FACT SHEET

a Program of the U.S. Department of Energy

DETERMINING ELECTRIC MOTOR LOAD AND EFFICIENCY

Most likely your operation's motors account for a large part of your monthly electric bill. Far too often motors are mismatched—or oversized—for the load they are intended to serve, or have been rewound multiple times.

To compare the operating costs of an existing standard motor with an appropriately-sized energy-efficient replacement, you need to determine operating hours, efficiency improvement values, and load. Part-load is a term used to describe the actual load served by the motor as compared to the rated full-load capability of the motor. Motor part-loads may be estimated through using input power, amperage, or speed measurements. This fact sheet briefly discusses several load estimation techniques.

Reasons to Determine Motor Loading

Most electric motors are designed to run at 50% to 100% of rated load. Maximum efficiency is usually near 75% of rated load. Thus, a 10-horsepower (hp) motor has an acceptable load range of 5 to 10 hp; peak efficiency is at 7.5 hp. A motor's efficiency tends to decrease dramatically below about 50% load. However, the range of good efficiency varies with individual motors and tends to extend over a broader range for larger motors, as shown in Figure 1. A motor is considered underloaded when it is in the range where efficiency drops significantly with decreasing load. Figure 2 shows that power factor tends to drop off sooner, but less steeply than efficiency, as load decreases.

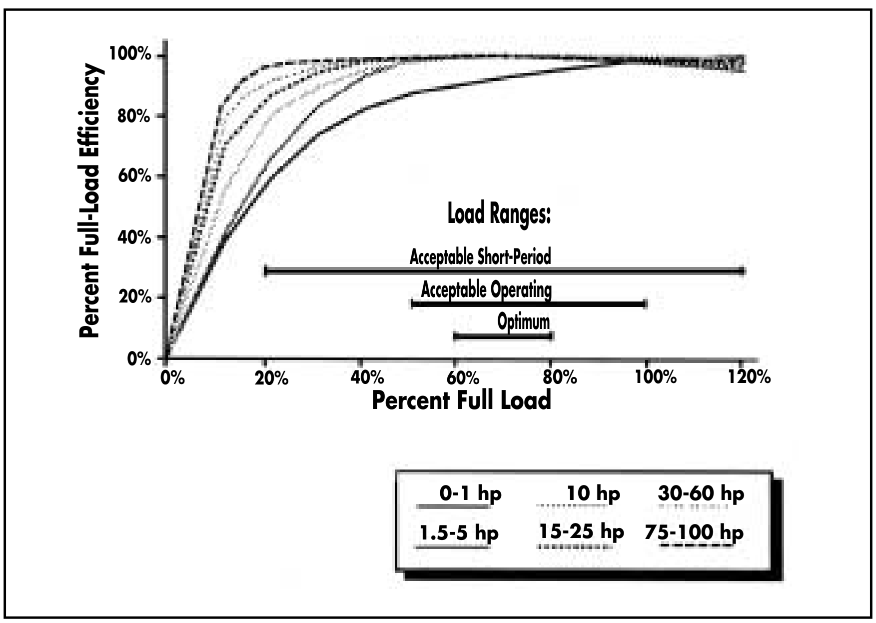

Figure 1 Motor Part-Load Efficiency (as a Function of % Full-Load Efficiency)

The energy savings network

Plug into it!

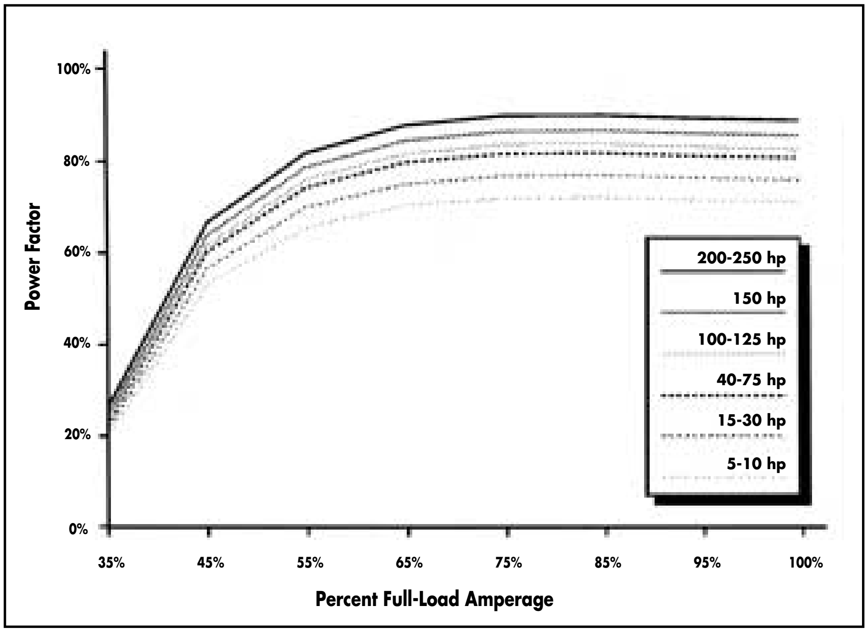

Figure 2 Motor Power Factor (as a Function of % Full-Load Amperage)

