Technical Information

Application Information

AGENCY LISTINGS

UL and CSA

LESSON Electric and Lincoln Motors Fire Pump and Explosion Proof motors are UL Listed. Other motor types are UL Recognized, including models with inherent overheating protection as noted (i.e. thermally protected models). Leeson and Lincoln motors are also CSA Certified for both explosion proof and non-explosion proof enclosures.

AC Motors

Non-Explosion Proof  

<table>
<thead>
<tr>
<th>UL File No.</th>
<th>CSA File No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEMA 25-449 Frame</td>
<td>E49747 LR2025</td>
</tr>
<tr>
<td>NEMA 500 and 5000 Frame</td>
<td>— LR2025*</td>
</tr>
<tr>
<td>IEC 63-90 Frame</td>
<td>E49747 LR2025</td>
</tr>
<tr>
<td>IEC 100-280 Frame</td>
<td>E49747 LR2025</td>
</tr>
<tr>
<td>Thermally Protected motors</td>
<td>E6312 LR2025</td>
</tr>
<tr>
<td>Insulation Systems</td>
<td>E37900 LR2025</td>
</tr>
</tbody>
</table>

* Does not include coverage for use with VFD

Explosion Proof  

<table>
<thead>
<tr>
<th>UL File No.</th>
<th>CSA File No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEMA 56-326 Frame</td>
<td>E12044 LR47504</td>
</tr>
<tr>
<td>NEMA 36-449 Frame</td>
<td>E12044 LR21839</td>
</tr>
<tr>
<td>Fire Pump Motors</td>
<td>E12044 LR21839</td>
</tr>
<tr>
<td>NEMA 143-510</td>
<td>E12044 LR47504</td>
</tr>
<tr>
<td>Class I, Division 2/Zone 2</td>
<td>E12044 LR21839</td>
</tr>
<tr>
<td>NEMA 48-449, 5000 Frame</td>
<td>E12044 LR21839</td>
</tr>
<tr>
<td>European ATEX Zone 2</td>
<td>Exs190 LR2025</td>
</tr>
<tr>
<td>NEMA 143-449, IEC 112-280</td>
<td>Exs190 LR2025</td>
</tr>
</tbody>
</table>

PMDC Motors + Gear Motors

Non-Explosion Proof  

<table>
<thead>
<tr>
<th>UL File No.</th>
<th>CSA File No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEMA 25-145</td>
<td>E49747 LR2025</td>
</tr>
<tr>
<td>AC Inverters</td>
<td>E161242</td>
</tr>
<tr>
<td>SpeedMaster SCR Controls</td>
<td>E132235 LR41380</td>
</tr>
<tr>
<td>FHP Speed Drives</td>
<td>E132235</td>
</tr>
<tr>
<td># - UL Certified for Canada under UL File E 1.67242</td>
<td></td>
</tr>
</tbody>
</table>

ATEX Directive (ATmospheres EXPlosibles)

Mandatory by law, the European Union (EU) Directive 94/9/EC requires that electric motors for use in explosive atmospheres carry the CE mark, notified body identifier, Ex symbol, equipment group and category, plus the date code. See “European Installations” for additional details, located on the next page.

NEMA (National Electrical Manufacturers Ass’n)

LEESON Electric and Lincoln Motors’ are manufactured in accordance with all applicable areas of NEMA standards in MG1-2006. When applied in accordance with the “Guidelines for Application of Three Phase Motors on Variable Frequency Drives”, LEESON Electric and Lincoln Motors’ are in full compliance with NEMA MG1-2006, Part 31, Section 4.4.2, as pertaining to voltage spikes. 460 volt motors must withstand voltage spikes of up to 1426 volts; 575 volt motors must withstand spikes up to 1788 volts. See “Insulation Systems” for additional detail on this subject. Website: www.nema.org

Commitment to RoHS and WEEE European Directives

European Directive 2002/95/EC “Restriction of Use of Certain Hazardous Substances” (RoHS) and Directive 2002/96/EC “Directives on Waste Electrical and Electronic Equipment” (WEEE) were enacted to control the amount of certain hazardous substances contained in products shipped into the E.U. Restricted substances include lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls and polybrominated diphenyl ethers.

The scope of products covered, affecting motors, is:

- Large household appliances
- Small household appliances
- IT and telecommunications equipment
- Consumer equipment
- Electrical and electronic tools (except large scale stationary and industrial tools)
- Toys, leisure and sports equipment
- Automatic dispensers

The Directives do not currently apply to medical devices, monitoring and control instruments, spare parts for the repair or reuse of electrical and electronic equipment placed on the market before July 1, 2006, and most military and state security equipment.

Regal Beloit Corporation worked closely with suppliers to assure that product falling within the scope of these Directives meets the specified levels of these substances. The Directives took effect July 1, 2006 however many products were converted in May and June. The products converted are motors in NEMA frame size 145 and below, both AC and DC motors with the following exceptions:

- Brakemotors in 56-145 frame will have to be ordered specifically as RoHS compliant.
- Some motors with specialty electro-mechanical components.

ISO QUALITY CERTIFICATION

Affiliate of The Regal Beloit corporation. We are ISO 9001:2008 and our registrar is NSF-ISR. The certificate number for the corporation is C0026928-IS2.

leeson.com/Technical Information

Continued on next page.
LEESON Electric and Lincoln Motors employ the use of Exxon POLYREX® EM grease, a specially formulated bearing grease designed for electric motors. POLYREX® EM provides superior lubricity, durability and resists corrosion, rust and washout. POLYREX® EM is a registered trademark of Mobil Corporation.

Maximum safe mechanical speed capability is a function of bearing size, type and grease selection, as well as rotor balance specifications. Consult the “Maximum Safe Mechanical Speed Limits” chart in the “Overspeed Capability” section.

Note that these values do not imply maximum constant horsepower RPM.

