Pump ED 101

AC Motors Part 4 – Motor Frame Size, Enclosures and Nameplate Data

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Frame Size

The frame sizes (physical dimensions) of AC motors have changed substantially over the years. Originally they were considerably larger than those in use today and this increased size was due to inefficiency and the need to dissipate heat. Also, there was not much standardization and a particular motor might be built on several different frames. This made replacement more difficult since the various dimensions including shaft height and the placement of the base mounting holes could also change. As new materials and advanced design techniques became available, the frame size necessary to produce a particular HP was reduced and, eventually, sizes began to be standardized.

In 1952 the National Electric Manufacturers Association (NEMA) introduced a new frame size standardization called the "U" frame. The U frame size was designed for Class A insulation which has a temperature rating of 105°C. Twelve years later the standardization was revamped and the "T" frame motor appeared. It was designed for higher temperature Class B insulation which has a rating of 130°C. The T frame remains the standard today but the U frame is still in use, especially in the automotive industry. Believe it or not, I recently visited a pump station in Seaside, Oregon that still operates two 100HP original frame (pre 1952) motors.

The result of these two standardizations was a systematic decrease in motor frame size. For example, prior to 1952 a 10HP, 1800RPM motor was built on a 324 frame. After 1952 that same motor utilized a 256U frame and in 1964 it was reduced to a 213T frame. Today, even higher temperature insulation classes (Class F - 155°C and Class H - 180°C) allow smaller frame sizes to accommodate even higher horsepower. The three digits that make up the frame size are directly related to the various dimensions of the motor built on that particular frame. The first two digits of the frame size when divided by four will result in the height of the shaft centerline above the bottom of the mounting foot. For a 445T frame shaft height would be 11" (44 / 4 = 11). Although there is no inch reference, the

third digit is indicative of the distance from the motor's vertical centerline to the front and rear foot mounting holes. It is also indicative of overall motor length. At the end of this article you will find a link to a frame size dimensional chart for U and T frame NEMA motors and IEC motors.

In addition to the standard, three digit nomenclature, an alphabetical suffix is added to designate any modifications to the standard T frame design. For example a suffix of "C" or "D" designates a C face or D mounting flange while "JM" or "JP" designates a close coupled pump motor that is designed for mechanical seals or packing. "S" specifies a short shaft that is designed for direct coupling and should not be used in belt dive applications. "Y" specifies a custom, non standard mounting configuration while "Z" specifies a custom, non standard shaft.

Motor Enclosures

There are two basic types of motor enclosures - - open and enclosed. Open enclosures allow the free flow of air through the motor internals while enclosed ones greatly restrict or prohibit the entry of outside air. The basic designs used in various applications are described below.

The Open Drip Proof (ODP) enclosure is intended for installation in a clean and dry environment and tends to be the standard in the HVAC industry and other clean, indoor applications. An internal fan circulates ambient air through the enclosure and provides for a highly efficient cooling process.

The Totally Enclosed Fan Cooled (TEFC) enclosure is designed for outdoor installation and dirty or dusty indoor applications. Special TEFC designs are also used in processing plants where periodic wash down is required. Unlike the ODP enclosure it utilizes an external fan to force ambient air over the motor's exterior surface. Cooling is not as efficient as that of the ODP enclosure and Service Factor (SF) is sometimes limited to unity (1.0).

The Totally Enclosed Air Over (TEAO) enclosure is designed for damp or wet environments where the driven machine provides the air flow required for cooling. A common application is cooling tower fans. TEAO motors often have multiple HP ratings and the usable HP depends upon the velocity and temperature of the air flowing over the motor.

The Totally Enclosed Non Ventilated (TENV) is designed for dusty environments and is usually limited to 5 HP and under. It utilizes the motor surface area to transfer heat to the surrounding air without the aid of an external fan.

