

GENERAL INFORMATION

PRODUCT
OVERVIEW

IMPORTANT INFORMATION

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SNOWMASTER™

THERMA SENTRY®
TITAN®
U.S. MOTORS®

VARIDYNE®
EVERSEAL®
INSULIFE™



GENERAL INFORMATION FOR INTEGRAL HORSEPOWER (IHP) MOTORS ON VARIABLE FREQUENCY DRIVES (VFDS)

Variable Frequency Drives (VFD)

A VFD is a type of controller used to vary the speed of an electric motor. The VFD takes a fixed AC voltage and frequency and allows it to be adjusted in order to get different speeds from the motor. Motor speed can be varied by changing the frequency of the input power waveform. The equation below shows how the frequency affects the speed of a three phase induction motor.

$$\text{Speed} = \frac{120^* \text{ Fundamental Input Frequency}}{\text{Number of Motor Poles}}$$

How does a VFD work?

A VFD takes the fixed frequency and voltage sine wave from the power grid or power station and puts it through a few steps in order to allow the VFD user to vary the frequency and in turn control the motor speed. First it rectifies the AC power into DC Power. Because of this step, a term commonly used instead of VFD is inverter. This only describes one step of what the VFD does to the power waveform. Once rectified into a DC voltage the drive sends the power through a set of transistors or switches. These switches can take the DC waveform and by opening and closing at certain speeds and durations can create an output waveform that mimics the sine wave that is required to drive a three phase electric motor. The output waveform is known as a Pulse Width Modulation (PWM) waveform because the waveform is created by multiple pulses of the switches at short intervals.

PULSE WIDTH MODULATION WAVEFORM

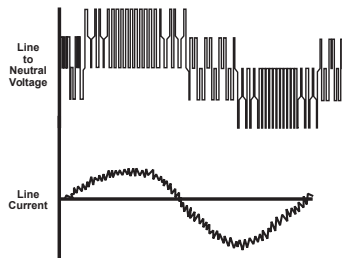


Figure 1 PWM Waveform

What variables should be considered when deciding whether to power a motor with a VFD?

VFD compatibility with motors is complex. As a result, many variables must be considered when determining the suitability of a particular motor for use with a VFD. These variables include:

- Torque requirements (Constant or Variable)
- Speed Range
- Line / System Voltage
- Cable length between the VFD and the motor
- Drive switching (carrier) frequency
- Motor construction
- VFD dv/dt
- High temperatures or high humidity
- Grounding system

*This information applies only to Integral Horsepower (IHP) motors as defined on the Agency Approval page, under UL® & CSA® listings where indicated.

Wider speed ranges, higher voltages, higher switching frequencies, insufficient grounding and increased cable lengths all add to the severity of the application and, therefore, the potential for premature motor failure.

How does a VFD affect the motor?

There are many things to consider when a motor is powered using a VFD or PWM power. When a motor is powered by a PWM waveform the motor windings very often see a large differential voltage, either from phase to phase or turn to turn. When the voltage differential becomes large enough it creates a reaction at the molecular level that converts available oxygen into O₃. This phenomenon is called partial discharge or corona. This reaction creates energy in the form of light and heat. This energy has a corrosive effect on the varnish used to protect the motor windings. PWM waveforms can also magnify shaft voltages which lead to arcing across the bearing and causing premature bearing failure. Corrective action must be taken to mitigate these issues that arise when using an electric motor with a VFD.

How do I protect the motor?

Nidec Motor Corporation (NMC) has developed specific motor designs to decrease the harmful effects that a VFD can have on a motor. NMC's INVERTER GRADE® insulation system is the first line of defense against corona and phase to phase faults that can be common when a motor is powered using a PWM waveform. The INVERTER GRADE® insulation system is standard on all of NMC's Inverter Duty products. Along with the INVERTER GRADE® insulation, thermostats are installed as a minimum protection against over heating the motor. Special consideration must also be given to bearings in motors powered by VFD's. In order to create a low resistance path to ground for built up shaft voltages a shaft grounding device can be used. On larger horsepower motors an insulated bearing system should be used in conjunction with the shaft grounding device when installed, to force the stray shaft voltages to ground. The bearing failures are more prominent on motors with thrust handling bearings. NMC has created an Inverter Duty vertical motor line that not only uses the INVERTER GRADE® insulation system, but that also comes standard with a shaft grounding device. On motors that are 100 HP and greater the thrust bearing is also insulated for additional protection.

What does "Inverter Duty" mean?

An Inverter Duty motor should describe a motor that helps mitigate potential failure modes of a motor that is powered by a VFD. Inverter duty motor windings should be able to withstand the voltage spikes per NEMA MG1 Part 31.4.4.2 and protect against overheating when the motor is run at slow speeds. On thrust handling bearings, it is apparent that the bearings require additional protection. Inverter Duty vertical motors should have a shaft grounding device to protect the motor bearings from fluting due to voltage discharge through the bearing. On larger motors (100HP and larger) the shaft should also be electrically isolated from the frame in order to aid the shaft grounding ring in discharging the shaft voltages to ground.



MOTOR/ INVERTER COMPATIBILITY

Thermal Overloads and Single Phase Motors

Motors with thermal overloads installed may not operate properly on a VFD. The current carrying thermal overload is designed for sine wave power. Operation on a VFD may cause nuisance tripping or potentially not protect the motor as would be expected on line power. Thermostats or thermistors installed in the motor and connected properly to the VFD may provide suitable thermal overload protection when operating on a VFD. (consult codes for installation requirements)

Single phase motors and other fractional horsepower ratings are not designed to be operated on a VFD. Within Nidec Motor Corporation standard products, all motors NEMA^{®†} 48 frame (5.5" diameter) and smaller are not suitable for VFD applications. Three phase 56 and 143/145 frame applications should be noted on the catalog price page; or if in doubt ask a Nidec Motor Corporation technical representative for recommendations on compatibility with a VFD.

Slow Speed Motors

Motors with a base design of slower than six poles require special consideration regarding VFD sizing and minimizing harmonic distortion created at the motor terminals due to cable installation characteristics. Additional external PWM waveform filters and shielded motor cables designed for PWM power may be required to provide acceptable motor life. Harmonic distortion on the output waveform should be kept to a minimum level (less than 10%) mismatch impedance.

690V Applications

Motors that are rated for 690VAC and that will be powered by 690VAC PWM VFDs require the use of an external filter to limit peak voltage spikes and the use of an INVERTER GRADE[®] motor. Where available, an alternative to using an output filter is to upgrade to a 2300V insulation system.

Low Voltage TITAN[®] Motors

When using 449 frame and larger motors on PWM type VFDs consider the use of an external filter and shielded motor cables designed for PWM power to minimize harmonic distortion and peak voltages at the motor terminals. Harmonic distortion on the output waveform should be kept to a minimum level (less than 10%).

Bearing Currents Related to PWM Waveforms

Due to the uniqueness of this condition occurring in the field, protection of the motor bearings from shaft currents caused by common mode voltages is not a standard feature on sine wave or Inverter Duty motor products, unless explicitly noted. Some installations may be prone to a voltage discharge condition through the motor bearings called Electrical Discharge Machining (EDM) or fluting.