**EFFICIENCY**

The efficiency of a motor is the ratio of its useful power output to its total power input and is usually expressed in a percentage. LEESON Electric and Lincoln Motors offers standard, high efficient EPAct, and NEMA Premium® efficient ratings. Standard efficiency motors may only be used on applications that are exempt from legislated efficiencies. The high efficient motor line is in compliance with the Energy Policy Act of 1992 (EPAct) and/or Canadian efficiencies as set by NRCan. The Energy Independence and Security Act of 2007 (EISA07) will become law on December 19, 2010, requiring current EPAct-EISA07, EISA07) efficient ratings. Unless otherwise noted, premium efficiency motors in this catalog meet NEMA Premium® unless otherwise noted.

The LEESON WattSAVERe® and Lincoln Ultimate-e™ line is a premium efficiency line, which exceeds mandated efficiencies of EPAct and/or NRCan. Unless otherwise noted, premium efficient motors in this catalog meet NEMA Premium® the newly promoted efficiency levels by NEMA and the Consortium for Energy Efficiency (CEE).

**ELECTRICAL TYPE/STARTING METHOD**

Motors in this catalog are capacitor start, split phase, permanent split capacitor, or three phase. Capacitor Start motors have high starting torque, high breakdown torque, and relatively low starting current. Split phase motors have medium starting torque and medium starting current. Permanent split capacitor motors have low starting torque and low starting current. Three phase motors have high starting, extra breakdown torque, and typically very low starting current. Single phase motors cannot be applied on variable frequency drives with three phase output.

**ENCLOSURE AND METHOD OF COOLING**

LEESON Electric and Lincoln Motors are available in various enclosures; Driprooff (DP), Driprooff Force Ventilated (DFV), Totally Enclosed Fan Cooled (TEFC), Totally Enclosed Non-Ventilated (TENV), Totally Enclosed (TEAO) and Totally Enclosed Blower Cooled (TEBC). Application conditions will determine the type of motor enclosure required.

Driprooff motors have open enclosures and are suitable for indoor use and in relatively clean atmospheres. Driprooff motors have ventilating openings constructed so that drops of liquid or solid particles falling on the machine at an angle of not greater than 15 degrees from the vertical cannot enter the machine.

Totally enclosed motors are suitable for use in humid environments or dusty, contaminated atmospheres. Totally enclosed non-ventilated motors are NOT cooled by external means. Totally enclosed fan cooled motors are cooled by external means that are part of the motor but not in the internal workings of the motor. Totally enclosed air over motors are sufficiently cooled by external means, provided by the customer.

**HAZARDOUS DUTY**

Hazardous Duty motors are totally enclosed (fan cooled or non-ventilated) motors designed for applications in hazardous atmospheres containing explosive gases and/or combustible dusts.

**North American installations**

North American standards for electric motors generally fall into one of two divisions. Division 1 Explosion Proof motors are LE Listed in accordance with NFPA Class I (Flammable Gases) or Class II (Combustible Dusts) and Groups (gases or dusts), depending upon the atmosphere. Division 2 motors are CSA Certified and are marked similarly to Division 1 equipment. Inverter Duty motors through 449T frames are CSA Certified for use in Division 2 locations.

**European installations**

Motors for hazardous locations in Europe must meet a different set of standards and require different markings than those of North America. CENELEC sets the standards for equipment in hazardous locations for Europe. Motors for use in explosive atmospheres in Europe are often referred to as flameproof (Zone 1) or non-sparking (Zone 2) motors. These motors must comply with the ATEX Directive. The ATEX Directive covers all electrical equipment used in explosive atmospheres. To ensure compliance with the Directive, equipment must meet the essential ATEX requirements and carry the CE mark on the nameplate. Other information required on the nameplate includes the Ex symbol, group & category, Ex protection method, gas group, and temperature code, example (Ex d I G Ex nA IIC T3).

The tables on the next page describe LEESON Electric and Lincoln Motors capabilities by Area Classification and by Temperature Code.
**LEESON Electric and Lincoln Motors Hazardous Duty Motor Area Classification Chart**

<table>
<thead>
<tr>
<th>Class I Area Classification (Flammable Gases, Vapors or Mists)</th>
<th>Class II Area Classification (Combustible Dusts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>Europe - ATEX (Category G - Gases)</td>
</tr>
<tr>
<td>Division 1 Explosion Proof</td>
<td>Division 2 Flameproof (TEFC)</td>
</tr>
<tr>
<td>Division 1 Flameproof</td>
<td>Zone 2 Non-Sparking</td>
</tr>
<tr>
<td>Division 1 Flameproof</td>
<td>Division 2 Non-Sparking</td>
</tr>
<tr>
<td>Group A</td>
<td>Group A</td>
</tr>
<tr>
<td>Group A</td>
<td>Group A</td>
</tr>
<tr>
<td>Group B</td>
<td>Group B</td>
</tr>
<tr>
<td>Group C</td>
<td>Group C</td>
</tr>
<tr>
<td>Group D</td>
<td>Group D</td>
</tr>
<tr>
<td>Group E</td>
<td>Group E</td>
</tr>
<tr>
<td>Group F</td>
<td>Group F</td>
</tr>
<tr>
<td>Group G</td>
<td>Group G</td>
</tr>
<tr>
<td>Group H</td>
<td>Group H</td>
</tr>
</tbody>
</table>

- Group is not applicable to that Division or Zone, or is not defined.
- Group is not available from LEESON Electric and Lincoln Motors.
- Contact factory representative for availability.
- Currently not available.