Overloaded motors can overheat and lose efficiency. Many motors are designed with a ***service factor*** that allows occasional overloading. Service factor is a multiplier that indicates how much a motor can be overloaded under ideal ambient conditions. For example, a 10-hp motor with a 1.15 service factor can handle an 11.5-hp load for short periods of time without incurring significant damage. Although many motors have service factors of 1.15, running the motor continuously above rated load reduces efficiency and motor life. Never operate overloaded when voltage is below nominal or when cooling is impaired by altitude, high ambient temperature, or dirty motor surfaces.

If your operation uses equipment with motors that operate for extended periods under 50% load, consider making modifications. Sometimes motors are oversized because they must accommodate peak conditions, such as when a pumping system must satisfy occasionally high demands. Options available to meet variable loads include two-speed motors, adjustable speed drives, and load management strategies that maintain loads within an acceptable range.

Determining if your motors are properly loaded enables you to make informed decisions about when to replace motors and which replacements to choose. Measuring motor loads is relatively quick and easy when you use the techniques discussed in this fact sheet. You should perform a motor load and efficiency analysis on all of your major working motors as part of your preventative maintenance and energy conservation program. Use Attachment A, "Motor Nameplate and Field Test Data Form," to record motor nameplate data and field measurements.

We recommend that you survey and test all motors operating over 1000 hours per year. Using the analysis results, divide your motors into the following categories:

- Motors that are significantly oversized and underloaded—replace with more efficient, properly sized models at the next opportunity, such as scheduled plant downtime.

- Motors that are moderately oversized and underloaded—replace with more efficient, properly sized models when they fail.

- Motors that are properly sized but standard efficiency—replace most of these with energy-efficient models when they fail. The cost effectiveness of an energy-efficient motor purchase depends on the number of hours the motor is used, the price of electricity, and the price premium of buying an energy-efficient motor. Use Attachment B, the "Motor Energy Savings Calculation Form," to determine the cost effectiveness of motor changeout options.

Determining Motor Loads

Input Power Measurements

When "direct-read" power measurements are available, use them to estimate motor part-load. With measured parameters taken from hand-held instruments, you can use Equation 1 to calculate the three-phase input power to the loaded motor. You can then quantify the motor's part-load by comparing the measured input power under load to the power required when the motor operates at rated capacity. The relationship is shown in Equation 3.

Equation 1

$$P_i = \frac{V \times I \times PF \times \sqrt{3}}{1000}$$

Where:

P_i = Three-phase power in kW
V = RMS voltage, mean line-to-line of 3 phases
I = RMS current, mean of 3 phases
PF = Power factor as a decimal

Equation 2

$$P_{ir} = hp \times \frac{0.7457}{\eta_{fl}}$$

Where:

P_{ir} = Input power at full-rated load in kW
hp = Nameplate rated horsepower
η_{fl} = Efficiency at full-rated load

Equation 3

$$Load = \frac{P_i}{P_{ir}} \times 100\%$$

Where:

Load = Output power as a % of rated power
P_i = Measured three-phase power in kW
P_{ir} = Input power at full-rated load in kW

Example: Input Power Calculation

An existing motor is identified as a 40-hp, 1800 rpm unit with an open drip-proof enclosure. The motor is 12-years old and has not been rewound.

The electrician makes the following measurements:

Measured Values:

$V_{ab} = 467V$	$I_a = 36$ *amps*	$PF_a = 0.75$
$V_{bc} = 473V$	$I_b = 38$ *amps*	$PF_b = 0.78$
$V_{ca} = 469V$	$I_a = 37$ *amps*	$PF_c = 0.76$

V = (467+473+469)/3 = 469.7 volts

I = (36+38+37)/3 = 37 amps

PF = (0.75+0.78+0.76)/3 = 0.763

Equation 1 reveals:

$$P_i = \frac{469.7 \ x \ 37 \ x \ 0.763 \ x \ \sqrt{3}}{1000} = 22.9 \ kW$$

Line Current Measurements

The current load estimation method is recommended when only amperage measurements are available. The amperage draw of a motor varies approximately linearly with respect to load, down to about 50% of full load. (See Figure 3.) Below the 50% load point, due to reactive magnetizing current requirements, power factor degrades and the amperage curve becomes increasingly non-linear. In the low load region, current measurements are not a useful indicator of load.