EDM damage is related to characteristics of the PWM waveform, and the VFD programming, and installation factors.

Bearing EDM as a result of VFD waveform characteristics may be prevented by the installation of a shaft grounding device such as a brush or ring and/or correction of the installation characteristics causing the shaft voltage condition. Insulated bearing(s) may be required. VFD filters may be used if bearing fluting is to be mitigated.

Bearing Protection on Inverter Duty Vertical Motors

All U.S. MOTORS[®] brand "Inverter Duty" vertical products have a shaft grounding system that allows damaging shaft currents a low resistance path to ground. **Bearings on vertical motors fed by VFD power without this bearing protection are not covered under any warranty.** All other bearing failure is covered per NMC's standard warranty. An electric motor repair shop approved to service U.S. MOTORS[®] brand motors must verify that the cause of the bearing failure was not due to EDM damage.

Multiple Motors on a Single VFD

Special considerations are required when multiple motors are powered from a single VFD unit. Most VFD manufacturers can provide guidelines for proper motor thermal considerations and starting/stopping of motors. Cable runs from the VFD and each motor can create conditions that will cause extra stress on the motor winding. Filters may be required at the motor to provide maximum motor life.

Grounding and Cable Installation Guidelines

Proper output winding and grounding practices can be instrumental in minimizing motor related failures caused by PWM waveform characteristics and installation factors. VFD manufacturers typically provide detailed guidelines on the proper grounding of the motor to the VFD and output cable routing. Cabling manufacturers provide recommended cable types for PWM installations and critical information concerning output wiring impedance and capacitance to ground.

Vertical Motors on VFDs

Vertical motors operated on VFD power present unique conditions that may require consideration by the user or installation engineer:

- Locked rotor and drive tripping caused by non-reversing-ratchet operation at low motor speeds. It is not recommended to operate motors at less than 1/4 of synchronous speed. If slow speeds are required contact NMC engineering.
- Unexpected / unacceptable system vibration and or noise levels caused by the torque pulsation characteristics of the PWM waveform, a system critical frequency falling inside the variable speed range of the process or the added harmonic content of the PWM waveform exciting a system component
- Application related problems related to the controlled acceleration/ deceleration and torque of the motor on VFD power and the building of system pressure/ load.
- The impact the reduction of pump speed has on the down thrust reflected to the pump motor and any minimum thrust requirements of the motor bearings
- Water hammer during shutdown damaging the non-reversing ratchet

Humidity and Non-operational Conditions

The possible build-up of condensation inside the motor due to storage in an uncontrolled environment or non-operational periods in an installation, can lead to an increased rate of premature winding or bearing failures when combined with the stresses associated with PWM waveform characteristics. Moisture and condensation in and on the motor winding over time can provide tracking paths to ground, lower the resistance of the motor winding to ground, and lower the Corona Inception Voltage (CIV) level of the winding.

Proper storage and maintenance guidelines are important to minimize the potential of premature failures. Space heaters or trickle voltage heating methods are the common methods for drying out a winding that has low resistance readings. Damage caused by these factors are not covered by the limited warranty provided for the motor unless appropriate heating methods are properly utilized during non-operational periods and prior to motor start-up.

NEMA^{®†} Application Guide for AC Adjustable Speed Drive Systems: <http://www.nema.org/stds/acadjustable.cfm#download>

*This information applies only to Integral Horsepower (IHP) motors as defined on the Agency Approval page, under UL^{®†} & CSA^{®†} listings where indicated.



† All marks shown within this document are properties of their respective owners.

WARRANTY GUIDELINES FOR INTEGRAL HORSEPOWER (IHP)* MOTORS ON VARIABLE FREQUENCY DRIVES

Warranty Guidelines

The information in the following section refers to the motor and drive application guidelines and limitations for warranty.

Hazardous Location Motors

Use of a variable frequency drive with the motors in this catalog, intended for use in hazardous locations, is only approved for Division 1, Class I, Group D hazardous location motors with a T2B temperature code, with a limitation of 2:1 constant torque or 10:1 variable torque output. No other stock hazardous location motors are inherently suitable for operation with a variable frequency drive. If other requirements are needed, including non-listed Division 2, please contact your Nidec Motor Corporation territory manager to conduct an engineering inquiry.

575 Volt Motors

575 volt motors can be applied on Inverters when output filters are used. Contact the drive manufacturer for filter selection and installation requirements.

Applying INVERTER GRADE[®] Insulated Motors on Variable Frequency Drives (2, 4, 6 pole)

The products within this catalog labeled "Inverter Duty" or "Vector Duty" are considered INVERTER GRADE[®] insulated motors. INVERTER GRADE[®] motors exceed the NEMA[®] MG-1 Part 31 standard. Nidec Motor Corporation provides a three-year limited warranty on all NEMA[®] frame INVERTER GRADE[®] insulated motors and allows long cable runs between the motor and the VFD (limited to 400 feet without output filters). Cable distance can be further limited by hot and humid environments and VFD manufacturers cable limits. These motors may be appropriate for certain severe inverter applications or when the factors relating to the end use application are undefined (such as spares).

Nidec Motor Corporation's U.S. Motors[®] brand is available in the following INVERTER GRADE[®] insulated motors:

- Inverter Duty NEMA[®] frame motors good for 10:1 Variable Torque & 5:1 Constant Torque, including Vertical Type RUSI
- Inverter Duty motors rated for 10:1 Constant Torque
- ACCU-Torq[®] and Vector Duty Motors with full torque to 0 Speed
- 841 Plus[®] NEMA[®] Frame Motors

Applying Premium Efficient motors (that do not have INVERTER GRADE[®] insulation) on Variable Frequency Drives (2, 4, 6 pole)

Premium efficient motors without INVERTER GRADE[®] insulation meet minimum NEMA[®] MG-1, Section IV, Part 31.4.4.2. These motors can be used with Variable Frequency Drives (with a reduced warranty period) under the following parameters:

- On NEMA[®] frame motors, 10:1 speed rating on variable torque loads & 4:1 speed range on constant torque loads.
- On TITAN[®] frame motors, 10:1 speed rating on variable torque loads.
- On TITAN[®] frame motors, inquiry required for suitability on constant torque loads.

Cable distances are for reference only and can be further limited by hot and

humid environments (refer to Table 1). Refer to specific VFD manufacturers cable limits. Refer to the Motor/ Inverter Compatibility page for special consideration of vertical motor bearings.

Table 1 - Cable Distances			
Maximum Cable Distance VFD to Motor			
Switching Frequency	460 Volt	230 Volt	380 Volt
3 Khz	127 ft	400 ft	218 ft
6 Khz	90 ft	307 ft	154 ft
9 Khz	73 ft	251 ft	126 ft
12 Khz	64 ft	217 ft	109 ft
15 Khz	57 ft	194 ft	98 ft
20 Khz	49 ft	168 ft	85 ft

Warranty Period Clarifications and Exceptions

Standard Energy Efficient Exclusion

Applying Standard & Energy Efficient Motors on Variable Frequency Drives is not recommended. VFD related failures on standard and energy efficient motors will not be covered under warranty.