**LEESON Electric and Lincoln Motors Hazardous Duty Motor Temperature Code Chart**

<table>
<thead>
<tr>
<th>TEMPERATURE CODES</th>
<th>Division 1 Explosion Proof / Flameproof</th>
<th>Division 2 / Non-Sparking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp. UL/CSA ATEX</td>
<td>Class I Area Classification (Flammable Gases, Vapors or Mists)</td>
<td>Class II Area Classification (Combustible Dusts)</td>
</tr>
<tr>
<td>280°C</td>
<td>T2A</td>
<td>T2(280)</td>
</tr>
<tr>
<td>260°C</td>
<td>T2B</td>
<td>T2(260)</td>
</tr>
<tr>
<td>215°C</td>
<td>T2D</td>
<td>T2(215)</td>
</tr>
<tr>
<td>200°C</td>
<td>T3</td>
<td>T3</td>
</tr>
<tr>
<td>165°C</td>
<td>T3B</td>
<td>T3(165)</td>
</tr>
<tr>
<td>160°C</td>
<td>T3C</td>
<td>T3(160)</td>
</tr>
<tr>
<td>135°C</td>
<td>T4</td>
<td>T4</td>
</tr>
</tbody>
</table>

* Class II, Division 2 motors are not available from LEESON Electric and Lincoln Motors.

Division I & II ambient range is -25°C to +40°C
VARIABLE SPEED INFORMATION

LEESON Electric and Lincoln Motors Vector-Duty and Inverter Duty motors, unless otherwise stated, are rated for continuous operation in a 40°C ambient and for altitudes up to 3300 feet (1000 meters) above sea level. Special application considerations, such as high or low ambient, intermittent ratings, high altitude, duty cycle rated, extended constant horsepower range, special base speed, voltage or frequency, or any other special requirements, should be reviewed by a factory representative.

It is the responsibility of the startup personnel during commissioning of the VFD/motor system to properly tune the drive to the motor for the specific application. The correct voltage boost and volts/hertz settings are application dependent and unique to each motor design. Procedures for these adjustments should be in your VFD user manual. Many Vector Duty and Inverter Duty motors in this catalog are equipped with thermostats; warranty coverage may be denied if they are not properly utilized.

Power factor correction capacitors should never be installed between the drive and the motor.

INVERTER DUTY OR INVERTER RATED

“Inverter Duty” (often called “Inverter Rated”) motors are suitable for use with Variable Frequency Drives, as long as operation is within the application guidelines published in this catalog. In general, LEESON Electric and Lincoln Motors’ three phase, general purpose, NEMA Design B motors are considered “Inverter Duty”, and meet or exceed the requirements of NEMA MG1, Part 30. As required under Federal law, these motors comply with EISA2007 efficiencies when operating from utility power.

Inverter Duty (Rated) motors are most often used in 10:1 speed range, variable torque or constant torque applications. A vector control is usually required for operation beyond 10:1 C.T.

Refer to “Guidelines for Application of General Purpose, Single Speed Three Phase Motors on Variable Frequency Drives” in this section of this catalog for the allowable speed range and cable length restrictions (from VFD to motor). Additional detail regarding a specific product’s capabilities is available on its catalog page, or by consulting your application engineer.

VECTOR DUTY – “Vector Duty” describes a class of motors that are used in conjunction with Open- (without encoder) or Closed-Loop (with encoder) Vector controls, that provide enhanced performance under low speed operating conditions, or in cases where torque (rather than speed) must be controlled. “Vector Duty” motors can be applied to Volts/Hertz (scalar) drives, as well.

LEESON Electric’s Speedmaster® motors and Lincoln Motors’ CTAC Motors, have been specifically designed for optimal operation on vector or volts/hertz controls. These motors feature a wide constant torque (up to 2000:1) and/or constant horsepower (up to 4:1) speed range and are performance-matched to all current technology IGBT drives. Vector Duty motors meet or exceed the requirements of NEMA MG1, Part 31, and are equipped with an enhanced insulation system (IRIS or Ultimate Spike Defense) to provide many years of trouble-free service. Consult the catalog page for each product’s capabilities and features. As these motors are specifically designed for operation through an inverter, they are exempt from EISA2007.

VARIABLE TORQUE LOADS – Applications include fans, blowers and centrifugal pumps. Torque varies as the square of the speed, and horsepower as the cube of the speed. Operation below base speed significantly lightens the load on the motor. While most variable torque applications do not require the motor to operate below half speed, the motor is fully capable of operation to zero speed. Operation above base speed significantly adds to the load on the motor; therefore, a factory representative must review applications requiring variable torque above base speed. Refer to the application chart found on page 14 for use of general purpose three phase motors on variable frequency drives. A bypass circuit is often employed in Variable Torque applications. If this device is intended to be used, selection of a NEMA Design B motor is recommended, to withstand the inrush current during across-the-line starting.

CONSTANT TORQUE LOADS – Applications include conveyors, elevators, hoists, extruders, positive displacement pumps, mixers and converting equipment. Torque remains constant throughout the range of operation, and extra care should be taken in the proper application of motors, especially at very low speeds. Most constant torque applications don’t require operation below 10:1 (i.e. 6 Hz operation on a 60 Hz motor), but an increasing number of applications historically reserved for servo and/or stepper systems are being served with motors capable of operation beyond 20:1…even up to 2000:1 (zero speed, constant torque). Refer to the application chart found on page 14 for use of general purpose three phase motors on variable frequency drives.

Applications requiring greater than 20:1 C.T. are ideal for LEESON Speedmaster® Inverter Duty/Vector Duty and Lincoln Vector Duty CTAC® motors. These motors provide full rated torque within their listed speed range, without exceeding a Class F temperature rating while under inverter power (many operate at Class B). Ratings in this catalog have been developed, based on extensive testing on IGBT inverters, set at a minimum 3 KHz (or equivalent) carrier frequency.

Vector Duty and Inverter Duty motors from LEESON Electric and Lincoln Motors are designed for operation at 150% of rated load for one minute, up to the base speed of the motor (overload capability declines to 100% as the motor reaches maximum constant HP speed). These motors accommodate constant horsepower operation to 1-1/2 to 2 times base speed, subject to the motor’s maximum safe mechanical speed limit. Refer to the Maximum Safe Mechanical Speed Chart, as well as the performance section for each motor’s capability.