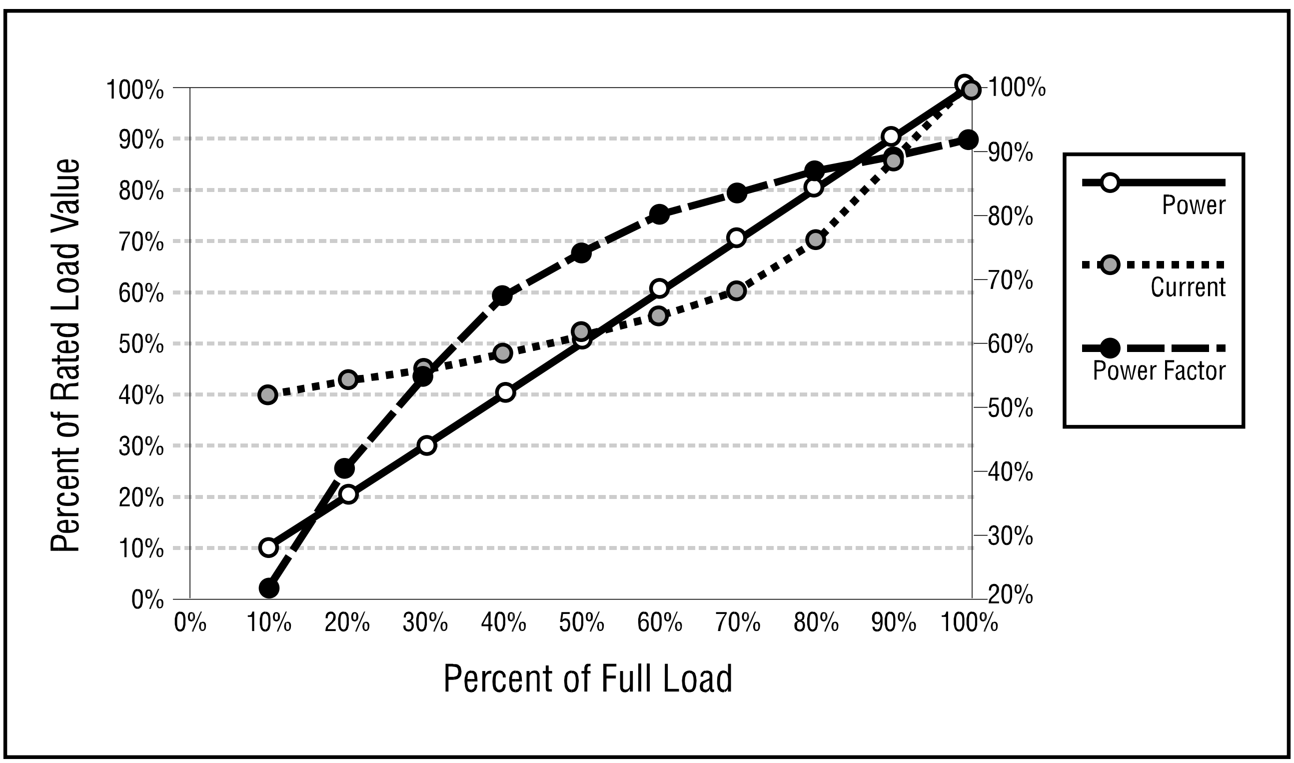

Figure 3 Relationships Between Power, Current, Power Factor and Motor Load

Nameplate full-load current value applies only at the rated motor voltage. Thus, root mean square (RMS) current measurements should always be corrected for voltage. If the supply voltage is below that indicated on the motor nameplate, the measured amperage value is correspondingly higher than expected under rated conditions and must be adjusted downwards. The converse holds true if the supply voltage at the motor terminals is above the motor rating. The equation that relates motor load to measured current values is shown in Equation 4.

Equation 4

$$Load = \frac{I}{I_r} \times \frac{V}{V_r} \times 100\%$$

Where:
Load = Output power as a % of rated power
I = RMS current, mean of 3 phases
I_r = Nameplate rated current
V = RMS voltage, mean line-to-line of 3 phases
V_r = Nameplate rated voltage

The Slip Method

The slip method for estimating motor load is recommended when only operating speed measurements are available. The synchronous speed of an induction motor depends on the frequency of the power supply and on the number of poles for which the motor is wound. The higher the frequency, the faster a motor runs. The more poles the motor has, the slower it runs. Table 1 indicates typical synchronous speeds.

