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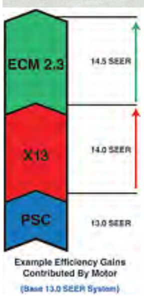
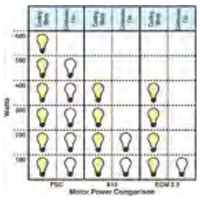


The heating, ventilation and air conditioning (HVAC) industry currently uses a variety of motor technologies in its equipment. The type specified in any product design depends upon several criteria, including the product's performance goals, positioning, cost and potential application. Historically, the two predominant motor types have been permanent split capacitor (PSC) single-speed motors and 2.3 electronically commutated motors (ECMs) with variable-speed capability. Most HVAC professionals understand the key differences between these two motor types and are comfortable discussing the benefits of one technology over another.

In 2006, Regal-Beloit (formerly known as General Electric, now known as Genteq) introduced a third motor technology to the industry. Referred to as its X13 motor, this new technology has significantly gained in popularity among all heating and air conditioning equipment manufacturers. What is this newer motor, and how does it compare to PSC single-speed and ECM variable-speed motor technologies? Why is it popular?

The Genteq X13 motor is a high-efficiency motor that help manufacturers meet the 13 SEER mandate implemented by the federal government in 2006 (hence, the branding name of X13). The motors are based on ECM technology and can contribute to the increased overall cooling efficiency of a complete HVAC system when used as the circulating air blower motor in a furnace, air handler or packaged unit. In fact, manufacturers of these types of motors may refer to them as a standard ECM motor, or as a constant torque motor.

For clarification, X13 is the Genteq brand name. Several other manufacturers offer similar motors. However, for the purpose of this article, the term constant torque motor will be used to describe all such motors.



MOTOR COMPARISONS

In order to understand the benefits of constant torque motor technology, it is important to look at, understand and compare the two other motor technologies prevalent in the industry - PSC single-speed and ECM 2.3 variable-speed. Constant torque motor technology offers several benefits with respect to efficiency, operation, comfort and cost when compared to these two other motor technologies.

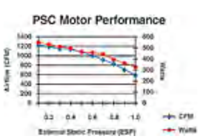
PSC single-speed motor technology has been the standard in the industry for many years and represents the highest installed base. PSC motors are typically positioned by most manufacturers as a standard product offering and are used in furnaces, air handlers, condensing units and packaged products. The popularity of the PSC motor can be attributed to its simplicity, reliability, low cost and flexibility.

PSC motors, often referred to as induction motors, typically use alternating current (AC) and include two key components in their design - a stator (the stationary section of the motor) and a rotor (the rotating section of the motor).

A magnetic field is induced in the rotor opposite in polarity of the magnetic field in the stator. Therefore, as the magnetic field rotates in the stator, the rotor also rotates to maintain its alignment with the stator’s magnetic field. In this operation, the rotor constantly lags behind the magnetic field in the stator, resulting in what is known as asynchronous (i.e., not synchronized) operation.

This operational characteristic, which also generates excessive heat, greatly contributes to the degraded operational efficiency of PSC motors (which are at best only 60 percent efficient). However, since there are few mechanical components, this design has proven to be very simple and reliable, and can be manufactured at a relatively low cost.

PSC motors are considered single-speed (speed refers to the rate of rotational motion) because they do not have any internal controls that can be programmed to automatically vary the rotation of the motor over an operating range. For example, an equipment manufacturer may utilize a ½ hp motor in a 3-ton drive furnace in order to deliver an average airflow of 1,200 CFM within a range of external static pressures (ESP) often found in assorted applications.



But what if the duct system layout in a specific application has an increased static pressure because the mechanical contractor added a very restrictive media filter?

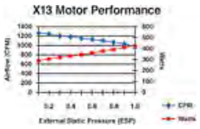
In order to make PSC motors more flexible for a variety of applications, they include speed taps that allow the mechanical contractor (or manufacturer) to manipulate the motor’s speed to ensure that the correct amount of airflow is delivered for both optimal performance and safety within a range of external static pressures. It should be understood that there is a limit to the amount of static pressure the motor can handle. As static pressure increases, a PSC motor’s performance drops off, because it cannot adjust speed or torque.

As a result, higher static pressures equate to lower airflows. Although the lack of programmability may appear to be a disadvantage, it actually makes PSC motors more flexible or universal because they can be used for most retrofit and original equipment manufacturer (OEM) applications.