Motors rated for zero RPM continuous duty (1000:1 or 2000:1) must be powered by vector drives to produce rated torque without overheating. Optimum zero speed and low-speed full torque performance may require a closed loop vector drive (with encoder feedback).

Continued on next page.
Technical Information

Variable Speed Operation

**CONSTANT HORSEPOWER LOADS** – Applications include coil winders, band saws, grinders, and turret lathes. Operation requires the motor to deliver the same horsepower rating, regardless of shaft speed. Torque increases at low speed and decreases at higher speeds. Most general purpose motors can deliver constant horsepower up to 1 1/2 times base speed (consult a factory representative to verify performance). However, many constant HP applications require operation to twice base speed, and some, such as coil winders, up to 4 times base speed.

**MOTOR GROUNDING** - Frames and accessories of all motors must be grounded in accordance with the National Electric Code (NEC) Article 430. Refer to NEC Article 250 for general information on grounding. Proper grounding of inverter-driven motors is essential to protect personnel and livestock from inverter-sourced common mode voltages, which may reach hazardous levels on the frame of ungrounded or poorly grounded motors.

**LOW INPUT VOLTAGE** – If, due to lower utility supply voltage, the input voltage from the VFD to the motor is lower than the motor’s rated voltage, derating of the motor’s base frequency, horsepower, full load RPM, and constant HP RPM is required. The revised values can be calculated by multiplying by the ratio of the voltage change. For example, to operate a 460 volt motor from an inverter fed by 50 or 60 HZ, 400 volt utility power, the multiplier is 400/460 or 0.87.

The VFD can be reprogrammed to match the new base point values, allowing the motor to provide rated torque at rated current from the new base speed down to its original minimum Constant torque speed. The motor’s CHP range will begin at the new base frequency and will be shortened by the same ratio as described above.

**OVERSPEED CAPABILITY** – Maximum safe mechanical speed capability is a function of bearing size and type, lubrication, rotor balancing technique and specifications, air gap, enclosure, frame construction and connection to the driven load. In addition, consideration must be given to ambient noise levels, as operation above base speed will increase motor noise and vibration, and reduce bearing life. Under no circumstances should bearing hub temperature exceed 100° C. Belted loads should not exceed 60 Hz operating RPM by more than 25% (NEMA “TS” shafts are not suitable for belted loads). Due to external cooling fans, TEFC (and Explosion Proof Fan Cooled) motors are limited to 4000 RPM maximum speed.

| Maximum Safe Mechanical Speed Limits (ODP, TENV, DPV OR TEBC ENCLOSURES) | 60 Hz base frequency |
|---|---|---|
| Frame Size | 2-Pole | 4, 6 or 8-Pole |
| 56-184 | 7200 | 5400 |
| 213-256 | 5400 | 4200 |
| 284-286 | 5400 | 3600 |
| 324-326 | 4000 | 3600 |
| 364-365 | 4000 | 2800 |
| 404-449 | 3600 | 2800 |
| 5000 Fr | N/A | CALL |
| 6800 Fr | N/A | CALL |
OTHER APPLICATION CONSIDERATIONS –
For proper selection, the following should be considered:
• Horsepower or torque requirements at various speeds.
• Desired speed range of the load and motor.
• Acceleration and deceleration rate requirements of the process being controlled.
• Starting requirements including the frequency of starting and a description of the load (reflected inertia at the motor, load torque during starting).
• Whether the application is a continuous process or duty cycle of starts, stops and speed changes.
• A general description of the type of application including the environment in which the VFD system components must operate (determines motor enclosure and/or explosion proof classification).

• Description of the available electrical power supply and wiring.
• Special performance requirements, if any.
• Whether the drive will be configured with a by-pass circuit. In case of its deployment, the motor will operate like its fixed speed counterpart and may require a NEMA B design which limits in-rush current, or selection of a larger motor starter or other protective circuitry.
• Load sharing
• Mounting and other mechanical considerations

Typical Temperature Rise Of Various Enclosures

@ Rated Torque  @ Rated Power
MOTOR SELECTION
Electric motors are the workhorses of industry. Many applications exist where more than one motor can be used and/or the exact replacement is not available. LEESON makes every effort to maximize interchangeability, mechanically and electrically, where compromise does not interfere with reliability and safety standards. If you are not certain of a replacement condition, contact any LEESON Authorized Distributor or the LEESON District Sales Office.

SELECTION
Identifying a motor for replacement purposes or specifying a motor for new applications can be done easily if the following information is known:
1. Nameplate Data
2. Motor Type
3. Electrical and Performance Characteristics
4. Mechanical Construction

TYPICAL SPEED TORQUE CURVES

Capacitor Start/Induction Run
A single phase general purpose design, with an electrolytic capacitor in series with the starting winding, offering maximum starting torque per ampere. A centrifugal switch removes the auxiliary winding and capacitor when the motor approaches full load speed. The design is a heavy-duty unit which has approximately 300% (of full load) starting torque. Common applications include compressors, pumps, conveyors and other “hard-to-start” applications.

Capacitor Start/Capacitor Run
This design has two capacitors of different values. A centrifugal switch is used to remove the electrolytic capacitor when the motor approaches full load speed. A second run capacitor remains in series with the auxiliary winding during full load operation. This type of design has lower full-load amps as a result of the run capacitor and is consequently used on most higher horsepower single phase motors.

Permanent Split Capacitor (PSC)
This design has an auxiliary winding with a “run” capacitor, but unlike the capacitor start/ induction run motor, the capacitor and auxiliary winding remain in the circuit under running conditions. (There is no centrifugal switch on this type motor.) A permanent split capacitor design has low starting torque and low starting current. They are generally used on direct-drive fans and blowers. They can also be designed for higher starting torque and intermittent applications, where rapid reversing is desired.

ELECTRICAL AND PERFORMANCE CHARACTERISTICS

One of the best ways to guarantee economical performance and long motor life is to make sure your motors operate at nameplate voltage. Applying too high a voltage may reduce the motor’s efficiency and increase operating temperatures. The net result is shorter motor life.