Poles	60 Hertz
2	3600
4	1800
6	1200
8	900
10	720
12	600

Table 1 Induction Motor Synchronous Speeds

The actual speed of the motor is less than its synchronous speed with the difference between the synchronous and actual speed referred to as slip. The amount of slip present is proportional to the load imposed upon the motor by the driven equipment (see Figure 4). For example, a motor running with a 50% load has a slip halfway between the full load and synchronous speeds.

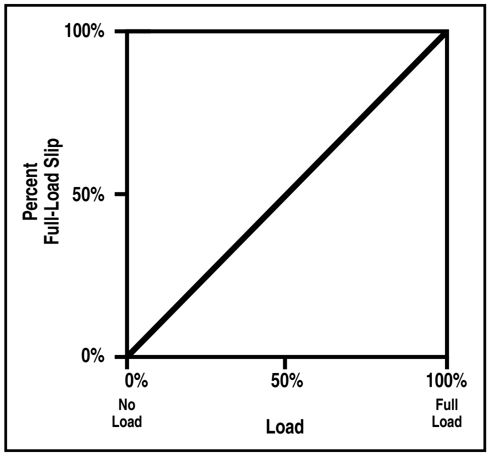

Figure 4 Percent Motor Slip as a Function of Motor Load

By using a tachometer to measure actual motor speed, it is possible to calculate motor loads. The safest, most convenient, and usually most accurate tachometer is a battery powered stroboscopic tachometer. Mechanical tachometers, plug-in tachometers, and tachometers which require stopping the motor to apply paint or reflective tape should be avoided. The motor load can be estimated with slip measurements as shown in Equation 5 and the following example.

Equation 5

$$Load = \frac{Slip}{S_s - S_r} \text{ x } 100\%$$

Where:

Load = Output power as a % of rated power

Slip = Synchronous speed - Measured speed in rpm

S_s = Synchronous speed in rpm

S_r = Nameplate full-load speed

Example: Slip Load Calculation

Given: Synchronous speed in rpm = 1800
Nameplate full load speed = 1750
Measured speed in rpm = 1770
Nameplate rated horsepower = 25 hp

Determine actual output horsepower.

From Equation 5

$$Load = \frac{1800 - 1770}{1800 - 1750} \text{ x } 100\% = 60\%$$

Actual output horsepower would be 60% *x* 25 hp = 15 hp

The speed/slip method of determining motor part-load is often favored due to its simplicity and safety advantages. Most motors are constructed such that the shaft is accessible to a tachometer or a strobe light.

The accuracy of the slip method, however, is limited. The largest uncertainty relates to the 20% tolerance that NEMA allows manufacturers in their reporting of nameplate full-load speed.

Given this broad tolerance, manufacturers generally round their reported full-load speed values to some multiple of 5 rpm. While 5 rpm is but a small percent of the full-load speed and may be thought of as insignificant, the slip method relies on the difference between full-load nameplate and synchronous speeds. Given a 40 rpm "correct" slip, a seemingly minor 5 rpm disparity causes a 12% change in calculated load.

Slip also varies inversely with respect to the motor terminal voltage squared—and voltage is subject to a separate NEMA tolerance of ± 10% at the motor terminals. A voltage correction factor can, of course, be inserted into the slip load equation. The voltage compensated load can be calculated as shown in Equation 6.

Equation 6

$$Load = \frac{Slip}{(S_s - S_r) \times (V_r / V)^2} \times 100\%$$

Where:
Load = Output power as a % of rated power
Slip = Synchronous speed - Measured speed in rpm
S_s = Synchronous speed in rpm
S_r = Nameplate full-load speed
V = RMS voltage, mean line to line of 3 phases
V_r = Nameplate rated voltage

An advantage of using the current-based load estimation technique is that NEMA MG1-12.47 allows a tolerance of only 10% when reporting nameplate full-load current. In addition, motor terminal voltages only affect current to the first power, while slip varies with the square of the voltage.

While the voltage-compensated slip method is attractive for its simplicity, its precision should not be overestimated. **The slip method is generally not recommended for determining motor loads in the field.**

Determining Motor Efficiency

The NEMA definition of energy efficiency is the ratio of its useful power output to its total power input and is usually expressed in percentage, as shown in Equation 7.

Equation 7

$$\eta = \frac{0.7457 \times hp \times Load}{P_i}$$

Where:
η = Efficiency as operated in %
P_{or} = Nameplate rated horsepower
Load = Output power as a % of rated power
P_i = Three-phase power in kW

By definition, a motor of a given rated horsepower is expected to deliver that quantity of power in a mechanical form at the motor shaft.

Figure 5 is a graphical depiction of the process of converting electrical energy to mechanical energy. Motor losses are the difference between the input and output power. Once the motor efficiency has been determined and the input power is known, you can calculate output power.

