FRANKLIN AID

Franklin Electric

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VOLTAGE, CURRENT, AND POWER IN A SUBMERSIBLE INSTALLATION … MORE IMPORTANTLY, HOW MUCH DOES IT COST?

One of the more confusing things about electricity is how it's measured and how we pay for it. This issue of Franklin AID will clear up some misunderstandings about electrical power, especially in terms of calculating the electrical cost of operating a submersible pump. As part of this, we'll examine the phase relationship between voltage and current, otherwise known as power factor. We'll learn that power consumption is not just about amp draw, but is a combination of voltage, current and power factor.

First, a quick review of voltage and current. Voltage is simply electrical pressure, and of course, is measured in volts. The equivalent measure in a water system is pounds per square inch, or psi. Current, which is measured in amperes (amps for short), is electrical flow. As a matter of fact, 1 amp is scientifically defined as 6.2×10^{18} electrons (that is, 6.2 followed by 18 zeros) flowing past a given point each second. You can see that the concept is very similar to flow in a water system, where the unit of measurement is gallons per minute (gpm) instead of electrons per second.

In the simplest terms, electrical power is a combination of voltage and current. To borrow the water systems analogy once more, a 2 horsepower (hp) pump obviously delivers more power than a ½ hp pump. Said another way, the 2 hp pump will deliver a higher combination of pressure and flow than the ½ hp unit. Electrical power works the same, although it's expressed in watts (W) or kilowatts (kW) instead of hp.

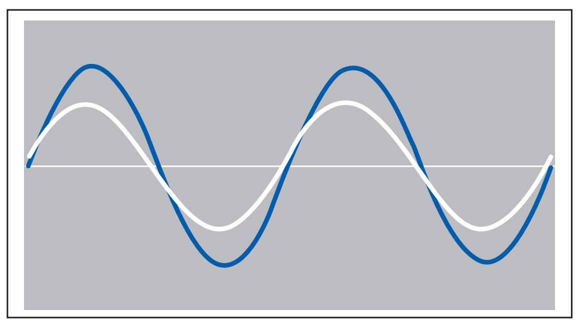
What is very different about electrical power versus a water system is that electricity is supplied as alternating current, generally just called AC. This simply means that the voltage and the current constantly change or "alternate". Hence, the familiar sine wave we've all seen many times. In the case of North America of course, the electrical power "alternates" at 60 hertz, or 60 cycles per second.

However, the waveforms of the voltage and current don't necessarily "line-up". That is, the peaks and zero crossing points don't occur at the same time, and are said to be "out-of-phase".

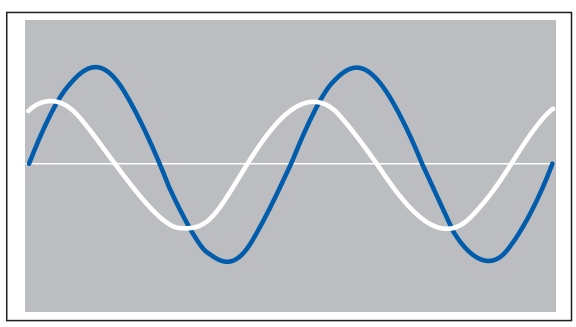
This phase relationship between voltage and current is expressed by what is called the Power Factor, or just PF for short.

The lower the power factor, the greater the voltage and current are out-of-phase. In the first example below, the power factor is relatively high, and you can see that the voltage and current are almost completely "in-phase".

The second diagram shows the case of a relatively low power factor, and the voltage and current are significantly out of phase with each other.



High Power Factor



Low Power Factor

By the way, power factor is always a number between 0 and 1, and is sometimes expressed as a percentage. It is also dimensionless. That is, it has no units.

The reason for this discussion is that it turns out that power in an AC electric circuit depends not only on the voltage supplied and the current consumed, but on the power factor of that circuit as well.

