

CSDA Best Practice



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Introduction

Hi-cycle/high frequency concrete cutting equipment has become more prevalent in the cutting and drilling industry. With increasing availability and serviceability of hi-cycle/high frequency systems, many contractors are more comfortable making the switch from hydraulic powered equipment. There is increasing pressure from general contractors and government municipalities for cutting contractors to provide alternatives to hydraulic equipment. These parties are looking at ways to prevent incidents or injuries that can result from hydraulic oil leaks in sensitive work areas.

Electric powered equipment has always been an alternative, but a lack of sufficient power from early electrical tools was a problem. For these tools, large and heavy 60-hertz motors were required and were a huge inconvenience for the operators. Hi-cycle/high frequency equipment was, and still is, the answer. This technology allows the tool to be a lighter, more manageable size with plenty of power. During the early days of hi-cycle/high frequency equipment, the tools were limited and difficult to obtain. More recently, however, there is an ever increasing availability of hi-cycle/high frequency equipment and a large number of manufacturers of cutting equipment have, or are in the process of, developing hi-cycle/high frequency products. Demand from operators, safety personnel and owners for equipment that is lighter and safer to handle is the driving force behind this increase.

This Best Practice Document will discuss the safe operation of hi-cycle/high frequency systems and explain the different terms that may arise in discussions about hi-cycle/high frequency equipment. The document will also cover the difference in systems that utilize power inverters and systems that run directly from a hi-cycle/high frequency generator.

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1. Systems Utilizing Power Inverters

Inverter driven systems operate by converting input voltage and frequency from a power source, like 480-volt 60-hertz 3-phase, 220-volt 60-hertz 3-phase and/or 220-volt 60-hertz single phase systems (Input voltage is dependent on manufacturer design). Each design will allow a predetermined input voltage and frequency range that the power inverter will accept.

Output voltage is provided by the power inverter—the hi-cycle/high frequency side of the system. A cable/cord connects the power inverter to the equipment. The voltage and frequency on the output, or hi-cycle/high frequency side of the system, is by design and determined by each manufacturer. Typical voltage and frequency is; 400 volt 400 hertz , 200 volt 400 hertz or 400 volt 1,000 hertz. The differences with each frequency will be explained further in the following sections. Inverter driven systems have made the availability of hi-cycle/high frequency systems much easier for the end user, due to the fact these systems run from 60-hertz power sources and many end users already own a 60-hertz generator. Today, manufacturers of hi-cycle/high frequency systems have all of the components needed for the complete system.

1.1 System Components

- a. Hi-cycle/high frequency motor
- b. Power inverter
- c. Power cable/cord from tool to power inverter
- d. Water hose (connects to water cooled motor and or power inverter)
- e. Wall saw, wire saw, core drill or slab saw
- f. Remote control (optional on some systems)
- g. Power and water source (generator, house power), water pump or house water

2. Why is a Hi-cycle/High Frequency Motor So Much Smaller Than a 60-hertz Motor?

By increasing the motor rpm the frequency/hertz is increased. For example:

- A 60-hertz, 20-horsepower, 3-phase motor operates with an internal rpm about 1,800
- A 400-hertz, 20-horsepower, 3-phase motor operates with an internal rpm about 12,000
- A 1,000-hertz, 20-horsepower, 3-phase motor operates with an internal rpm about 30,000

Horsepower is determined by manufacturer design, with each manufacturer offering its own horsepower for each system.

Increasing rpm increases frequency. The higher the frequency the smaller the rotor and stator can be, therefore a lighter weight with motors of a smaller size.

With higher rpm the motor generates more heat, which has to be dealt with in order for the motor to survive. Water cooling is the most effective method to accomplish the job of removing heat. There are water cooling jackets built around the motor stator and rotor, so it is extremely important that the motors are not run without water flowing. Most inverter driven systems will have some method of monitoring internal motor temperature and will try to protect the motor from overheating with warning lights or by shutting the motor down.

3. Operating Inverter Driven Systems with Remote Control and Auto Feed

Safety is a big advantage with a remote controlled auto feed system. The operator is at a safe distance away from the cutting. The operator moves a lever or switch on the remote control to feed the blade into the cut and control the direction of the cut. The power inverter software then controls the load and feed rate while the blade is cutting. The operator cannot overload the motor, the software will slow or stop the feed rate when load on the motor changes such as when cutting steel bar or hard aggregate. If the blade jams, the software will sense the sudden change in load and turn the motor off.