Under-voltage can also shorten motor life. Operating on too low a voltage reduces the motor’s effective horsepower. The motor will attempt to drive the load it was intended to drive, become overloaded, draw more current than normal, and overheat. Again, the result will be premature failure.

ENCLOSURES AND ENVIRONMENT

DRIP-PROOF: Venting in end frame and/or main frame located to prevent drops of liquid from falling into motor within a 15° angle from vertical. Designed for use in areas that are reasonably dry, clean, and well ventilated (usually indoors). If installed outdoors, it is recommended that the motor be protected with a cover that does not restrict the flow of air to the motor.

TOTALLY ENCLOSED AIR OVER (TEAO): Dust-tight fan and blower duty motors designed for shaft mounted fans or belt driven fans. The motor must be mounted within the airflow of the fan. TOTALLY ENCLOSED NON-VENTILATED (TENV): No vent openings, tightly enclosed to prevent the free exchange of air, but not airtight. Has no external cooling fan and relies on convection for cooling. Suitable for use where exposed to dirt or dampness, but not for hazardous (explosive) locations.

TOTALLY ENCLOSED FAN COOLED (TEFC): Same as the TENV except has external fan as an integral part of the motor, to provide cooling by blowing air around the outside frame of the motor.

TOTALLY ENCLOSED, HOSTILE AND SEVERE ENVIRONMENT MOTORS: Designed for use in extremely moist or chemical environments, but not for hazardous locations.

TOTALLY ENCLOSED BLOWER COOLED MOTORS (TEBC): Used to extend the safe speed range of inverter-fed motors. Similar to TEFC except a small, constant-speed fan provides uniform airflow regardless of the drive motor’s operating speed.

EXPLOSION-PROOF MOTORS: These motors meet Underwriters Laboratories and Canadian Standards Association standards for use in hazardous (explosive) locations, as indicated by the UL label affixed to the motor. Locations are considered hazardous because the atmosphere does or may contain gas, vapor, or dust in explosive quantities.

NAMEPLATE DATA

Nameplate data is the most important first step in determining motor replacement. Much of the information needed can generally be obtained from the nameplate of the motor to be replaced. Take time to record all the nameplate information because it can save time, avoid confusion and MISAPPLICATION.

MOTOR TYPE
Alternating current (AC) induction motors are divided into two electrical categories, based on power source—single phase and polyphase (three phase). Direct current (DC) motors are used in applications where precise speed control is required or when battery or generated direct current is the available power source.

Three Phase or Polyphase
General purpose three phase motors have different electrical design classifications as defined by NEMA. NEMA Design A and B motors are of normal starting torque with normal starting current. NEMA Design C motors have higher starting torque with normal starting current. All three types have slip of less than 5%. (”Slip” being a term which expresses, as a percentage, the difference between synchronous motor speed and full load motor speed, for example, 1800 rpm synchronous versus a full load speed of 1740 rpm.

NEMA’s Design B and C standards are minimum performance standards. In practice, some manufacturers (including LEESON) build small integral HP Design B motors with locked rotor and breakdown torque levels equaling NEMA Design C standards.

NEMA T frame motors 1 through 200 HP covered by EPACT (identified with a “G” catalog prefix) are labeled Design B, exceed NEMA Design B performance levels, and have efficiencies equal to EPACT mandated levels. EPACT exempt three phase, base-mounted motors are labeled Design C and have performance characteristics meeting NEMA’s Design C standards, with standard motor efficiencies. Motors 250 HP and larger are exempt from EPACT legislation.

Permanent Magnet DC
This design has linear speed/torque characteristics over the entire speed range. SCR rated motor features include high starting torque for heavy load applications and dynamic braking, variable speed and reversing capabilities. Designs are also available for use on generated low voltage DC power or remote applications requiring battery power.
NEMA SERVICE FACTORS

<table>
<thead>
<tr>
<th>HP</th>
<th>ENCLOSED</th>
<th>RPM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3600</td>
</tr>
<tr>
<td>1/4-1/3 Open</td>
<td>1.35</td>
<td>35</td>
</tr>
<tr>
<td>1/2-3/4 Open</td>
<td>1.25</td>
<td>35</td>
</tr>
<tr>
<td>1 &amp; Larger Open</td>
<td>1.15</td>
<td>35</td>
</tr>
<tr>
<td>All Totally Enclosed</td>
<td>1.00</td>
<td>35</td>
</tr>
</tbody>
</table>

Most LEESON Totally Enclosed Motors have a 1.15 Service Factor. Refer to the Service Factor information on each page to identify specifically enclosed motors with NEMA 1.00 Service Factor or LEESON 1.15 Service Factor. All drip-proof motors have NEMA Service Factors of 1.15 or higher. All three phase totally enclosed motors have NEMA Service Factors of 1.15 except when noted (I).

SCR PM DC MOTORS ON PWM POWER SUPPLIES

Pulse width modulated DC controls have a voltage output similar to pure direct current which has a form factor of 1.00. SCR thyristor drives, such as the SPEEDMASTER® controls listed on page 117, have a form factor of 1.4.

LEESON stock SCR rated motors can also be used with PWM controls. In fact, the motor’s HP rating can be increased because of less heating in the motor. In addition, the motor will operate quieter and the brush life will be extended.

<table>
<thead>
<tr>
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METRIC (IEC) DESIGNATIONS

The International Electrotechnical Commission (IEC) is a European-based organization that publishes and promotes worldwide mechanical and electrical standards for motors, among other things. In simple terms, it can be said that IEC is the international counterpart to the National Electrical Manufacturers Association (NEMA), which publishes the motor standards used in the United States. IEC standards are expressed in metric units.

IEC ENCLOSURE PROTECTION INDEXES

Like NEMA, IEC has designations indicating the protection provided by a motor’s enclosure. However, where NEMA designations are word descriptive, such as Open Drip-Proof or Totally Enclosed Fan Cooled, IEC uses a two-digit Index of Protection (IP) designation. The first digit indicates how well-protected the motor is against the entry of solid objects, the second digit refers to water entry.