FRANKLINTECH TRAINING DATES

DATE	LOCATION	TYPE
March 6 - 7, 2007	Wilburton, Oklahoma	Three Phase Seminar
April 17 - 18, 2007	Siloam Springs, Arkansas	Single Phase Seminar
May 15 - 16, 2007	Wilburton, Oklahoma	Three Phase Seminar
June 5 - 6, 2007	Siloam Springs, Arkansas	Single Phase Seminar
September 18 - 19, 2007	Siloam Springs, Arkansas	Single Phase Seminar
October 16 - 17, 2007	Wilburton, Oklahoma	Three Phase Seminar
November 13 - 14, 2007	Wilburton, Oklahoma	Three Phase Seminar
December 11 - 12, 2007	Siloam Springs, Arkansas	Single Phase Seminar

Let’s look at a real world example. From the table on page 13 of the Franklin Electric AIM Manual, a 230 volt, 1 hp motor has the following characteristics at service factor load (SF):

TYPE	MOTOR MODEL PREFIX	RATING					FULL LOAD		MAXIMUM (S.F. LOAD)		WINDING (1) RES. IN OHMS	EFFICIENCY %		POWER FACTOR %		LOCKED ROTOR AMPS	KVA CODE
		HP	KW	VOLTS	HZ	S.F.	(2) AMPS	WATTS	(2) AMPS	WATTS	M=MAIN RES. S=START RES.	S.F.	F.L.	S.F.	F.L.		
4-INCH 2-WIRE	214508	1	0.75	230	60	1.4	Y8.2 B8.2 R0	1210	Y9.8 B9.8 R0	1600	M2.2-2.7 S9.9-12.1	65	62	74	63	41.8	L

Power, in a single-phase AC circuit, is calculated as follows:

Power = Voltage x Current x Power Factor

Voltage = 230 volts

Amperage = 9.8 amps

Power Factor = 0.74

So, **Power = 230 x 9.8 x 0.74**

= 1,668 watts

= 1.67 kilowatts

Note that in this same table of the Franklin AIM Manual, power consumption is stated as 1600 watts, which, with rounding, agrees with the value we just calculated.

Now, in reality, manufacturers simply state the power consumption of the device without making you go through the calculation above. A key point here is that power is "what you pay for". You don't pay for voltage or current, but for the combination of the two.

One note before we leave the topic of power factor. The formula above is for single-phase. The calculation for power with a 3-phase circuit is slightly different:

Power = Voltage x Current x Power Factor x 1.732

Calculating Dollars And Cents

So, how does this translate into dollars and cents? Well, we all pay for power in terms of kilowatt-hours. One kilowatt-hour is simply 1 kilowatt for 1 hour.

To calculate the monthly cost, we need to know three things:

1. Power consumption of the device in kilowatts
2. How many hours per day or month the device operates
3. Cost of power in kilowatt-hours

Monthly Cost = Power x hours of operation per month x cost per kilowatt-hour

Once again, let's look at an example:

1. Power consumption – For a Franklin submersible, this can also be found on page 13 of the AIM Manual. Going back to our example above, a 1 hp motor uses 1.67 kilowatts.

2. Hours per month – For the sake of our example, let's assume that the motor/pump runs an average of 2 hours per day. That would mean it runs about 60 hours per month.

3. Cost of power – According to the United States Department of Energy, the average residential cost of electricity in 2006 was 10.5 cents per kilowatt-hour. This makes for a convenient round number of 10 cents per kilowatt-hour.

So, monthly cost = 1.67 kW x 60 hours x $0.10 kW hour = $10.02

There you have it. A quick way to calculate how much it costs to operate a submersible pump. So, the next time your customer wants to know how much it costs to operate their private water system, you can show them that once again, a submersible pump is one of the best deals around.

Also, don't forget one of the key points above. Don't confuse current (amperage) with power – current is only one component of electrical power, much like flow (gpm) is only one component in the performance of a water system.

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