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3.1. Power Source and Cable/Cords

These cables and cords should be sufficient for the tool in use. Manufacturer recommendations on generator size and cable/cord size must be followed to achieve the best performance from the equipment in use. Voltage and/or frequency fluctuations due to an undersized cable/cord or power source can cause undesirable behavior with the equipment. Never allow higher than the maximum rated voltage to be plugged into the system. Damage to the equipment can, and will, occur.

3.2. Connections

Electrical connections are the single most important item in any system that utilizes electrical power to operate a tool. Make sure connections are tight. Inspect clamping devices or clamping rings for damage and make sure when connected that they remain tight. Inspect cable/cords for cuts in insulation, crushed wires, cord grip damage or fatigue of cable/cord at the cord grip.

3.3. Clean Pins and Sockets

A dirty or worn pin or socket in a connection is a problem waiting to happen. If a pin and socket are full of slurry or worn there is less than 100 percent contact between the two. In order to transfer the power load through the connection efficiently, the pins and sockets need 100 percent of the surface contact area. When the contact area is reduced, heat will be generated, arcing will begin and eventual failure is bound to follow. On some inverter driven systems the loss of a phase in a connection or from the power source can cause a warning light to flash and shut the motor off to protect the machine and the operator.

4. Inverter Driven Manual Feed Systems

This system has no auto feed function. The operator manually feeds blade or bit into cut and manually controls feeding rate. Operators must utilize load warning lights or meters in order to stay within the operating range specified by the operator. Ignoring the warnings will cause overloading and damage can occur to motor and other components.

Some systems have overload protection and will shut down when the system reaches a specified overload range. Always follow manufacturer recommended operating procedure.

5. Systems Run Directly from a Hi-cycle/High Frequency Generator

Systems that run directly from a hi-cycle/high frequency power source differ slightly to an inverter driven system. These systems operate by connecting a power source directly to a switch box or control box that is used to turn the power on and off to the hi-cycle/high frequency motor.

The most common voltage and frequency for these systems is 200 volts and 400 hertz. This was the first level of voltage and frequency introduced to the concrete cutting industry for hi-cycle equipment. There are also some 400-volt, 400-hertz systems of this type in circulation.

Connections should be cared for in the same way as with the inverter driven systems and any other system that utilizes electricity.

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5.1. System Components

- a. Hi-cycle/high frequency motor
- b. Hi-cycle/high frequency generator
- c. Switch box/control box
- d. Power cable/cord from tool to switch box/control box
- e. Wall saw, wire saw, core drill and slab saw
- f. Power and water source, (Hi-cycle/high frequency generator), water pump or house water.

5.2. Power Source

The power source is very important with this type of system. Voltage drops and frequency variations have a different affect on this type of system. When voltage drops from the generator it also drops at the motor. As voltage drops, amperage rises. More heat is generated and the motor, cords and connections run hotter. If the heat is severe enough, damage can occur to the equipment. Some systems utilize a temperature sensor inside the motor for protection, however, most do not.

Operators must utilize volt meters and/or amp meters to properly apply the correct load when sawing or drilling with this type of system. Always follow manufacturer recommended operating procedure.

6. Common Terms and Definitions

Here are some commonly-used terms with regards to electric powered equipment, together with a brief definition of each. The terms are listed in alphabetical order.

AC (Alternating Current)

The commonly available electric power, supplied or distributed in single or three-phase forms. AC current changes its direction of flow (cycles).

Air Gap

The space between the rotating (rotor) and stationary (stator) part of an electric motor.

Ampere (Amp)

The standard unit of electrical current. The current produced by a pressure of one volt in a circuit having a resistance of one ohm.

Bearings

These are used to reduce friction and wear while supporting rotating elements. For a motor, it must provide a relatively rigid support for the output shaft. The bearing acts as the connection point between the rotating and stationary elements of a motor. The ball bearing is the most commonly used type of bearing in virtually all types and sizes of electric motors.

Coil

The electrical conductors wound into the core slot that are electrically insulated from the iron core. It is these coils that carry and produce the magnetic field when the current passes through them.

Current

The time rate flow of an electrical charge. Current is measured in amps (amperes).

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Cycles Per Second (Hertz)

One complete reverse of flow of alternating current per rate of time, hertz is a measure of frequency. 60 hertz (cycles per second) AC Power is common throughout the USA, while 50 hertz is more common in other parts of the world.

Fuse

A piece of metal connected in the circuit to be protected, that melts and interrupts the circuit when excess current flows.

Hertz (HZ)

One cycle per second (as in 60 hertz, which is 60 cycles per second).