By way of general comparison, an IP22 motor relates to Open Drip-Proof, IP54 to Totally Enclosed.

IEC DESIGN TYPES

The electrical performance characteristics of IEC Design N motors in general mirror those of NEMA Design B—the most common type of motor for industrial applications. By the same token, the characteristics of IEC Design H are nearly identical to those of NEMA Design C. There is no specific IEC equivalent to NEMA Design D.

MOTOR EFFICIENCY TEST METHODS

Performance data of single phase motors is determined by using I.E.E.E. Std. 114 (Method B), three phase motors by I.E.E.E. Std. 112 (Method B). Motor efficiency is calculated using CSA C390. These testing methods meet the requirements of EPACT of 1992 and most utility companies.

For complete performance data on all LEESON motors, please review the Find-A-Product section on www.leeson.com.
Technical Information

Motors Designed For Use In The Automotive Industry

Automotive Duty 56 frame and U Frame motors (pages 233-240) are designed to meet automotive industry specifications from General Motors (GM-7EQ, GM-7EH), Ford (EM1) and Chrysler (NPPEM-100). Actual qualifications for individual ratings are indicated in the footnotes on the price pages.

Automotive Duty T Frame motors (pages 233-240) are designed to meet or exceed Ford EM1-1996 specification (see footnotes on the price pages).

UL Recognized Component Listing

Low voltage (< 600 V) motors in frames 48-449T and 182U-445U listed in this catalog (excludes REW, SREW, SEW, SSEW, MD and SE models) carry UL Recognized Component Listing (contact Lincoln for file number).

Web: www.ul.com

NAFTA

A NAFTA (North American Free Trade Agreement) Certificate of Origin can be supplied on request.

Canadian Standards Association (CSA)

Low voltage (< 600 V) motors in frames 48-449T and 182U-445U listed in this catalog have Canadian Standards Association approval (contact Lincoln for file number).

Web: www.csa-international.org

CE (Conformité Européenne)

Lincoln offers a variety of CE-compliant motors.

Copies of Lincoln’s Declaration of Conformity for the Low Voltage Directive and Manufacturer’s Declaration for the Machinery Directive are available on request.

Motors for Hazardous Locations

NEMA defines an explosion-proof motor as follows: “a totally-enclosed machine designed and constructed to withstand an explosion of a specified gas or vapor which may occur within it and to prevent ignition of specified gas or vapor surrounding the machine by sparks, flashes or explosions of the specified gas or vapor which may occur within the machine casing”. Typical applications include petroleum and chemical plants or pipelines, gasoline pumps and natural gas compressors.

A dust-ignition-proof motor is “a totally enclosed machine whose enclosure is designed and constructed in a manner which will exclude ignitable amounts of dust or amounts which might affect performance or rating, and which will not permit arcs, sparks, or heat otherwise generated or liberated inside of the enclosure to cause ignition of exterior accumulations or atmospheric suspensions of a specific dust on or in the vicinity of the enclosure. Successful operation of this type of machine requires avoidance of overheating from such causes as excessive loads, stalling, or accumulation of excessive quantities of dust on the machine”. Typical applications include grain elevators, coal handling equipment, feed and cereal mills, sugar refineries and chemical plants. Both types of motors are submitted to Underwriters Laboratories (UL) for approval.

The following is a brief description of the hazardous locations of both gaseous and dusty atmospheres as classified by the National Fire Protection Association’s (NFPA) National Electrical Code (NEC) and printed from the 1996 Handbook. Consult the National Electrical Code for more information on explosion proof regulations.

Class 2 Group Classifications:

Group F - atmospheres containing carbonaceous dusts, including carbon black, charcoal, coal or coke dusts that have more than 8% total entrapped volatiles, or dusts that have been sensitized by other materials so that they present an explosion hazard.

Group G - atmospheres containing combustible dusts not included in Group E or F, including flour, grain, wood, plastic, and chemicals.

BAKING INDUSTRY SANITATION STANDARDS COMMITTEE

WASHGUARD II, stainless steel washdown duty motors, NEMA frames 56, 143T, 145T, 182T and 184T are certified to Standard No. 29 for Electric Motors and Accessory Equipment, authorization number 769. The WBMQ Series of gear reducers are BISSC certified to Standard No. 29 for Electric Motors and Accessory Equipment, authorization number 941.

SAUDI ARABIAN STANDARDS ORGANIZATION

SCCP Ref. No.: R-100157

U.S. DEPARTMENT OF ENERGY (DOE)

Compliance Certification (CC) number: CC005A

The CE Mark

CE is an acronym for the French phrase “Conformité Européene” and is similar to the UL or CSA marks of North America. However, unlike UL or CSA which require independent laboratory testing, the CE mark can be applied by the motor manufacturer through “self certifying” that its products are designed to the appropriate standards. The European Union has issued 24 directives related to the CE mark. Three Directives apply to electric motors.

Low Voltage Directive (2006/95/EC) This directive applies to electrical equipment operating in the voltage range of 50-1000 volts AC or 75-1500 volts DC. Virtually all LEESON motors (except low voltage DC) are included in this directive.

Based on our testing to the applicable electrical and mechanical standards EN60034 and IEC 34, LEESON certifies conformity to this directive. All three phase 50 Hz stock motors comply with the nameplate designations, lead markings and connection diagrams required. A “Declaration of Conformity” accompanies these motors and a CE label is applied.

Machinery Directive (89/392/EEC) This directive applies to machinery that may contain certain motors. This is an issue with equipment manufacturers and requires the use of a motor meeting the Low Voltage Directive and requires a “Declaration of Incorporation” document which means that only the motor complies with the requirements of the Low Voltage Directive. A CE label is applied to the motor but it remains the responsibility of the equipment manufacturer to obtain certification for the finished product.