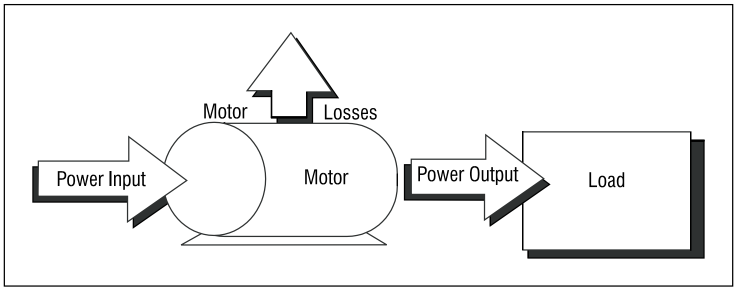

Figure 5 Depiction of Motor Losses

NEMA design A and B motors up to 500 hp in size are required to have a full-load efficiency value (selected from a table of nominal efficiencies) stamped on the nameplate. Most analyses of motor energy conservation savings assume that the existing motor is operating at its nameplate efficiency. This assumption is reasonable above the 50% load point as motor efficiencies generally peak at around 3/4 load with performance at 50% load almost identical to that at full load. Larger horsepower motors exhibit a relatively flat efficiency curve down to 25% of full load.

It is more difficult to determine the efficiency of a motor that has been in service a long time. It is not uncommon for the nameplate on the motor to be lost or painted over. In that case, it is almost impossible to locate efficiency information. Also, if the motor has been rewound, there is a probability that the motor efficiency has been reduced.

When nameplate efficiency is missing or unreadable, you must determine the efficiency value at the operating load point for the motor. If available, record significant nameplate data and contact the motor manufacturer. With the style, type, and serial number, the manufacturer can identify approximately when the motor was manufactured. Often the manufacturer will have historical records and can supply nominal efficiency values as a function of load for a family of motors.

When the manufacturer cannot provide motor efficiency values, you may use estimates from Attachment C. Attachment C contains nominal efficiency values at full, 75%, 50%, and 25% load for typical standard efficiency motors of various sizes and with synchronous speeds of 900, 1200, 1800, and 3600 rpm. Attachment C indicates "industry average" full- and part-load performance for all standard efficiency motors currently on the market.

Three steps are used to estimate efficiency and load. First, use power, amperage, or slip measurements to identify the load imposed on the operating motor. Second, obtain a motor part-load efficiency value consistent with the approximated load either from the manufacturer or by interpolating from the data supplied in Attachment C. Finally, if direct-read power measurements are available, derive a revised load estimate using both the power measurement at the motor terminals and the part-load efficiency value as shown in Equation 8.

Equation 8

$$Load = \frac{P_i \ x \ \eta}{hp \ x \ 0.7457}$$

Where:

Load = Output power as a % of rated power

P_i = Three-phase power in kW

η = Efficiency as operated in %

hp = Nameplate rated horsepower

For rewound motors, you should make an adjustment to the efficiency values in Attachment C. Tests of rewound motors show that rewound motor efficiency is less than that of the original motor. To reflect typical rewind losses, you should subtract two points from your standard motor efficiency on smaller motors ($\leq$40 hp) and subtract one point for larger motors. **Shops with the best quality-control practices can often rewind with no significant efficiency degradation.**

Computerized Load and Efficiency Estimation Techniques

There are several sophisticated methods for determining motor efficiency. These fall into three categories: special devices, software methods, and analytical methods. The special devices package all or most of the required instrumentation in a portable box. Software and analytical methods require generic portable instruments for measuring watts, vars, resistance, volts, amps, and speed. These need to be instruments of premium accuracy, especially the wattmeter that must have a broad range including good accuracy at low power and low power factor.

Washington State University Cooperative Extension Energy Program, in partnership with the Oregon State University Motor Systems Resource Facility, recently conducted lab testing of several efficiency-measuring methods. These included three special devices: the Vogelsang and Benning Motor-Check, the ECNZ Vectron Motor Monitor, and the Niagara Instruments MAS-1000. Their efficiency readings were carefully compared to "true" efficiency, measured by a dynamometer and precision lab instruments per IEEE testing standards. From 25% load to 150% load the special devices tended to hold an accuracy within 3%, even in adverse conditions of voltage deviation and unbalance on old, damaged, or rewound motors. In less challenging test conditions, they tended to operate within 2% accuracy. These instruments require a skilled electrician or other personnel trained in the safe connection of electrical equipment in industrial power systems plus about a day of training and practice. The motors must be temporarily unpowered for a resistance test and temporarily uncoupled for a no-load test, i.e., running at normal voltage unloaded. Uncoupling in-situ is rarely convenient, but the no-load test can be run at times such as receiving inspection or following service at the shop. No-load performance does not tend to change significantly over time in the absence of a failure/repair event.