Horsepower

The measure of rate of work. One horsepower is equivalent to lifting 33,000 pounds to a height of one foot in one minute. The horsepower of a motor is expressed as a function of torque and rpm. For motors, the following approximate formula may be used:

$$\text{hp} = \frac{t \times \text{rpm}}{5,252}$$

Where hp = horsepower, t = torque (lb ft.)
rpm = Revolutions per minute

Usually torque is unknown to the end user in the concrete cutting industry. Horsepower is the most commonly known rating. Torque = horsepower x 5,252/rpm. This calculation will provide the rated torque. The common rpms of hi-cycle/high frequency motors in this industry are 60 hertz at 1,800 rpm, 400 hertz at 12,000 rpm and 1,000 hertz at 30,000 rpm.

Inverter

An electrical device that converts fixed frequency and fixed voltages to variable frequency and voltage. An inverter enables the operator to electrically vary the speed of an AC motor.

Kilowatt

Since the watt is a relatively small unit of power, the kilowatt (kW) is used where larger units of power measurements are desirable. Generators are rated in kW and kVA. If you know the kVA and need to convert to kW, or you know the kW and need to convert to kVA:

$$\text{kW} = \text{kVA} \times 0.8$$

Example: 25kVA x 0.8 = 20kW

$$\text{kVA} = \text{kW} \text{ divided by } 0.8$$

Example: 20kW divided by 0.8 = 25kVA

The minimum supply of kilowatts needed to run hi-cycle/high frequency systems is determined by each manufacturer. Always follow manufacturer recommendations. A general rule is that 1 kW per rated horsepower of the hi-cycle/high frequency motor should be the absolute bare minimum. At least 1.25 kW or more per rated horsepower is a much better option, and leaves more of a margin for losses in these systems.

Laminations

The steel portion of the rotor and stator cores made up of a series of thin laminations (sheets) which are stacked and fastened together by cleats, rivets or welds.

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Losses

A motor converts electrical energy into a mechanical energy and in so doing, encounters losses. These losses are all the energy that is put into a motor and not transformed to usable power but are converted into heat, causing the temperature of the windings and other motor parts to rise.

Motor

A device that takes electrical energy and converts it into mechanical energy to turn a shaft.

Phase

The number of individual voltages applied to an AC motor. A single-phase motor has one voltage in the shape of a sine wave applied to it. A three-phase motor has three individual voltages applied to it. The three phases are at 120 degrees with respect to each other so that peaks of voltage occur at even time intervals to balance the power received and delivered by the motor throughout its 360 degrees of rotation.

Poles

In an AC motor, poles refer to the number of magnetic poles in the stator winding. The number of poles is a determinant of the motors speed.

Resistance

The degree of obstacle presented by a material to the flow of electric current is known as resistance, and is measured in ohms.

Rotor

The rotating member of an induction motor made up of stacked laminations. A shaft running through the center and a squirrel cage made in most cases of aluminum which holds the laminations together and act as a conductor for the induced magnetic field. Hi-cycle/high frequency motors in the concrete cutting industry tend to use copper squirrel cages for better performance and strength.

RPM (revolutions per minute)

The number of times per minute the shaft of the motor (machine) rotates. This is a function of design and the power supply.

Speed

The speed of the motor refers to the rpms (revolutions per minute) of the shaft. For a three-phase AC motor the synchronous speed is:

$120 \times \text{frequency measured in hertz or cycles per second, divided by the number of poles.}$
The numbers of poles are a function of design.

In the concrete cutting industry common pole counts are:
2 Pole, 4 Pole and 8 Pole. 4 Pole is the most common.

Stator

The part of an AC induction motor's magnetic structure which does not rotate. It usually contains the primary winding. The stator is made up of laminations with a large hole in the center in which the rotor can turn; there are slots in the stator in which the windings for the coils are inserted.

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Thermal Protector (inherent)

An inherent overheating protective device which is responsive to motor temperature and which, when properly applied to a motor, protects the motor against dangerous overheating due to overload or failure to start.

Thermistor-Thermally Sensitive Resistor

A semiconductor used to measure temperature. A thermistor can be attached to an alarm or meter to detect motor overheating.

Torque

Turning force delivered by a motor or gear motor shaft, usually expressed in pounds. Torque can be derived by completing $hp \times 5252/rpm = \text{full load torque}$.

Transformer

A device which converts electrical power (alternating current) to electrical power of a different voltage. In this device both primary and secondary windings are usually stationary, and are wound on a common magnetic core.

Voltage

The force that causes a current to flow in an electrical circuit. A device which causes a current to flow in an electrical circuit. Analogous to pressure in hydraulics, voltage is often referred to as electrical pressure. The voltage of a motor is usually determined by the supply to which it is being attached.

Watt

The amount of power required to maintain a current of one ampere at a pressure of one volt. Most motors are rated in kilowatts equal to 1,000 watts. One horsepower is equal to 746 watts.

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