Because of the motor’s design, there are some disadvantages inherent in PSC motors. For example, PSC motors are significantly less efficient than constant torque or ECM 2.3 motors because they consume more watts, making them more difficult for a manufacturer to apply to a high-SEER system design. On average, PSC motors will use approximately 552 watts in cooling mode and 515 watts in continuous fan mode. Therefore, they are not ideal for continuous fan operation because they run close to full speed when applied in this manner, using more energy than this function really requires. (As a comparison, imagine the power consumed by five 100-watt light bulbs lit all day long). This also makes them less attractive for continuous filtration applications. Additionally, since PSC motors are not programmable and their motor speed cannot be easily varied, it is more difficult to apply the motors to two-stage or advanced systems.

PSC motors are also the least quiet of the three motor technologies. In addition, PSC motors do not offer customized airflow patterns, which are often critical in designs intended to manage humidity. Consistent air stratification and temperatures are also harder to obtain.

Finally, products that utilize PSC motors typically do not qualify for the federal tax credit program based on the motor itself. However, if the rest of the system components meet performance requirements (specific SEER, EER and HSPF combinations or a minimum 95 percent AFUE) as outlined under the program, then the installation may be eligible for a federal tax credit.



PREMIUM ECM 2.3 VARIABLE-SPEED MOTOR TECHNOLOGY

ECM 2.3 variable-speed motor technology can be compared to using a dimmer switch in lighting applications, meaning it is highly variable, making its precise performance ideal for a variety of advanced applications. Most manufacturers typically position an ECM 2.3 motor as a premium product offering and use the motors in furnaces, air handlers, condensing units and packaged products. The popularity of the ECM 2.3 motor can be attributed to its performance, flexibility and reliability.

(Note: There are several other ECM motor designs on the market. Some of these models are identified as ECM 2.5 or ECM 3.0 and include additional features that allow for more sophisticated programming options specifically intended for equipment that utilizes communicating control systems (also known as four-wire systems). In any case, the information that follows generally applies to all three ECM motor types.)

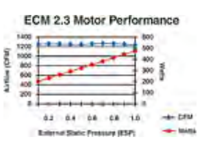
ECM technology is based on a direct current (DC) design that is inherently more efficient and runs cooler than alternating current PSC motor designs. In fact, ECM 2.3 motors are approximately 80 percent efficient compared to the 60 percent efficiency rating typical of PSC designs.

In a traditional DC motor, permanent magnets replace the stator, and a series of windings wrap around the rotor. When electricity is applied to the motor, a magnetic field is created in the windings, causing it to turn toward the magnetic field created by the stator. From there, brushes in contact with a commutator (i.e., an electrical switch that periodically reverses electrical current) allow the current and magnetic field to shift from winding to winding, forcing the rotor to continuously rotate. Unfortunately, the brushes and the commutator eventually wear out, resulting in motor failure.

So what makes ECM 2.3 motor designs better than their traditional DC counterparts? First, in the ECM 2.3 motor, the magnets and windings switch positions - the permanent magnet is on the rotor and the series of windings are placed around the rotor. This makes the ECM 2.3 a brushless motor, eliminating failures caused by worn brushes and commutators.

Second, the ECM 2.3 design combines a microprocessor and an electronic control directly with the motor. These electronics precisely manage the commutation of the stator so that it is always synchronous (i.e., in tune) with the rotor. They also make the motor programmable. Additionally, in the case of a failure, either the control or the motor can be replaced without necessarily replacing the entire unit.

Unlike conventional PSC motors, which are designed to operate at one speed, ECM 2.3 variable-speed motors can run over a wide range of speeds. This is critical because blowers need to be flexible in order to deliver the airflow required by a multitude of system designs. ECM 2.3 motor technology provides the ability to program and deliver constant airflow over a wide range of ESP, typically up to 1.0 inches water column.



This feature automatically compensates for any added pressure drop introduced to the system. For example, if a duct system layout has an increased static pressure due to a dirty filter, the presence of a media filter or simply because of poor design, the motor will automatically ramp up to ensure that the programmed amount of airflow is delivered. This is accomplished without the use of any additional components.

Equipment manufacturers don’t condone poor duct design, but ECM 2.3 motor technology can compensate for some applications if sized incorrectly. However, it is important to be cautious, because increased noise levels, which are uncharacteristic of these motors, may result if the design is overly restrictive.

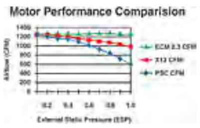
Overall, ECM 2.3 motors draw the least amount of watts, which makes them the most efficient. On average, they will use approximately 413 watts in cooling mode and only 83 watts (less than a 100-watt light bulb) in continuous fan mode. This combination of performance, reliability and programmable flexibility makes ECM 2.3 motors an ideal solution for high-SEER or multi-stage system designs. It also has the potential to increase overall cooling system performance by as much as one or more SEER points.