Software and analytical methods were also tested in the lab research described above. When measurement of input data was made with precision lab instruments, the accuracy of methods requiring a no-load test approached that of the special devices' performance.

The Oak Ridge National Laboratory has developed ORMEL96 (Oak Ridge Motor Efficiency and Load, 1996), a software program that uses an equivalent circuit method to estimate the load and efficiency of an in-service motor. Only nameplate data and a measurement of rotor speed are required to compute both the motor efficiency and load factor. The program allows the user to enter optional measured data, such as stator resistance, to improve accuracy of the efficiency estimate. Future refinements of ORMEL96 are expected to create a more user-friendly product.

Finally, motor load and efficiency values are automatically determined when measured values are entered into ***MotorMaster+*** software's motor inventory module. ***MotorMaster+*** contains a database of new motor price and performance, and features many motor energy management capabilities including replacement analysis, maintenance logging, inventory control, energy and dollar savings tracking, and life cycle cost analysis. ***MotorMaster+*** is available at no cost to Motor Challenge Partners.

Electrical Glossary

Power Factor

Instantaneous power is proportional to instantaneous voltage times instantaneous current. AC voltage causes the current to flow in a sine wave replicating the voltage wave. However, inductance in the motor windings somewhat delays current flow, resulting in a phase shift. This transmits less net power than perfectly time-matched voltage and current of the same RMS values. Power factor is the fraction of power actually delivered in relation to the power that would be delivered by the same voltage and current without the phase shift. Low power factor does not imply lost or wasted power, just excess current. The energy associated with the excess current is alternately stored in the windings' magnetic field and regenerated back to the line with each AC cycle. This exchange is called reactive power. Though reactive power is theoretically not lost, the distribution system must be sized to accommodate it, which is a cost factor. To reduce these costs, capacitors are used to "correct" low power factor. Capacitors can be thought of as electrical reservoirs to capture and reflect reactive power back to the motor.

RMS Voltage

AC voltage rises positive and falls negative 60 times per second, so how do you state its value? Industry practice is to quote the RMS voltage. RMS is a value 70.7% of the peak positive voltage. An RMS voltage will produce exactly the same heating rate in a resistive load as a DC voltage of the same value. RMS is the acronym for the mathematical steps used in its derivation. *Square* the voltage at all moments in an AC cycle, take the *mean* of these, and then take the square *root* of the mean. For reasons lost in obscurity, the steps are stated in reverse sequence, Root Mean Square.

Three-Phase Power

Following the voltage, the power derived from an AC source peaks and falls to zero 120 times per second. This causes torque pulsations in motors, creating noise, vibration, and higher shaft stresses. Though minimal in fractional-horsepower household motors, this would be intolerable in larger motors. Larger motors usually require three-phase power, which avoids the problem. Three conductors supply AC voltage, offset in time or phase, so that they peak not simultaneously but at equally spaced intervals. This produces constant smooth torque from a motor, because at all moments, the sum of power from all three phases is constant. Three-phase power also eliminates the need for special starting windings required in single-phase motors.

Voltage Measurement

Voltage is a differential parameter; it is always measured *between* two points. There are two ways to measure three-phase voltage—between two of the three lines or between a line and neutral or ground. Service and motor voltages are quoted as line to line, unless otherwise noted. Because of the phase difference, line-to-line readings are 1.73 times line-to-neutral readings.

Inside a three-phase motor there are three windings, one for each phase. The easiest three-phase motor connection to visualize is with each of the three windings connected line to neutral. This is called wye because, schematically, it looks like the letter "Y". A more common connection eliminates the neutral tie and connects the three windings from line to line. This is called delta because, schematically, this looks like a triangle or the Greek letter Delta. The winding experiences 73% higher voltage when connected line to line, so it must be designed for the type of connection it will have. Even if a motor's windings are internally wye connected, its nameplate voltage rating is the line-to-line value.

Attachment A

Motor Nameplate and Field Test Data Form

Employee Name ______________________

Company ______________________

Date ______________________

Facility/Location ______________________

Department ______________________

Process ______________________

General Data

Serving Electrical Utility ______________________

Energy Rate ($/kWh) ______________________

Monthly Demand Charge ($/kW/mo.) ______________________

Application ______________________
Type of equipment that motor drives

Coupling Type ______________________

Motor Type (Design A,B,C,D AC, DC, etc.) ______________________

Motor Purchase Date / Age ______________________

Rewound ☐ **Yes** ☐ **No**

Motor Nameplate Data

1. **Manufacturer** ______________________
2. **Motor ID Number** ______________________
3. **Model** ______________________
4. **Serial Number** ______________________
5. **NEMA Design Type** ______________________
6. **Size (hp)** ______________________
7. **Enclosure Type** ______________________
8. **Synchronous Speed (RPM)** ______________________
9. **Full-Load Speed (RPM)** ______________________
10. **Voltage Rating** ______________________
11. **Frame Designation** ______________________
12. **Full-Load Amperage** ______________________
13. **Full-Load Power Factor (%)** ______________________
14. **Full-Load Efficiency (%)** ______________________
15. **Service Factor Rating** ______________________
16. **Temperature Rise** ______________________
17. **Insulation Class** ______________________
18. **kVA Code** ______________________