Vertical Motor Windings

Premium efficient vertical motors without INVERTER GRADE[®] insulation that are installed using the criteria described in this document and applied in the correct applications shall have a warranty while powered by a VFD for 12 months from date of installation or 18 months from date of manufacturing whichever comes first. See limited warranty page for horizontal motor warranty periods.

Bearing Exclusion for Thrust Handling Bearings

Bearings used in premium efficient vertical motors, and all thrust handling bearings, that are powered by VFDs without shaft grounding devices or insulated bearings (when required) will not be covered under any warranty for damages caused from being powered by a VFD. All other bearing failure is covered per NMC's standard warranty. An electric motor repair shop approved to service U.S. MOTORS[®] brand motors must verify that the cause of the bearing failure was not due to Electrical Discharge Machining.

Medium Voltage and Slow Speed Considerations

Motors that are rated above 700 VAC or that are eight pole and slower require special consideration and installation and are not covered under the warranty guidelines in this document. Motors that are rated above 700VAC have special cable length and voltage differential issues that are specific to the VFD type and manufacture. The motor construction and cost may vary dramatically depending on the VFD topology and construction. Contact your NMC representative with VFD manufacturer name and model type for application and motor construction considerations. Motors that are designed eight pole and slower also require special installation and filters per the drive manufacturer.

*This information applies only to Integral Horsepower (IHP) motors as defined on the Agency Approval page, under UL[®] & CSA[®] listings where indicated.



NIDEC MOTOR CORPORATION

DIVISION OF NIDEC MOTOR CORPORATION

TERMS AND CONDITIONS OF SALE

Nidec Motor Corporation, referred to herein as the "Seller" and the customer or person or entity purchasing goods ("Goods") from Seller is referred to as the "Buyer." These Terms and Conditions, any price list or schedule, quotation, acknowledgment or invoice from Seller relevant to the sale of the Goods and all documents incorporated by specific reference herein or therein, constitute the complete and exclusive statement of the terms of the agreement governing the sale of Goods by Seller to Buyer. Seller's acceptance of Buyer's purchase order is expressly conditional on Buyer's assent to all of Seller's terms and conditions of sale, including terms and conditions that are different from or additional to the terms and conditions of Buyer's purchase order. Buyer's acceptance of or payment for the Goods will manifest Buyer's assent to these Terms and Conditions. Seller reserves the right in its sole discretion to refuse orders.

1. **PRICES:** Prices for Goods, whether specified in Seller's price list or schedule, acknowledgment or written quotation, are subject to change without notice. Such prices shall be adjusted to reflect Seller's prices for Goods as in effect at the time of requested shipment date, and each shipment will be invoiced at such prices. All prices are exclusive of taxes, transportation and insurance, which are to be borne by Buyer.

2. **TAXES:** Any current or future tax or governmental charge (or increase in same) affecting Seller's costs of production, sale, or delivery or shipment, or which Seller is otherwise required to pay or collect in connection with the sale, purchase, delivery, storage, processing, use or consumption of Goods, shall be for Buyer's account and shall be added to the price or billed to Buyer separately, at Seller's election.

3. **TERMS OF PAYMENT:** Unless otherwise specified by Seller, terms are net thirty (30) days from date of Seller's invoice in U.S. currency. Seller shall have the right, among other remedies, either to terminate this agreement or to suspend further performance under this and/or other agreements with Buyer in the event Buyer fails to make any payment when due, which other agreements Buyer and Seller hereby amend accordingly. Buyer shall be liable for all expenses, including attorneys' fees, relating to the collection of past due amounts. If any payment owed to Seller is not paid when due, it shall bear interest, at a rate to be determined by Seller, which shall not exceed the maximum rate permitted by law, from the date on which it is due until it is paid. Should Buyer's financial responsibility become unsatisfactory to Seller, cash payments or security satisfactory to Seller may be required by Seller for future deliveries and for the Goods theretofore delivered. If such cash payment or security is not provided, in addition to Seller's other rights and remedies, Seller may discontinue deliveries. Buyer hereby grants Seller a security interest in all Goods sold to Buyer by Seller, which security interest shall continue until all such Goods are fully paid for in cash, and Buyer, upon Seller's demand, will execute and deliver to Seller such instruments as Seller requests to protect and perfect such security interest.

4. **SHIPMENT AND DELIVERY:** While Seller will use all reasonable commercial efforts to maintain the delivery date(s) acknowledged or quoted by Seller, all shipping dates are approximate and not guaranteed. Seller reserves the right to make partial shipments. Seller, at its option, shall not be bound to tender delivery of any Goods for which Buyer has not provided shipping instructions and other required information. If the shipment of the Goods is postponed or delayed by Buyer for any reason, Buyer agrees to reimburse Seller for any and all storage costs and other additional expenses resulting therefrom. Each shipment is F.C.A. Seller's shipping point (Incoterms 2010). In accordance with the foregoing Incoterm, risk of loss for damage and responsibility for the Goods shall pass from Seller to Buyer for each shipment upon delivery to and receipt by carrier at Seller's shipping point and legal title to the shipped Goods shall transfer to Buyer for each shipment as and when risk of loss with respect to such shipment is transferred to Buyer. Any claims for shortages or damages suffered in transit are the responsibility of Buyer and shall be submitted by Buyer directly to the carrier. Shortages or damages must be identified and signed for at the time of delivery.

5. **LIMITED WARRANTY:** Subject to the limitations of Section 6, Seller warrants that the Goods manufactured by Seller, other than those specifically identified below, will be free from defects in material and workmanship and meet Seller's published specifications at the time of shipment under normal use and regular service and maintenance for a period of twelve (12) months from the date of shipment of the Goods by Seller or eighteen (18) months from the date of manufacture, whichever occurs sooner, unless otherwise specified by Seller in writing. Partial Motors of any kind not fully assembled by Seller shall carry no warranty of any kind, express or implied. Products purchased by Seller from a third party for resale to Buyer ("Resale Products") shall carry only the warranty extended by the original manufacturer. **THE WARRANTY SET FORTH IN THIS SECTION 5 AND THE WARRANTY SET FORTH IN SECTION 7, ARE THE SOLE AND EXCLUSIVE WARRANTIES GIVEN BY SELLER WITH RESPECT TO THE GOODS AND ARE IN LIEU OF AND EXCLUDE ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, ARISING BY OPERATION OF LAW OR OTHERWISE, INCLUDING WITHOUT LIMITATION, MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE WHETHER OR NOT THE PURPOSE OR USE HAS BEEN DISCLOSED TO SELLER IN SPECIFICATIONS, DRAWINGS OR OTHERWISE, AND WHETHER OR NOT SELLER'S PRODUCTS ARE SPECIFICALLY DESIGNED AND/OR MANUFACTURED BY SELLER FOR BUYER'S USE OR PURPOSE.**

This warranty does not extend to any losses or damages due to misuse, accident, abuse, neglect, normal wear and tear, negligence (other than Seller's), unauthorized modification or alteration, use beyond rated capacity, unsuitable power sources or environmental conditions, improper installation, repair, handling, maintenance or application or any other cause not the fault of Seller. To the extent that Buyer or its agents has supplied specifications, information, representation of operating conditions or other data to Seller in the selection or design of the Goods and the preparation of Seller's quotation, and in the event that actual operating conditions or other conditions differ from those represented by Buyer, any warranties or other provisions contained herein which are affected by such conditions shall be null and void.