Electromagnetic Compatibility (EMC) Directive (2004/108/EC) This directive addresses the final product and is again a concern for the equipment manufacturer. Since this Directive addresses electromagnetic interference (EMI) concerns, it does not affect three phase AC motors because they do not produce EMI. DC motors, however, do produce EMI. How much of the “noise” is emitted outside the machine depends on a host of factors. LEESON’S Engineering Department can assist OEM’s in applying DC motors in machinery destined for Europe and requiring certification to the EMC Directive.
### Technical Information

#### Dimensions - AC Metric (IEC) Motors

**B3 FOOT-MOUNTED**

![B3 FOOT-MOUNTED Diagram](image)

#### METRIC (IEC) FRAME DIMENSIONS (Millimeters)

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*2 Pole Dimensions

The overall length dimension for each catalog item is listed on pages 148-151 of this catalog.

Frames DF100L through DF132M, conduit box is located in the center of the frame.

---

**Notes:**

- **B5 FLANGE:**
  - 4 Holes Through S Dia. (8 holes on 225S & M)

- **B14 FACE:**
  - 4 Holes Tapped S Dia.
## Technical Information

### Dimensions - Definite Purpose - Close Coupled Pump Motors

#### TYPICAL CLOSE COUPLED PUMP MOTOR

![Diagram of a typical close coupled pump motor]

### Dimensions for Type JM

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### Keyseat

For standard NEMA base dimensions, see pages 280 and 282.

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All dimensions are measured in inches. For “C” dimensions, refer to the appropriate catalog page. Certified drawings are available upon request - contact LEESON for details.
Technical Information
Dimensions - NEMA Explosion Proof - 158 Series

NEMA EXPLOSION-PROOF • 158 SERIES • RIGID MOUNT DIMENSIONS (Inches)

Frame Size A B D E F G H J K L M N O P T U V N-M ES AA AB AC AF BA KEY
182T 184T 9 6 4 1/2 3 1/2 1 3/8 1 1/4 1 1/4 6 3/4 4 1/4 2 1/2 1 3/8 1/4 1.125 2 1/4 2 1/4 1 1/4 1/4 7/16 6 1/4 3 3/4 2 1/4
213T 215T 10 1/2 7 5 1/2 4 3/4 2 1 1/4 8 5/8 6 1/4 3 1/2 10 1/4 10 1/2 2 1/2 1.375 3 1/4 3 3/4 2 1/4 1 9/16 7 3/16 3 1/2 3/16
254T 256T 12 11/4 6 1/4 5 1 1/4 2 1/4 2 1/4 8 7/8 6 3/4 3 1/2 12 1/4 12 1/2 2 1/2 1.625 3 3/4 3 3/4 2 1/4 1 10 1/4 8 1/4 3 1/2 4 1/4
284T 284TS 286T 286TS 13 11/4 5 1/2 4 1/2 2 1/4 11 3/4 9 1/4 4 1/2 12 1/4 12 1/2 2 1/2 1.875 4 1/2 4 1/2 3 1/2 1 1/2 10 1/4 4 1/4 4 1/4
324T 324TS 326T 326TS 15 1/2 8 5/8 5 1/4 1 1/4 2 1/4 3 1/4 13 3/4 10 1/4 3 1/4 16 16 2 1/2 2.125 5 5/8 3 1/2 1 1/4 11 1/4 5 1/4 5 1/4
364T 364TS 365ST 365STS 17 5 1/2 7 3/4 1 1/4 2 1/4 3 1/4 13 3/4 11 1/4 6 18 1/4 19 12 1/4 2.375 5 5/8 3 1/2 2 1/4 16 1/4 13 1/4 6 1/4 5 1/4
404TS 405ST 405STS 19 11 10 8 6 1/4 1 1/2 1 1/4 1 1/4 3 1/4 17 1/4 13 1/4 3 1/4 21 1/4 22 1/4 21 1/4 2.875 7 7/8 5 5/8 4 10 1/4 13 1/4 7 1/4 6 1/4

NEMA EXPLOSION-PROOF • 158 SERIES • C FACE DIMENSIONS (INCHES)

Frame Size A B D E F G H J K L M N O P T U V N-M ES AA AB AC AF BA KEYWAY
182T 184T 9 6 4 1/2 3 1/2 1 3/8 1 1/4 1 1/4 6 3/4 4 1/4 2 1/2 1 3/8 1/4 1.125 2 1/2 2 1/2 1 1/4 1/4 7/16 6 1/4 3 3/4 2 1/4

The condensed dimensions shown on these pages are for general reference only and are not for construction. The overall length or “C” dimension for each catalog item is included in this catalog. Certified drawings of all ratings are available for construction purposes.
**Technical Information**

**Dimensions - NEMA Explosion Proof - G Series**

**Rigid Mount G-Series**

![Diagram of G-Series Rigid Mount]