Motor Operating Profile

Hours Per Day	Weekdays Days/Year	Wknd/Holiday Days/Year
1st Shift	________	________
2nd Shift	________	________
3rd Shift	________	________

Annual Operating Time ______ **hours/year**

Type of load (Place an "X" by the most appropriate type)

____ 1. Load is quite steady, motor "On" during shift

____ 2. Load starts, stops, but is constant when "On"

____ 3. Load starts, stops, and fluctuates when "On"

Answer the following only if #2 or #3 above was selected:

% of time load is "on" ____%

Answer the following only if #3 was selected:

Estimate average load as a % of motor size____%

Measured Data

Supply Voltage

By Voltmeter

Line-to-Line
V_{ab} ________
V_{bc} ________
V_{ca} ________

V_{avg} ________

Input Amps

By Ampmeter

A_a ________
A_b ________
A_c ________

A_{avg} ________

Power Factor (PF) ______________________

Input Power (kW) ______________________

If available. Otherwise equal to:

$$V_{avg} \times A_{avg} \times PF \times \sqrt{3} / 1000$$

Motor Operating Speed ______________________

By Tachometer

Driven Equipment Operating Speed ______________________

Attachment B

Motor Energy Savings Calculation Form

Employee Name ________________________

Company ________________________

Date ________________________

Facility/Location ________________________

Department ________________________

Process ________________________

Motor Nameplate & Operating Information

Manufacturer ____________________

Motor ID Number ____________________

Size (hp) ____________________

Enclosure Type ____________________

Synchronous Speed (RPM) ____________

Full-Load Speed (RPM) ____________

Full-Load Amperage ____________

Full-Load Power Factor (%) ____________

Full-Load Efficiency (%) ____________

Utility Rates

Energy Rate ($/kWh) ____________

Monthly Demand Charge ($/kW/mo.) ________

Annual Operating Hours (hrs/yr.) ________

Annual Energy Use and Cost

Input Power (kW) ____________

Annual Energy Use ____________
Input Power x Annual Operating Hours

Annual Energy Cost ____________
Annual Energy Use x Energy Rate

Annual DemandCost ____________
Input Power x Monthly Demand Charge x 12

Total Annual Cost ____________
Annual Energy Cost + Annual Demand Cost

Motor Load and Efficiency Determination

Load ____________________
Input Power(kW) **/ [** *Motor Size(hp) x 0.746 / Efficiency at Full Load* **]**

Motor Efficiency at Operating Load ________
(Interpolate from Attachment C)

Energy Savings and Value

kW saved ____________________
Input Power **- [** *Load x hp x 0.746 / Efficiency of Replacement Motor at Load Point* **]**

kWh saved ____________________
kW saved x Annual Operating Hours

Total Annual Savings

Total Annual Savings $ ____________
(*kW saved x 12 x Monthly Demand Charge***) + (***kWh saved x Energy Rate***)**

Economic Justification

Cost for Replacement Motor ____________
(or Incremental Cost for New Motor)

Simple Payback (years) ____________
(*Cost for Replacement Motor + Installation Charge - Utility Rebate* **)** */ Total Annual Savings*

Attachment C

Average Efficiencies for Standard Efficiency Motors at Various Load Points

Efficiencies for 900 rpm, Standard Efficiency Motors								
Motor Size	Load Level In Percent							
	ODP				TEFC			
	100%	75%	50%	25%	100%	75%	50%	25%
10	87.2	87.6	86.3	78.3	86.8	87.6	86.8	77.3
15	87.8	88.8	88.2	79.6	87.5	88.7	88.1	79.1
20	88.2	89.2	88.0	81.8	89.2	89.9	89.2	82.6
25	88.6	89.2	88.0	83.0	89.7	90.3	89.1	78.6
30	89.9	90.7	90.2	84.5	89.6	90.5	86.5	84.1
40	91.0	91.8	91.7	86.2	90.5	91.4	85.5	85.0
50	90.8	91.9	91.1	87.1	90.2	91.0	90.2	84.9
75	91.7	92.4	92.1	86.5	91.6	91.8	91.0	87.0
100	92.2	92.2	91.8	85.8	92.4	92.5	92.0	83.6
125	92.9	92.3	91.7	86.9	93.0	93.1	92.1	87.9
150	93.3	93.1	92.6	89.5	93.0	93.4	92.5	NA
200	92.8	93.5	93.1	NA	93.7	94.1	93.4	NA
250	93.1	93.5	93.0	NA	91.7	94.8	94.5	NA
300	93.1	93.7	92.9	92.7	94.4	94.2	93.7	NA