If within thirty (30) days after Buyer's discovery of any warranty defects within the warranty period, Buyer notifies Seller thereof in writing, Seller shall, at its option and as Buyer's exclusive remedy, repair, correct or replace or refund the purchase price for that portion of the Goods found by Seller to be defective. Failure by Buyer to give such written notice within the applicable time period shall be deemed an absolute and unconditional waiver of Buyer's claim for such defects. Seller shall have the right to require the Buyer to deliver the Goods to Seller's designated repair center or manufacturing facility. All costs associated with dismantling, reinstallation and transportation to and from Seller's designated repair center or manufacturing facility and the time and expense of Seller's personnel and representatives for site travel and diagnosis under this warranty shall be borne by the Buyer. Goods repaired or replaced during the warranty period shall be covered by the foregoing warranty for the remainder of the original warranty period or ninety (90) days from the date of shipment, whichever is longer. Buyer assumes all other responsibility for any loss, damage, or injury to persons or property arising out of, connected with, or resulting from the use of Goods, either alone or in combination with other products/components.

Section 5 applies to any entity or person who may buy, acquire or use the Goods, including any entity or person who obtains the Goods from Buyer, and shall be bound by the limitations therein, including Section 6. Buyer agrees to provide such subsequent transferee conspicuous, written notice of the provisions of Sections 5 and 6.

6. **LIMITATION OF REMEDY AND LIABILITY:** **THE SOLE AND EXCLUSIVE REMEDY FOR BREACH OF ANY WARRANTY HEREUNDER (OTHER THAN THE WARRANTY PROVIDED UNDER SECTION 7) SHALL BE LIMITED TO REPAIR, CORRECTION OR REPLACEMENT, OR REFUND OF THE PURCHASE PRICE UNDER SECTION 5.**

SELLER SHALL NOT BE LIABLE FOR DAMAGES CAUSED BY DELAY IN PERFORMANCE AND THE REMEDIES OF BUYER SET FORTH IN THIS AGREEMENT ARE EXCLUSIVE. IN NO EVENT, REGARDLESS OF THE FORM OF THE CLAIM OR CAUSE OF ACTION (WHETHER BASED IN CONTRACT, INFRACTION, NEGLIGENCE, STRICT LIABILITY, OTHER TORT OR OTHERWISE), SHALL SELLER'S LIABILITY TO BUYER AND/OR ITS CUSTOMERS EXCEED THE PRICE PAID BY BUYER FOR THE SPECIFIC GOODS PROVIDED BY SELLER GIVING RISE TO THE CLAIM OR CAUSE OF ACTION. BUYER AGREES THAT IN NO EVENT SHALL SELLER'S LIABILITY TO BUYER AND/OR ITS CUSTOMERS EXTEND TO INCLUDE INCIDENTAL, CONSEQUENTIAL OR PUNITIVE DAMAGES. The term "consequential damages" shall include, but not be limited to, loss of anticipated profits, business interruption, loss of use, revenue, reputation and data, costs incurred, including without limitation, for capital, fuel, power and loss or damage to property or equipment.

It is expressly understood that any technical advice furnished by Seller with respect to the use of the Goods is given without charge, and Seller assumes no obligation or liability for the advice given, or results obtained, all such advice being given and accepted at Buyer's risk.

7. **PATENTS AND COPYRIGHTS:** Subject to the limitations of the second paragraph of Section 6, Seller warrants that the Goods sold, except as are made specifically for Buyer according to Buyer's specifications, do not infringe any valid U.S. patent or copyright in existence as of the date of shipment. This warranty is given upon the condition that Buyer promptly notifies Seller of any claim or suit involving Buyer in which such infringement is alleged and cooperates fully with Seller and permit Seller to control completely the defense, settlement or compromise of any such allegation of infringement. Seller's warranty as to use patents only applies to infringement arising solely out of the inherent operation according to Seller's specifications and instructions (i) of such Goods, or (ii) of any combination of Goods acquired from Seller in a system designed by Seller. In the event such Goods are held to infringe such a U.S. patent or copyright in such suit, and the use of such Goods is enjoined, or in the case of a compromise or settlement by Seller, Seller shall have the right, at its option and expense, to procure for Buyer the right to continue using such Goods, or replace them with non-infringing Goods, or modify same to become non-infringing, or grant Buyer a credit for the depreciated value of such Goods and accept return of them. In the event of the foregoing, Seller may also, at its option, cancel the agreement as to future deliveries of such Goods, without liability. No license or rights in any of Seller's intellectual property associated with the Goods is granted hereby.

In the event that the Goods provided by Seller, as well as any services provided by Seller ("Services"), regardless of whether the Services are at the request or on behalf of Buyer, are part of a project ("Project"), or are performed

alone or are related to the provision of Goods, contain or incorporate any work product, including but not limited to concepts, inventions (patentable or otherwise), works, drawings, designs, information, specifications, customizations, optimizations, improvements, documentation, and programs or software, in each case regardless of whether developed by Seller alone or with others, whether completed or work-in-progress, or whether completed at Buyer's request, Buyer's cost, or as part of a Project performed for Buyer (any and all of the foregoing being "Work Product"), Seller owns all right, title, and interest (including, but not limited to, any patents, copyrights, or other intellectual property rights) in such final Work Product, including any and all intermediate Work Product developed as part or in pursuit of the final Work Product, in connection with, embodied in, or encompassed by any Good, Service, or Project deliverable. Seller makes no transfer or license to Buyer of any right, title, or interest in or to the Work Product or in or to any of Seller's intellectual property or proprietary rights.

8. **EXCUSE OF PERFORMANCE:** Seller shall not be liable for delays in performance or for non-performance due to acts of God; acts of Buyer; war; fire; flood; weather; sabotage; strikes or labor disputes; civil disturbances or riots; governmental requests, restrictions, allocations, laws, regulations, orders or actions; unavailability of or delays in transportation; default of suppliers; or unforeseen circumstances or any events or causes beyond Seller's reasonable control. Deliveries or other performance may be suspended for an appropriate period of time or canceled by Seller upon notice to Buyer in the event of any of the foregoing, but the balance of the agreement shall otherwise remain unaffected as a result of the foregoing.

If Seller determines that its ability to supply the total demand for the Goods, or to obtain material used directly or indirectly in the manufacture of the Goods, is hindered, limited or made impracticable due to causes set forth in the preceding paragraph, Seller may allocate its available supply of the Goods or such material (without obligation to acquire other supplies of any such Goods or material) among itself and its purchasers on such basis as Seller determines to be equitable without liability for any failure of performance which may result therefrom.

9. **CANCELLATION:** Buyer may cancel orders only upon reasonable advance written notice and upon payment to Seller of Seller's cancellation charges which include, among other things, all costs and expenses incurred, and, to cover commitments made, by the Seller and a reasonable profit thereon. Seller's determination of such termination charges shall be conclusive.