Beyond programmability and efficiency, ECM 2.3 motors offer many other advantages that enhance consumer comfort. These motors are the quietest of the three motor types because they have the ability to ramp up and down slowly, making them ideal for applications where noise is a concern.

Variable-speed motors are also the best choice for constant fan or constant filtering applications because the motor will only run at about one-third of its designed speed, using less power than a 100-watt light bulb and resulting in both noise reduction and energy savings that the consumer will appreciate. The indoor environment will also benefit from better air stratification, ensuring more consistent and precise temperatures.

In addition, ECM 2.3 motors have the ability to deliver customized airflow based on the consumer’s geographic region, making them versatile in humid, arid or temperate climates. If dehumidification is required, variable-speed motors offer the best solution because of the wide range of speeds, and they are particularly effective when combined with two-stage compressors and a dehumidification control. Lastly, due to their efficiency, most products that utilize ECM 2.3 motors may qualify for up to $1,500 under the federal tax credit program.

ECM 2.3 variable-speed motors do have a few disadvantages, including a cost premium. On average, a mechanical contractor can anticipate a 40-60 percent cost premium for products that utilize ECM 2.3 motors.



STANDARD ECM CONSTANT TORQUE MOTOR TECHNOLOGY

Constant torque motor technology is quickly becoming a popular motor technology. As a matter of fact, it may totally replace PSC motors in the near future as government actions and regulations continue to mandate increased efficiencies. Most manufacturers typically position constant torque motors as a mid-tier product offering and use the motors in furnaces, air handlers and packaged products. The popularity of the constant torque motor can be attributed to its performance and cost.

Constant torque motors are high-efficiency, brushless DC motors that are based on the same ECM technology described in ECM 2.3 variable-speed motors. They are controlled by 24-volt signals and were designed so that OEMs can program them, using a programming tool at the factory, for use in a variety of high-efficiency applications without modifying or increasing the size of existing product designs. The programming is not as flexible as a premium ECM 2.3 motor (for example, it does not allow for wider speed ranges, climate-based airflow performance profiles or constant airflow algorithms). Although constant torque motors utilize ECM technology, they are not variable-speed motors, as many people have considered or defined them. This is probably one of the biggest misconceptions regarding constant torque technology.

For comparison’s sake, constant torque motors are basically upgraded, next-generation PSC motors. What differentiates constant torque motors from PSC motors is their ability to deliver constant torque (i.e., rotational force or power output down a shaft). In other words, if the ESP changes, then the motor program will maintain the amount of torque for which it was programmed (this is not the same as constant airflow).

Even though constant torque motors can maintain torque, if the external static pressure increases, airflow will decrease similar to a PSC motor. However, the decrease is not as drastic, since the torque is being maintained. At the other extreme, an ECM 2.3 motor has the ability, via programming, to increase torque in order to maintain constant airflow in response to changes in ESP.

When compared to similarly sized PSC motors, constant torque motors reduce power consumption, using approximately 413 watts in cooling mode and only 200 watts in continuous fan mode - compared to 552 watts and 515 watts, respectively, for PSC models. These savings make the overall efficiency of a constant torque motor similar to that of an ECM 2.3 variable-speed motor, which is approximately 80 percent.

Constant torque motors are programmed by the OEM at the factory. But what do they actually program? Constant torque motors are designed to deliver constant torque (not speed). But the same amount of torque may not be required for all functions or all applications. So, equipment manufacturers determine the level of torque needed for each product application. Once determined, they program each of the motor’s speed taps (typically up to five taps) to produce the desired airflow for heating, cooling or continuous fan operation, depending upon which tap is used.

The manufacturer has the flexibility to specify either a percentage of the maximum torque or the actual torque value in their motor programs. For example, tap 1 = 100 percent torque, tap 2 = 85 percent torque, tap 3 = 65 percent torque, tap 4 = 50 percent torque and tap 5 = 25 percent torque.

Many manufacturers will only program the taps needed for the specific equipment design, meaning some taps may not be active. The manufacturer also programs any off-delays needed at each tap. On-delays cannot be programmed. However, the manufacturer can accomplish on-delays with external control boards (i.e., an integrated furnace control board or a fan control board).

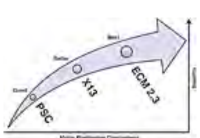
So how does the mechanical contractor use these taps? Let’s assume that we have applied a 4-ton drive (1,600 CFM nominal) gas furnace to a duct system. In order to make certain that the furnace is operating at the correct ATR, which ensures proper and safe heating operation as well as heat exchanger longevity, the motor speed typically must be adjusted. The technician will usually do this by re-assigning the heating speed tap from one designated speed to another (often labeled as low, medium low, medium, medium high or high).