Efficiencies for 1200 rpm, Standard Efficiency Motors								
Motor Size	Load Level In Percent							
	ODP				TEFC			
	100%	75%	50%	25%	100%	75%	50%	25%
10	87.3	86.9	85.7	78.5	87.1	87.7	86.4	80.3
15	87.4	87.5	86.8	80.8	88.2	88.1	87.3	80.7
20	88.5	89.2	88.8	84.1	89.1	89.7	89.4	82.8
25	89.4	89.7	89.3	85.0	89.8	90.5	89.8	83.5
30	89.2	90.1	89.8	87.6	90.1	91.3	90.7	84.6
40	90.1	90.4	90.0	85.8	90.3	90.1	89.3	85.3
50	90.7	91.2	90.9	86.9	91.6	92.0	91.5	86.7
75	92.0	92.5	92.3	88.6	91.9	91.6	91.0	87.2
100	92.3	92.7	92.2	87.4	92.8	92.7	91.9	86.5
125	92.6	92.9	92.8	87.9	93.0	93.0	92.6	88.7
150	93.1	93.3	92.9	89.7	93.3	93.8	93.4	91.1
200	94.1	94.6	93.5	91.5	94.0	94.3	93.6	NA
250	93.5	94.4	94.0	91.9	94.6	94.5	94.0	NA
300	93.8	94.4	94.3	92.9	94.7	94.8	94.0	NA

Attachment C (continued)

Efficiencies for 1800 rpm, Standard Efficiency Motors								
Motor Size	Load Level In Percent							
	ODP				TEFC			
	100%	75%	50%	25%	100%	75%	50%	25%
10	86.3	86.8	85.9	80.0	87.0	88.4	87.7	80.0
15	88.0	89.0	88.5	82.6	88.2	89.3	88.4	80.7
20	88.6	89.2	88.9	83.3	89.6	90.8	90.0	83.4
25	89.5	90.6	90.0	86.6	90.0	90.9	90.3	83.4
30	89.7	91.0	90.9	87.3	90.6	91.6	91.0	85.6
40	90.1	90.0	89.0	86.3	90.7	90.5	89.2	84.2
50	90.4	90.8	90.3	88.1	91.6	91.8	91.1	86.3
75	91.7	92.4	92.0	87.7	92.2	92.5	91.3	87.1
100	92.2	92.8	92.3	89.2	92.3	92.1	91.4	85.5
125	92.8	93.2	92.7	90.7	92.6	92.3	91.3	84.0
150	93.3	93.3	93.0	89.2	93.3	93.1	92.2	86.7
200	93.4	93.8	93.3	90.7	94.2	94.0	93.1	87.8
250	93.9	94.4	94.0	92.6	93.8	94.2	93.5	89.4
300	94.0	94.5	94.2	93.4	94.5	94.4	93.3	89.9

Efficiencies for 3600 rpm, Standard Efficiency Motors								
Motor Size	Load Level In Percent							
	ODP				TEFC			
	100%	75%	50%	25%	100%	75%	50%	25%
10	86.3	87.7	86.4	79.2	86.1	87.2	85.7	77.8
15	87.9	88.0	87.3	82.8	86.8	87.8	85.9	79.5
20	89.1	89.5	88.7	85.2	87.8	89.6	88.3	79.7
25	89.0	89.9	89.1	84.4	88.6	89.6	87.9	79.3
30	89.2	89.3	88.3	84.8	89.2	90.0	88.7	81.0
40	90.0	90.4	89.9	86.9	89.0	88.4	86.8	79.7
50	90.1	90.3	88.7	85.8	89.3	89.2	87.3	82.0
75	90.7	91.0	90.1	85.7	91.2	90.5	88.7	82.5
100	91.9	92.1	91.5	89.0	91.2	90.4	89.3	83.8
125	91.6	91.8	91.1	88.8	91.7	90.8	89.2	82.6
150	92.0	92.3	92.0	89.2	92.3	91.7	90.1	85.6
200	93.0	93.0	92.1	87.9	92.8	92.2	90.5	84.9
250	92.7	93.1	92.4	87.1	92.7	92.5	91.2	90.3
300	93.9	94.3	93.8	90.4	93.2	92.8	91.1	89.9

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