### NEMA EXPLOSION-PROOF • G-SERIES • RIGID MOUNT DIMENSIONS (inches)

| Frame Size | A  | B  | C   | D   | E   | F*  | G   | H   | J   | K   | N   | O   | P   | T   | U   | N-W | ES  | AA  | AB  | AC  | AF  | BA  | BS  | KEY  |
|------------|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 182T 194T | 8.88 | 7.75 | –   | 3.75 | 6.75 | 0.45 | 0.41-0.46 | 1.56 | –   | 2.78 | 9.36 | 9.76 | 2.62 | 1.125 | 2.75 | 1.75 | 0.75 | 9.73 | 7.13 | –   | 2.75 | 3.37 | 0.25 | 17.12 |
| 213T      | 10.38 | 8.50 | 5.19 | 5.25 | 4.25 | 7.00 | 0.60 | 0.44 | 1.87 | –   | 3.41 | 10.60 | 11.50 | 2.62 | 1.375 | 3.38 | 2.38 | 0.75 | 10.94 | 8.32 | 2.55 | 3.50 | 3.50 | 0.31 | 20.18 |
| 254T 256T | 12.12 | 10.25 | 6.19 | 6.25 | 5.00 | 8.25 | 10.00 | 0.55 | 0.53-0.58 | 2.08 | –   | 4.19 | 14.07 | 14.12 | –   | 1.625 | 4.00 | 2.88 | 1.25 | 13.67 | 10.65 | 3.12 | 4.25 | 4.12 | 0.38 | 25.52 | 25.27 |
| 284T 284TS| 13.00 | 11.50 | 6.94 | 9.50 | 5.50 | 8.88 | 0.53-0.58 | 2.50 | 2.50 | 1.87 | 14.74 | 15.50 | 3.25 | 1.925 | 4.62 | 1.88 | 1.50 | 15.33 | 11.44 | 5.38 | 4.75 | 4.75 | 0.50 | 26.30 | 24.94 |
| 286T 286TS| 13.00 | 13.00 | 7.00 | 11.00 | –   | 0.86 | 0.66-0.71 | 3.50 | –   | 17.10 | 16.00 | 3.25 | 2.125 | 5.25 | 3.98 | 2.00 | 16.50 | 12.64 | 5.38 | 5.25 | 5.25 | 0.50 | 28.87 | 27.37 |
| 324T 324TS| 15.75 | 13.00 | 7.94 | 10.50 | 6.25 | 0.86 | 0.66-0.71 | 3.50 | –   | 17.10 | 16.00 | 3.25 | 2.125 | 5.25 | 3.98 | 2.00 | 16.50 | 12.64 | 5.38 | 5.25 | 5.25 | 0.50 | 30.37 | 29.87 |
| 326T 326TS| 15.00 | 14.50 | 8.00 | 12.00 | –   | 0.55 | 0.44 | 1.87 | –   | 17.10 | 16.00 | 3.25 | 2.125 | 5.25 | 3.98 | 2.00 | 16.50 | 12.64 | 5.38 | 5.25 | 5.25 | 0.50 | 30.37 | 29.87 |
| 364T 364TS| 17.75 | 13.25 | 8.94 | 11.25 | 7.00 | 1.12 | 0.66-0.71 | 4.00 | 3.25 | 4.00 | 19.00 | 20.00 | 3.62 | 2.375 | 5.88 | 4.24 | 2.50 | 19.75 | 14.50 | 5.38 | 5.88 | 5.62 | 0.62 | 32.50 | 32.50 |
| 365T 365TS| 17.50 | 14.25 | 9.00 | 12.25 | 7.00 | 1.12 | 0.66-0.71 | 4.00 | 3.25 | 4.00 | 19.00 | 20.00 | 3.62 | 2.375 | 5.88 | 4.24 | 2.50 | 19.75 | 14.50 | 5.38 | 5.88 | 5.62 | 0.62 | 32.50 | 32.50 |
| 405T 405TS| 19.25 | 16.25 | –   | 8.00 | 13.75 | 1.12 | 0.81-0.86 | 4.25 | 3.75 | 7.50 | 20.87 | 21.75 | 3.62 | 2.675 | 7.25 | 5.62 | 2.50 | 21.50 | 16.38 | 5.38 | 6.62 | 6.68 | 0.75 | 37.12 | 34.12 |
| 444T 444TS| 21.50 | 18.00 | 10.94 | 14.50 | 1.25 | 4.50 | 8.75 | 23.12 | 24.25 | 3.62 | 3.375 | 8.50 | 6.88 | 2.50 | 22.75 | 17.50 | 5.38 | 7.25 | 8.88 | 41.25 | 0.62 | 37.50 | 37.50 |
| 445T 445TS| 21.95 | 19.75 | 9.00 | 16.50 | 1.22 | 4.50 | 8.75 | 24.11 | 26.31 | 3.75 | 3.375 | 8.50 | 6.88 | 2.50 | 22.75 | 17.50 | 5.38 | 7.25 | 8.88 | 43.19 | 0.62 | 38.44 | 38.44 |
| 449T 449TS| 22.25 | 21.50 | 11.00 | 25.00 | 1.25 | 4.88 | 8.75 | 24.19 | 26.31 | 0.77 | 3.375 | 8.50 | 6.88 | 2.669 | 18.88 | 1.75 | 0.88 | 51.69 | 0.62 | 47.97 | 47.97 |

* 182-4T and 213-5T frames have eight-hole bases. 449T and TS frames have six-hole bases. Others have four-hole bases.

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518
### TENV—C FACE, RIGID BASE

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### TEBC—TOTALLY ENCLOSED BLOWER COOLED, RIGID BASE

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Technical Information
Dimensions - NEMA Steel Frame Motors

RIGID MOUNT

The condensed dimensions shown on these pages are for general reference only and are not for construction. The overall length or “C” dimension for each catalog item is included in this catalog. Certified drawings of all ratings are available for construction purposes.

NEMA SHAFT AND KEYWAY DIMENSIONS (Inches)

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** Note:** Motors with U = .625 have a 3/16" keyway.
Technical Information

Dimensions - NEMA Steel Frame Motors

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WASHGUARD 42C FACE MOUNT STYLE DIMENSIONS (Inches)

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<th>AJ</th>
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ALL DIMENSIONS IN INCHES
## Commercial Duty Metric (IEC) Frame Motors

### Dimensions (Inches)

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<td>M5x.8</td>
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### 25 & 31 Frame Square Flange Mount Dimensions (Inches)

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<td>1.00</td>
<td>2.83</td>
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**Catalog numbers M1120041 & M1120044 have an ‘AG’ & ‘F’ dimension that is .5” longer than stated in table.

### 42C Face Mount Dimensions (Inches)

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### 56C Face Mount Dimensions (Inches)

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*For 1/4 HP 34 frame TEFC designs. Fan cover diameter is 3.88".
### Technical Information

**5000 Frame Motors**

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All dimensions are measured in inches. For “C” dimensions, refer to the appropriate catalog page. Certified drawings are available upon request - contact LEESON Electric for details.