10. **CHANGES:** Buyer may request changes or additions to the Goods consistent with Seller's specifications and criteria. In the event such changes or additions are accepted by Seller, Seller may revise the price and dates of delivery. Seller reserves the right to change designs and specifications for the Goods without prior notice to Buyer, except with respect to Goods being made to order for Buyer. Seller shall have no obligation to install or make such change in any Goods manufactured prior to the date of such change.

11. **NUCLEAR/MEDICAL:** UNLESS OTHERWISE AGREED IN WRITING BY SELLER: (i) GOODS SOLD HEREUNDER ARE NOT FOR USE IN CONNECTION WITH ANY NUCLEAR, MEDICAL, LIFE-SUPPORT AND RELATED APPLICATIONS. (ii) Buyer accepts Goods with the foregoing understanding, agrees to communicate the same in writing to any subsequent purchasers or users and (iii) Buyer agrees to defend, indemnify and hold harmless Seller from any claims, losses, suits, judgments and damages, including incidental and consequential damages, arising from such use, whether the cause of action be based in tort, contract or otherwise, including allegations that the Seller's liability is based on negligence or strict liability.

12. **ASSIGNMENT:** Buyer shall not assign its rights or delegate its duties hereunder or any interest herein without the prior written consent of Seller, and any such assignment, without such consent, shall be void.

13. **QUANTITY:** Buyer agrees to accept overruns of up to ten percent (10%) of the order on "made-to-order" goods, including parts. Any such additional items shall be priced at the price per item charged for the specific quantity ordered.

14. **REPLACEMENT / SERVICE GOODS:** Upon the cancellation or fulfillment of this order, Seller will have no obligation to sell and Buyer will have no obligation to purchase the Goods sold hereunder, including, but not limited to, the supply of replacement parts for Goods or Goods for Buyer's consumer service division. Seller is not obligated to sell Buyer or its consumer service divisions Goods: (i) for any fixed period of time after production of the Goods supplied hereunder ceases or after the last date of shipment made under this order; or (ii) at any pre-established price to fulfill Buyer's or its consumer service divisions requirements during or after production of the Goods ceases or after the last date of shipment under this order. Seller shall have the absolute right to revise the price of Goods and the terms of sale and to modify or discontinue the sale of the Goods, and such action shall not form the basis of any claim by Buyer against Seller.

15. **TOOLING:** Tool, die, and pattern charges, if any, are in addition to the price of the Goods and are due and payable upon completion of the tooling. All such tools, dies and patterns shall be and remain the property of Seller. Charges for tools, dies, and patterns do not convey to Buyer, title, ownership interest in, or rights to possession or removal, or prevent their use by Seller for other purchasers, except as otherwise expressly provided by Seller and Buyer in writing with reference to this provision.

16. **INSPECTION/TESTING:** Buyer, at its option and expense, may inspect and observe the testing by Seller of the Goods for compliance with Seller's standard test procedures prior to shipment, which inspection and testing shall be conducted at Seller's plant at such reasonable time as is specified by Seller. Any rejection of the Goods must be made promptly by Buyer before shipment. Tests shall be deemed to be satisfactorily completed and the test fully met when the Goods meet Seller's criteria for such procedures.

17. **DRAWINGS:** Seller's prints and drawings (including without limitation, the underlying technology) furnished by Seller to Buyer in connection with this agreement are the property of Seller and Seller retains all rights, including without limitation, exclusive rights of use, licensing and sale. Possession of such prints or drawings does not convey to Buyer any rights or license, and Buyer shall return all copies (in whatever medium) of such prints or drawings to Seller immediately upon request therefor.

18. **EXPORT/IMPORT:** Buyer agrees that all applicable import and export control laws, regulations, orders and requirements, including without limitation those of the United States and the European Union, and the jurisdictions in which the Seller and Buyer are established or from which Goods may be supplied, will apply to their receipt and use. In no event shall Buyer use, transfer, release, import, export, Goods in violation of such applicable laws, regulations, orders or requirements.

19. **INSURANCE:** Seller shall carry adequate product liability and commercial general liability insurance. Seller shall, upon written request from Buyer, furnish Buyer with certificates of insurance confirming the existence of such insurance. Seller does not waive its, or its insurers', rights of subrogation.

20. **GENERAL PROVISIONS:** These terms and conditions supersede all other communications, negotiations and prior oral or written statements regarding the subject matter of these terms and conditions. No change, modification, rescission, discharge, abandonment, or waiver of these terms and conditions shall be binding upon the Seller unless made in writing and signed on its behalf by a duly authorized representative of Seller. No conditions, usage of trade, course of dealing or performance, understanding or agreement purporting to modify, vary, explain, or supplement these terms and conditions shall be binding unless hereafter made in writing and signed by the party to be bound, and no modification or additional terms shall be applicable to this agreement by Seller's receipt, acknowledgment, or acceptance of purchase orders, shipping instruction forms, or other documentation containing terms at variance with or in addition to those set forth herein. Any such modifications or additional terms are specifically rejected and deemed a material alteration hereof. If this document shall be deemed an acceptance of a prior offer by Buyer, such acceptance is expressly conditional upon Buyer's assent to any additional or different terms set forth herein. No waiver by either party with respect to any breach or default or of any right or remedy, and no course of dealing, shall be deemed to constitute a continuing waiver of any other breach or default or of any other right or remedy, unless such waiver be expressed in writing and signed by the party to be bound. All typographical or clerical errors made by Seller in any quotation, acknowledgment or publication are subject to correction.

The validity, performance, and all other matters relating to the interpretation and effect of this agreement shall be governed by the law of the state of Missouri without regard to its conflicts of laws principles. Buyer and Seller agree that the proper venue for all actions arising in connection herewith shall be only in Missouri and the parties agree to submit to such jurisdiction. No action, regardless of form, arising out of transactions relating to this contract, may be brought by either party more than two (2) years after the cause of action has accrued. The U.N. Convention on Contracts for the International Sales of Goods shall not apply to this agreement.



INTRODUCTION

This pricing guide provides the user with Nidec Motor Corporation's product capabilities for vertical motors. The U.S. Motors® brand is the most used and specified motor in our industry today.

Quality

We set rigid standards for ourselves and our suppliers with constant field monitoring to provide you with the assurance of the utmost product reliability.

Experience

Since the 1922 introduction of the patented HOLLOSHAFT® motor, we have been producing vertical high-thrust motors for the pumping industry ensuring your specific needs are met.