Now let’s assume that the consumer has a fairly restrictive media filter installed at a later date. The technician most likely had to manipulate the motor speed once again in order to ensure correct operation.

This manipulation interface is familiar to all mechanical contractors, which is important because the reality is that changing tap connections on constant torque motors does not actually change the speed of the motor. Instead, it changes the programmed torque levels of the motor (most technicians understand adjusting speed and not torque). The manufacturer will most often not provide the actual torque values, but instead will indicate, via a chart, which of the five taps are to be selected for proper heating, cooling or continuous fan airflow.

Constant torque motors offer several consumer benefits. With increased SEER ratings in cooling mode, homeowners will appreciate lower utility bills. Since these motors utilize ECM technology, they are also slightly quieter than a traditional PSC motor and will contribute to the emotional comfort factor.

Additionally, products that use constant torque motors can contribute to a slight improvement in dehumidification. Lastly, because of their efficiency, some products that utilize constant torque motor technology may qualify for up to $1,500 under the federal tax credit program. (Check with the equipment manufacturer for confirmation.)



KEY HIGHLIGHTS OF THE CONSTANT TORQUE MOTOR

Now that there is an understanding of the three main motor technologies used in the industry, contractors should realize the importance and benefit of including equipment in their product offering that features constant torque motor technology and be prepared to discuss them with their customers.

• **Product Positioning.** Independent research confirms that consumers prefer choices and often migrate to the middle option when presented with a "good, better, best" scenario. Products with constant torque motor technology are typically positioned as mid-tier product offerings - they are the "better" in a good, better, best proposal. It is doubtful that the price point to upgrade to a product with constant torque motor technology will be hard to defend.

• **Reduced Utility Bills.** Many consumers are interested in lowering their energy costs, especially in the current economic climate. When applied as a complete system, constant torque motors can increase the overall cooling efficiency by as much as one or more SEER points. Depending on the consumer's lifestyle, the size of their home and the region where they live, this can equate to several hundred dollars in energy savings per year.

• **Federal Tax Credits.** Furnace products that utilize constant torque motor technology may qualify for up to $1,500 in tax credits under the current federal program due to the motor's contribution to efficiency. (Check with the furnace equipment manufacturer to determine eligibility.) If eligible, the constant torque motor would be defined as an advanced air circulating fan, meaning that the motor itself has an annual electricity usage of no more than 2 percent of the total annual energy used by the furnace, as determined by Department of Energy (DOE) test procedures.

It should be noted that this criteria, including the tax credit itself, does not apply to air handlers with constant torque motors because the benefit of the advanced main air circulating fan has already been accounted for in the overall energy efficiency ratings of the outdoor products.

• **Sustainability.** One of the hottest buzzwords today is sustainability. All contractors and service technicians should be aware of what the term means and how sustainability relates to the equipment they sell and service. The Environmental Protection Agency (EPA) Website defines sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs."

Sustainability certainly applies to the HVACR industry. In the case of products with constant torque motor technology, sustainability can be associated with reduced energy use and less environmental pollution. And, depending on the equipment manufacturer, the sustainability conversation may include green or recycled packaging and reduced noise levels.

Constant torque technology is rapidly gaining popularity among OEMs in the industry and among consumers interested in improving the efficiency of their home comfort systems. By understanding the advantages this new motor technology offers, contractors can create a unique, professional selling proposition that will set them apart from their competition, contribute to higher profit margins and address consumer demands for efficiency, reliability and comfort.

Sources: Technical information about the three motor technologies was primarily obtained from Regal-Beloit (General Electric) documentation. For additional details, please visit www.thedealertoolbox.com and www.regalbeloit.com).

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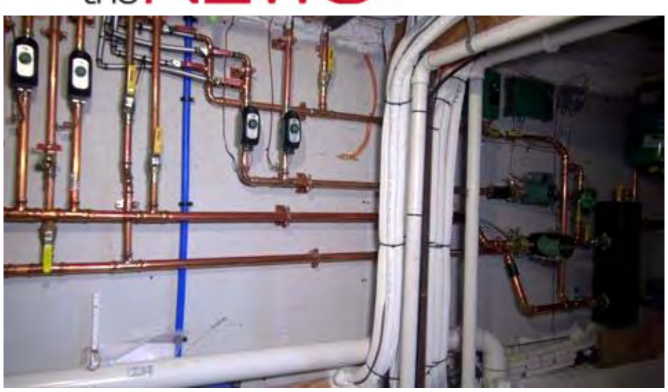

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