium, 3 to 5 times full-load current.	Simple construction; long service with medium maintenance; requires more space to accommodate larger capacitor; nearly constant speed with varying loads.	yes	Conveyor, barn cleaner, elevator, silo unloader.

Table C2.6 : General Purpose Single-Phase Motor Types and Their Characteristics (Continued)

Type	Horsepower ranges	Load-starting ability	Starting Current	Characteristics	Electrically reversible	Typical Uses
Repulsion	1/6 to 10	Very hard starting loads. Develop 350 to 400% of full-load torque.	Low, 2 to 4 times full-load current	Larger than equivalent size split phase or capacitor motors; requires more maintenance because of brush wear; running current varies only slightly with load.	NO – the usual method of reversing the direction of rotation is by brushing adjustment.	Conveyor, drag, burr mill, deep-well pump, hoist, silo unloader, bucket elevator.
Series, *or universal*	1/150 to 1	Hard starting loads. Develop 350 to 450% of full-load torque.	High	High speed; small size for a given horsepower; usually directly connected to load; speed varies with variations in load.	YES – some types.	Portable tools for the shop and kitchen appliances for the home.

From: Single-Phase Electric Motors for Farms Use, U S Department of Agriculture, Farmer's Bulletin No. 2177.

Motor Control

Control switches for electric motors must be able to withstand the high starting currents required by the motor, and the arcing that occurs when the circuit opens. "Quick-make, quick-break" switches equipped with "arc quenchers" should be used. These switches are rated in horsepower and voltage. The switch must not have a lower horsepower or voltage rating than the motor that it is to control.

In applications where explosion proof motors are required, the switch and controlling devices should also be explosion proof.

Common toggle type light switches should not be used to control electric motors. They are not designed to withstanding the arcing that occurs and will usually burn out quickly.

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A magnetic motor switch is the best method of controlling a motor. This type switch should be used for all motors larger than one horsepower. The magnetic switch is essential for automatic control systems and where several motors must be started in the proper sequence.

Table C2.7: Recommended Dual-Element Fuse Sizes for Electric Motors

Motor Full Load Running Current (from motor nameplate) *Amperes*	Dual-Element Fuse Size (*Amperes*)
1.81 to 2.25	2.5
2.26 to 3.00	3.2
3.10 to 3.60	4.0
3.61 to 4.00	4.5
4.10 to 4.55	5.0
4.56 to 5.70	6.25
5.71 to 7.30	8.0
7.31 to 9.25	10.0
9.26 to 11.0	12.0
11.1 to 14.0	15.0
14.1 to 18.0	20.0
18.1 to 22.0	25.0
22.1 to 28.0	30.0

NOTE: When in doubt consult the motor manufacturer or supplier.

From: Midwest Farm Handbook, Iowa State University Press, 1964.

Current Requirements for Motors

Table C2.8: Estimated Full Load Electrical Requirements for AC Motors

Horsepower	Single-Phase Motors Current Amperes 115 volts	230 volts	Three-Phase Motors Current Amperes 110 volts	220 volts	440 volts
1/6	4.4	2.2	--	--	--
1/4	5.8	2.9	--	--	--
1/3	7.2	3.6	--	--	--
1/2	9.8	4.9	4.9	2.0	1.0
3/4	13.8	6.9	5.6	2.8	1.4
1	16.0	8.0	7.0	3.5	1.8
1-1/2	20.0	10.0	10.0	5.0	2.5
2	24.0	12.0	13.0	6.5	3.3
3	34.0	17.0	--	9.0	4.5
5	56.0	28.0	--	15.0	7.5
7-1/2	80.0	40.0	--	22.0	11.0
10	100.0	50.0	--	27.0	14.0
15	--	--	--	40.0	20.0
20	--	--	--	52.0	26.0
25	--	--	--	64.0	32.0
30	--	--	--	78.0	39.0
40	--	--	--	104.0	52.0
50	--	--	--	125.0	63.0
60	--	--	--	150.0	75.0
75	--	--	--	185.0	93.0
100	--	--	--	246.0	123.0

Cost of Operating Electric Motors

For estimating the cost of operation of motors, the following relationships can be used:
(1) For motors of 1/2 horsepower or less, figure 1200 watts per HP.
(2) For motors larger than 1/2 horsepower, figure 1000 watts per HP.

This assumes efficiencies of 62- and 75-percent respectively.

Electric Motor Versus Internal Combustion Engines

Table C2.9: Guide for Interchanging Electric Motors with Internal Combustion Engines or Tractor PTO Power*

Electric Motor	Internal Combustion Engine
5 HP	5 - 7-1/2 HP
7-1/2	8 - 12
10	13 - 15
15	16 - 23
20	24 - 30
25	31 - 38
30	39 - 45
40	46 - 60
50	61 - 75
60	76 - 90
75	91 - 115
100	116 - 150

* All of these electric motors require connection to a 230-volt circuit. It is wise to consult with your electric power supplier or a competent electrical firm before purchasing any of these electric motors, to determine wiring and service requirements. This guide assumes the efficiency of power transmission to the driven device is equal for each type; i. e., both directly driven or both belted.