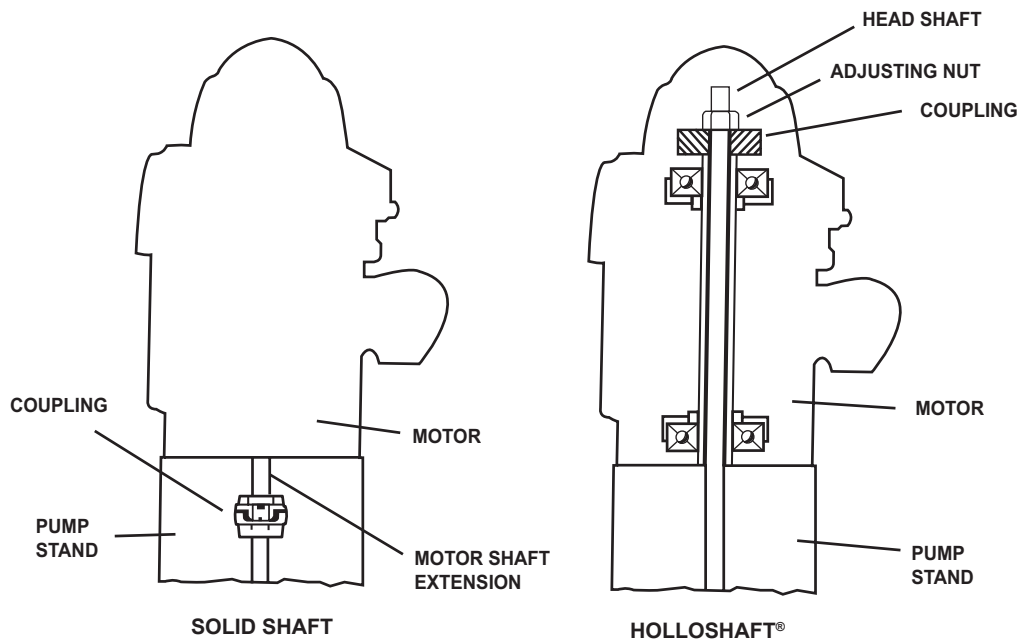
Service

From quotation to field installation, our service team will provide you with all the necessary support.

Innovation

We continually add product value by providing the latest engineering and manufacturing designs to provide quality standards that meet your current application demands.

Our vertical motors are offered in solid shaft and HOLLOSHAFT® configurations.



OUR MOTORS

Introduced in 1922, U.S. Motors® brand vertical HOLLOWSHAFT® motor was developed to meet the specific needs of the vertical turbine pump industry. With the pump shaft extended through the hollow shaft, adjustment can be made by a nut threaded on the shaft at the accessible top portion of the motor. This adjustment is required to lift the impellers and give a running clearance with the pump casing. The stretch of several hundred feet of shafting may require a lift at the top of the well, and the impeller at the bottom must be positioned within a fraction of an inch.

The drive coupling also provides a solution to the problem of power reversal. The pump shaft is usually composed of many lengths joined by screw thread couplings. A power reversal would unscrew the joints, causing the shaft to lengthen and buckle or break. The self-release coupling lifts out of its engagement position and prevents this problem.

In addition to normal induction motor classifications, the vertical motor is classified by thrust. Thrust is the sum of the axial forces of the weight of the pump and lineshaft and the dynamic forces of the pump to lift the liquid to the surface. NEMA does not specifically define thrust ratings for motors, but each manufacturer will define thrust ratings for their product rating. 100 percent high thrust, 175 percent high thrust and 300 percent high thrust are common.

Normal-thrust motors are used in general applications where there is very low or no external thrust applied to the motor bearing. It is often a footless horizontal motor with a “P” flange (the “P” flange mounting for the vertical motor).

In-line thrust, sometime called medium thrust, is a definite purpose motor. The pump impellers are mounted directly on the motor shaft. Since the pump impeller performance depends on close tolerance with the pump housing, the motor shaft and flange round-out tolerances must also be tighter than normal. The thrust bearing is usually located at the bottom rather than the top, as in high-thrust construction. This keeps the motor rotor’s thermal growth from affecting the impeller clearances.

Enclosures provide protection against specific environmental conditions. Our motors are available with Weather Protected I, Weather Protected II, Totally Enclosed and Hazardous Location enclosures.



MOTOR VARIETIES

Weather Protected Type I (WPI)

Open motors are constructed to minimize the entrance of rain, snow and airborne particles. Our enclosures exceed NEMA^{®†} requirements through built-in extra protection for rugged outdoor applications. The ventilation system, available in all motor sizes, is designed to provide optimum cooling to the thrust bearing and electrical components.

HOLLOSHAFT[®] motors *page P-1*
Solid Shaft motors *page P-31*
WPI
3–5000 Horsepower

Weather Protected Type II (WP II)

This NEMA^{®†} enclosure offers maximum protection against hostile outdoor atmospheres. The special ventilation system minimizes the entrance of high velocity air, moisture and airborne particles into the cooling passages of the motor.

HOLLOSHAFT[®] motors
Solid Shaft motors
WP II
150–5000 Horsepower

Totally Enclosed and Hazardous Location (TEFC/HAZARDOUS LOCATION)

Totally enclosed and Hazardous Location models are available with our non-sparking, non-reverse ratchet design for severe atmospheres where destructive dusts, vapors and other harmful substances are found. When Underwriters Laboratories' approval is necessary, our Hazardous Location design is the answer. They are available in motor sizes through 700 horsepower.

HOLLOSHAFT[®] motors *page P-22*
Solid Shaft motors *page P-53*
TEFC 3 – 2000 Horsepower
HAZARDOUS LOCATION 3-700 Horsepower

CORRO-DUTY[®] cast-iron construction is also available with external corrosion-resistant paint and hardware for extremely harsh environments.



MOTOR VARIETIES (continued)

Normal Thrust

Normal-thrust motors are designed for use with pumps and other general industrial applications. Axial thrust is normally very low, while radial loads are generally higher. The thrust bearing is locked for thrust in either direction.

Available in Open and Enclosed Designs

*Solid Shaft motors
1–800 Horsepower*

page P-71

In-line Pump Motor

The in-line pump motor is specially designed and manufactured for long life in applications involving radial load due to suction variation and changes in pump capacity.

Available in Enclosed and Hazardous Location Designs

*Solid Shaft motors
3–200 Horsepower*

page P-65

Vertical Aerator Motor

A special CORRO-DUTY® treatment makes our motors unsurpassed for reliability in hostile environments, particularly those related to waste aeration. For severe applications, the CORRO-DUTY® vertical aerator to the municipal, pulp and paper, and petroleum and chemical industries, among others.

*Solid Shaft motors
TEFC
5–200 Horsepower*

page P-68



CLASSIFICATIONS

For your assistance, below is a comparison of environmental protection classifications of IEC 34-5 and NEMA MG 1 - 1.25 and 1.26. Because direct correlation is not always possible, the following represents the more common interpretations.