Hazardous Location motors are a totally enclosed design that are intended for use in potentially dangerous areas. The Class I, Explosion Proof (XP) enclosure is a special type that is designed for use in locations where potentially explosive liquids and gases may be present. Class II enclosures are used in locations that are subject to combustible dusts such as coal and grains. The areas where the rotor shaft exits the enclosure are designed to contain any sparks that could occur inside the motor enclosure.

Nameplate Information

NEMA MG-1 requires that certain information be included on the nameplate of all single and three phase motors. Typical nameplate information includes HP, Volts, Amps, Hz, Phase, RPM, Insulation Class, Enclosure, Frame Size, Efficiency, Service Factor, Power Factor, Duty, Ambient, Code and Design. Most are straight forward but, there are several that require further explanation.

Efficiency (Eff) defines how well a motor converts electrical energy into mechanical energy. The motor's full load efficiency is shown on the nameplate and it is often less than the actual maximum efficiency. Maximum motor efficiency typically occurs between 70% and 95% of full load and most NEMA motors can be operated as low as 60% of full load without any significant loss in efficiency. This allows the flexibility of upgrading to the next higher HP when loading is at or very near the full load capacity of the lower HP motor.

Service Factor (SF) is an often misunderstood piece of information. SF is a multiplier that indicates the actual HP the motor can deliver over and above the nameplate HP. For example, if a 10HP motor has a SF of 1.15 it is designed to deliver 11.5HP without overloading. SF is intended to handle small, intermittent overloads, occasional increases in ambient temperature and periods when actual voltage is lower than nameplate voltage. For example, a typical 10HP, 230V motor draws approximately 24 amps at full load. If the voltage is reduced to 200V current increases to 28A which is the normal current draw of an 11.5HP motor. Therefore a 230V motor with a 1.15 SF can accommodate such a short term voltage drop. However, it should not be operated on a true 200/208V circuit since there would be no remaining SF available to accommodate any additional drop in voltage.

Power Factor (PF) is the ratio of active power in watts to the apparent power in volt/amps at full load. A motor can be designed for high efficiency or high PF but not both. Since efficiency cannot be enhanced in the field, motors are designed for high efficiency and the trade off is lower PF. Fortunately PF can be easily

increased in the field by adding an appropriate capacitor to the circuit.

Duty defines the length of time the motor can operate while meeting its other nameplate ratings. Most industrial motors are rated Continuous (or Cont.) while certain special application motors will show intermittent run times in minutes.

Ambient temperature is the maximum allowable temperature of the air surrounding a motor when it is operated continuously at full load. A typical ambient rating is 40°C (104°F). The actual operating temperature is the sum of the ambient temperature and the internal temperature rise at full load. For example, Class B insulation is rated at 130°C and is designed to handle an internal temperature rise of 90°C (assumes a 1.15SF) when operating in a 40°C ambient environment.

Code letters (A-V) provide the range of current required (locked rotor current) during across the line starting for a particular motor. The value indicated by the code letter is in units of KVA/HP. A typical industrial motor will require five to seven times full load current during starting. Motors 15HP and above require a lower KVA/HP when starting than do lower HP designs. The simple equation below will provide approximate LRC results at 460 volts. For 230 volts change the constant to 2.5 and for 200 volts, change it to 2.9

460 Volts Locked Rotor Current = Code Letter Value X HP X 1.25

Design letters (A-D) are an indication of the shape of the torque curve produced by a particular motor. Design B is the standard for industrial duty motors and provides excellent performance in most industrial applications. Design C provides a higher starting torque while Design D is a high slip motor that provides the highest starting torque. Design A is a special purpose motor that offers the highest pullout torque.

Next month we will review the conditions that affect the life of the AC motor.

NEMA & IEC frame dimension chart -
http://www.baldor.com/pdf/501_Catalog/BackCover.pdf

Joe Evans is responsible for customer and employee education at PumpTech Inc, a pumps & packaged systems manufacturer & distributor with branches throughout the Pacific Northwest. He can be reached via his website www.pumped101.com. If there are topics that you would like to see discussed in future columns, drop him an email.