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Table C2.10: Troubles in Single-Phase Motor Operation, Causes and Remedies

Motor Fails To Start

Cause	Remedy
Fuses blown Switch open Broken connections No voltage on line	Examine fuses, switches, and connections between motor terminals and points of service. Also look for broken wires and connections.
Poor connections	Examine and repair connections.
Wiring too small	Increase size of wire.
Overloaded service	Notify power company.
Not sufficient torque	Reduce load and check for low voltage.
Bearing linings worn so that bore. rotor rubs on stator.	Renew sleeves, center rotor in stator
Bearing too tight, or lack of proper lubrication.	Adjust and lubricate bearings. Check end bells for alignment.
Broken connections Burned-out windings, indicated by smoke and local heating.	Locate and repair.[1]

Excessive Heating

Cause	Remedy
Overloaded	Reduce load.
Poor or broken insulation Broken connections Grounds or short circuits	Test and repair.[1]
Worn bearings	Test with feeler and renew or repair
Wrong Connections	Check with wiring diagram of motor.

Rotor rubs on stator	check end bells alignment.[1]
Bearings too tight	Renew bearing sleeves.[1]
Belt too tight	Slacken belt.

Table C2.10: Troubles in Single-Phase Motor Operation, Causes and Remedies (continued)

Excessive Vibration

Cause	Remedy
Unbalanced rotor	Have rotor balanced.[1]
Worn bearings	Replace sleeves.[1]
Misaligned with load	Align motor shaft with load shaft.
Loose mounting bolts	Tighten.
Unbalanced pulley	Have pulley balanced or replace with new.
Uneven weight of belt	Get new belt.

Excessive Sparking When Started

Cause	Remedy
Dirty or rough commutator	Clean and sandpaper.[1]
Worn or stuck brushes	Renew or adjust brushes.[1]
High or low commutator bars	Turn off in lathe.[1]
Excessive sparking at one commutator	Check for shorted rotor winding or loose winding to bar connection.[1]
High mica	Undercut mica.[1]
Overloaded	Lighten load.

Table C2.10:Troubles in Single-Phase Motor Operation, Causes and Remedies(continued)

Open rotor or stator coil Grounds Poor connections	Inspect, test, and repair.[1]
High or low voltage	Notify power company and inspect wiring.

Low Speed

Cause	Remedy
Overloaded	Reduce load.
Dirty or rough commutator	Clean and sandpaper.[1]
Badly worn brushes	Replace with new brushes.[1]
Brushes stuck	Clean and adjust.
Brushes not properly set	Adjust brushes.[1]
Wrong or bad connections	Check for proper voltage connections and repair.
Low voltage	Reduce load.
Overloaded line Wiring too small	Increase size of wire.[1]

Motor Hums But Will Not Start

Cause	Remedy
Worn brushes	Renew brushes.
Start winding switch does not	Clean or replace and lubricate if close
Brushes stuck in holder	Adjust brushes.[1]
Brushes not properly set	Check with marks on frame.
Motor overloaded	Lighten load.

Open rotor or stator coil	Test and repair.[1]
Defective starting capacitor	Replace.[1]
Worn bearings	Replace bearings.[1]
Burned or broken connections	Test and repair.[1]
Overloaded line voltage	Notify power company and check Low wiring.
Poor connections	Repair.

Table C2.10: Troubles in Single-Phase Motor Operation, Causes and Remedies (continued)

Motor Will Not Start With Rotor In Certain Position

Cause	Remedy
Broken	Inspect, test, and repair.[1]
Open rotor or stator coil	Inspect, test, and repair.[1]

Slow Acceleration

Cause	Remedy
Dirty or rough commutator	Clean and sandpaper.
Worn or stuck brushes	Renew or adjust.[1]
Brushes not set properly	Adjust brushes.[1]
Overloaded	Lighten load.
Poor connections	Test and repair.
Low voltage Overloaded line	Lighten line load or increase size of line line wire.[1]

Table C2.10:Troubles in Single-Phase Motor Operation, Causes and Remedies (continued)

Rapid Brush Wear

Cause	Remedy
Rough commutator	Smooth with fine (00) sandpaper. (Do not use emery cloth.)
High or low bars	Turn off in lathe.[1]
High mica	Undercut mica.[1]
Overload	Lighten motor load.
Poor connections	Test and repair.
Low voltage	Increase size of wire.[1]
Commutator not round	Test and repair.[1]

Excessive Sparking at Normal Speed

Cause	Remedy
Dirty short-circuiting device	Clean with acceptable solvent - *do not use carbon tetrachloride.*
Governing mechanism sticks or is badly adjusted.	Readjust mechanism.[1]
Worn brushes	Replace.

Table C2.10:Troubles in Single-Phase Motor Operation, Causes and Remedies (continued)

Excessive Speed	
Cause	Remedy
Dirty short-circuiting device	Clean with acceptable solvent - *do not use carbon tetrachloride.*
Governing mechanism sticks or is badly adjusted	Readjust mechanism.[1]

[1] These repairs should be made by an experienced electrician or technician.