NEMA	IEC
<p style="text-align: center;">OPEN MACHINES</p> <p>An open machine is one having ventilating openings which permit passage of external cooling air over and around the windings of the machine. The term “open machine,” when applied to large apparatus without qualification, designates the machine having no restriction to ventilation other than that necessitated by mechanical construction.</p> <p><i>Reference only. Nidec Motor Corporation does not provide for P-base verticals</i></p>	
<p style="text-align: center;">DRIP PROOF MACHINE</p> <p>A drip proof machine is an open machine in which the ventilating openings are so constructed that successful operation is not interfered with when drops of liquid or solid particles strike or enter the enclosure at any angle from 0 degrees to 15 degrees downward from the vertical.</p> <p><i>Reference only. Nidec Motor Corporation does not provide for P-base verticals</i></p>	<p style="text-align: center;">IP 21</p> <p>Protection against accidental or inadvertent contact with live and moving parts inside the enclosure by a large surface of the human body (for example, a hand) but no protection against deliberate access to such parts.</p> <p>Protection against ingress of large solid foreign bodies (diameter greater than 50 mm).</p> <p>Machine protected against drops of water falling up to 15 percent from the vertical.</p>
<p style="text-align: center;">DRIP PROOF GUARDED</p> <p>A guarded machine is an open machine in which all openings giving direct access to live metal or rotating parts (except smooth rotating surfaces) are limited in size by the structural parts or by screens, baffles, grilles, expanded metal or other means to prevent accidental contact with hazardous parts. Openings giving direct access to such live or rotating parts shall not permit the passage of a 3/4-inch diameter cylindrical rod.</p> <p><i>Reference only. Nidec Motor Corporation does not provide for P-base verticals</i></p>	<p style="text-align: center;">IP 22</p> <p>IP 22 protection against contact by finger with live or moving parts inside the enclosure.</p> <p>Protection against ingress of small, solid foreign bodies (diameter greater than 50 mm).</p> <p>Machine protected against drops of water falling up to 15 degrees from the vertical.</p>



CLASSIFICATIONS (continued)

NEMA	IEC
<p style="text-align: center;">Weather Protected Machines</p> <p>A Weather Protected Type I machine is a guarded machine with ventilating passages constructed to minimize the entrance of rain, snow and airborne particles to the electric parts. Ventilating openings are constructed to prevent the passage of a cylindrical rod 3/4 diameter.</p> <p><i>Standard on P-base</i></p> <p>A Weather Protected Type II machine has its ventilating passages at both intake and discharge so arranged that high-velocity air and airborne particles blown into the machine by storms or high winds can be discharged without entering the internal ventilating passages leading directly to the electric parts of the machine itself. The normal path of ventilating air which enters the electric parts of the machine shall be so arranged by baffling or separate housings as to provide at least three abrupt changes in direction, none of which shall be less than 90 degrees. In addition, an area of low velocity not exceeding 600 feet per minute shall be provided in the intake air path to minimize the possibility of moisture or dirt being carried into the electric parts of the machine.</p>	<p style="text-align: center;">IP 23</p> <p>Machine protected against spraying water. A machine is weather protected when its design reduces the ingress of rain, snow and airborne particles, under specified conditions, to an amount consistent with correct operation.</p> <p style="text-align: center;">IPW 23</p> <p>Protection against contact by finger with live or moving parts inside the enclosure. Protection against ingress of small, solid foreign bodies (diameter greater than 12mm). Water falling as a spray at an angle equal to or smaller than 60° with respect to the vertical shall have no harmful effect.*</p> <p style="text-align: center;">IPW 24</p> <p>Protection against contact by finger or live or moving parts inside the enclosure.* Protection against ingress of small solid, foreign bodies (diameter greater than 12mm). Water splashed against the machine from any direction shall have no harmful effect.</p>
<p style="text-align: center;">Totally Enclosed Machines</p> <p>A Totally Enclosed machine is enclosed to prevent the free exchange of air between the inside and outside of the case, but not sufficiently enclosed to be termed airtight.</p> <p>A Totally Enclosed non-ventilated machine is a frame surface cooled totally enclosed machine only equipped for cooling by free convection.</p> <p>A Totally Enclosed fan-cooled machine is a frame-surface cooled totally enclosed machine equipped for self-exterior cooling by means of a fan or fans integral with the machine but external to the enclosing parts.</p>	

*For machines cooled by an external cooling fan, the fan shall be protected to prevent contact with the blades or spokes of the fan with a standard test finger. However, at the outlet of the fan, the test finger is not inserted past the 50mm diameter guard.



CLASSIFICATIONS (continued)

NEMA	IEC
<p>Totally Enclosed Fan Cooled Guarded</p> <p>A Totally Enclosed Fan Cooled Guarded machine is a totally enclosed fan cooled machine in which all openings giving direct access to the fan are limited in size by the design of the structural parts or screens, grilles, expanded metal, etc., to prevent accidental contact with the fan. Such openings shall not permit the passage of a cylindrical rod .75 inch in diameter and a probe shall not contact the blades, spokes or other irregular fan surfaces.</p> <p><i>Standard WP11 with filters meets the intent of IP-44</i></p>	<p>IP 44</p> <p>Protection against contact with live or moving parts inside the enclosure by tools, wires or such objects of thickness greater than 1mm.</p> <p>Protection against ingress of small, solid foreign bodies (diameter greater than 1mm), excluding ventilation openings (intake and discharge of external fans) and the drain hole of enclosed machine, which may have degree of 2 protection.</p> <p>Water splashed against the machine from any direction shall have no harmful effect.</p>
<p>WPI and WP11 on TITAN® frames may be utilized in place of IP-54. In extremely dusty areas WP11 motors with filters should be used. On frames 440 or smaller, TEFC is an acceptable enclosure.</p>	<p>IP 54</p> <p>Complete protection against contact with live or moving parts inside the enclosure.*</p> <p>Protection against harmful deposits of dust. The ingress of dust is not totally prevented, but dust cannot enter in an amount sufficient to interfere with satisfactory operation of the machine.</p> <p>Water splashed against the motor from any direction shall have no harmful effects.</p>
<p>Totally Enclosed Fan Cooled Waterproof Machine</p> <p>A waterproof machine is a totally enclosed machine constructed to exclude water applied in the form of a stream from a hose, except that leakage may occur around the shaft, provided it is prevented from entering the reservoir and a provision is made for automatically draining the machine. The means for automatic draining may be a check valve or a tapped hole at the lowest part of the frame which will serve for application of a drain pipe.</p>	<p>IP 55</p> <p>Complete protection against contact with live or moving parts inside the enclosure.*</p> <p>Protection against harmful deposits of dust. The ingress of dust is not totally prevented, but dust cannot enter in an amount sufficient to interfere with satisfactory operation of the machine.</p> <p>Water projected by a nozzle against the machine from any direction shall have no harmful effect.</p>

*For machines cooled by an external cooling fan, the fan shall be protected to prevent contact with the blades or spokes of the fan with a standard test finger. However, at the outlet of the fan, the test finger is not inserted past the 50mm diameter guard.



TYPE DESIGNATIONS

U.S. MOTORS® type codes for vertical motors do have meaning -- the first letter designates the enclosures:

R = NEMA[†] and TITAN® WPI T = NEMA[†] TEFC L = NEMA[†] Hazardous Location U.L. Listed
 H = TITAN® WPI, WP11 A = NEMA[†] WPI E = TITAN® Hazardous Location U.L. Listed
 J = TITAN® TEFC N = NEMA[†] Hazardous

The second letter designates the type of shaft, V for solid shaft, U for hollow shaft. The third letter designates special features, such as:

E = Premium Efficient (TITAN®) E = Energy Efficient (NEMA[†]) C= CORRO-DUTY®
 R = Single Phase Cap Run S = Premium Efficient (NEMA[†]) I = VFD/Inverter Duty

The fourth letter designates the thrust, as follows:

Blank = Solid Shaft Normal Thrust and Hollow Shaft High Thrust
 -3 = Medium Thrust (JV-3) -4 = High Thrust
 -9 = In-Line (Medium) -5 = High Thrust with Plate Bearings

Standard combinations are as follows:

ENCLOSURE	HIGH THRUST			
	NEMA		TITAN	
	HOLLOW SHAFT	SOLID SHAFT	HOLLOW SHAFT	SOLID SHAFT
OPEN OPEN - Energy Efficient OPEN - Premium Efficient OPEN - Inverter	AU/RU AUE/RUE AUS/RUS AUSI/RUSI	AV-4/RV-4 AVE-4/RVE-4 AVS-4/RVS-4 AVSI-4/RVSI-4	HU/RU --- HUE/RUS/RUE HUEI/RUEI RUSI	HV-4/RV-4 --- HVE-4/RVS-4/RVE-4 HVEI-4/RVEI-4 RVSI-4
ENCLOSED ENCLOSED - Energy Efficient ENCLOSED - Premium Efficient ENCLOSED - Inverter	TU TUE TUS TUI	TV-4 TVE-4 TVS-4 TVI-4	JU --- JUE JUEI	JV-4 --- JVE-4 JVI-4
U.L. Listed Division 1 ◊ U.L. Listed Division 1 - Energy Efficient U.L. Listed Division 1 - Premium Efficient	LU LUE LUS	LV-4 LVE-4 LVS-4	EU --- EUE	EV-4 --- EVE-4
U.L. Listed DIVISION 2 U.L. Listed DIVISION 2 - Energy Efficient U.L. Listed DIVISION 2 - Premium Efficient	NU NUE ---	NV-4 NVE-4 ---	--- --- ---	--- NVE-4 ---

◊ Inverter-duty Hazardous Location motors must be referred to engineering for approval.

In this section, NEMA denotes NEMA[†] standard motors, and Titan denotes TITAN® large motors.



† All marks shown within this document are properties of their respective owners.

TYPE DESIGNATIONS (continued)

Standard combinations are as follows:

NORMAL THRUST SOLID SHAFT

ENCLOSURE	NEMA	TITAN
OPEN OPEN - Energy Efficient OPEN - Premium Efficient OPEN - Inverter	AV/RV AVE/RVE RVS AVSI/RVSI	HV/RV --- HVE/RVE HVEI/RVEI
ENCLOSED ENCLOSED - Energy Efficient ENCLOSED - Premium Efficient ENCLOSED - Inverter	TV, CTV TVE TVS TVI	JV --- JVE JVEI
U.L. Listed Division 1 U.L. Listed Division 1 - Energy Efficient U.L. Listed Division 1 - Premium Efficient	LV LVE LVS	EV --- EVE
U.L. Listed DIVISION 2 U.L. Listed DIVISION 2 - Energy Efficient U.L. Listed DIVISION 2 - Premium Efficient	NV NVE ---	--- --- ---

IN-LINE/AERATOR

ENCLOSURE	NEMA	TITAN
ENCLOSED ENCLOSED - Energy Efficient ENCLOSED - Premium Efficient U.L. Listed Division 1 U.L. Listed Division 1 - Energy Efficient U.L. Listed Division 1 - Premium Efficient	TV-9 TVE-9 TVS-9 LV-9 LVE-9 LVS-9	--- --- --- --- --- ---

◇ In this section, NEMA denotes NEMA^{®†} standard motors, and Titan denotes TITAN[®] large motors.



CONSTRUCTION FEATURES

BEARING CAPS: All vertical motors are furnished with lower bearing caps constructed of aluminum or cast iron.

STANDARD BEARING LUBRICATION:

FRAME	TYPE	UPPER BEARING	LOWER BEARING	THRUST CAPACITY
180-280	AU, AV-4	GREASE	GREASE**	HIGH
180-440	AV, TV, LV	GREASE	GREASE**	NORMAL
	AV-9, TV-9, LV-9			MEDIUM
320-440	RV	GREASE	GREASE**	NORMAL
	RV-9			MEDIUM
	RU, RV-4	OIL	GREASE	HIGH
180-360	TU, TV-4 LU, LV-4	GREASE	GREASE**	HIGH
400-440		OIL	GREASE	HIGH
449, 2P	JV	GREASE	GREASE	NORMAL
	JV-4	OIL	GREASE	HIGH
449, 4P & SLOWER	RU, RV-4	OIL	GREASE	HIGH
	RV	GREASE	GREASE	NORMAL
	JV	GREASE	GREASE	NORMAL
	JV-3	GREASE	GREASE	MEDIUM
	JU, JV-4	OIL	GREASE	HIGH
5000	RV	GREASE	GREASE	NORMAL
	RU, RV-4	OIL	GREASE	HIGH
	EV, JV	GREASE	GREASE	NORMAL
	JU, JV-4 EU, EV-4	OIL	OIL	HIGH
5800	EV, JV+	GREASE	GREASE	NORMAL
	JU, JV-4 EU, EV-4	OIL	OIL	HIGH
5813	RV	GREASE	GREASE	NORMAL
	RU, RV-4	OIL	OIL	HIGH
6800	RV	OIL	OIL	NORMAL
	RU, RV-4 JV-4 JU	OIL	OIL	HIGH
	RV	GREASE	GREASE	NORMAL
8000	RV	GREASE	GREASE	NORMAL
	RU, RV-4	OIL	OIL	HIGH
9600	RV	GREASE	GREASE	NORMAL
	RU, RV-4	OIL	OIL	HIGH

** LOWER BEARING IS THRUST BEARING

+ 2 pole designs will be oil – oil design

BRACKETS: NEMA^{®†} frame motors: Both end brackets are cast iron except for the following motors:
 Type AV; Upper bracket on 180 & 210 frames is aluminum.
 Type TV & TV9; Upper bracket on 180 - 280 frames is aluminum.*
 Type TU & TV-4; Upper bracket on 250 & 280 frames is aluminum.*

*Note: CORRO-DUTY[®] option has cast-iron brackets.



† All marks shown within this document are properties of their respective owners.

CONSTRUCTION FEATURES (continued)

BRACKETS (continued)

TITAN® frame motors: Cast iron on 449 - 5800 frames.
 Cast iron or fabricated steel on 6800 - 8000 frames.
 Fabricated steel on 9600 frames.

CANOPY CAP: Constructed of plastic, steel, aluminum, fiberglass or cast iron depending on exact frame and type

CORRO-DUTY® motors have a cast iron canopy cap.

(1) ENCLOSURES:

NEMA®† frame motors: 180 through 447

Type:	AV, AU, AV4, RV, RU, RV4	=	WPI
	TV, CTV, TU, TV4, TV9	=	TEFC
	LV, LU, LV4, LV9	=	HAZARDOUS - DIVISION 1(U.L. Listed)
	NV, NU, NV4, NV9	=	HAZARDOUS - DIVISION 2 (U.L. Listed)

TITAN® frame motors: 449 and larger

Type:	HV, HU, HV4, RV, RU, RV4	=	WPI (WPII option available)
	JV, JU, JV4	=	TEFC
	EV, EU, EV4	=	HAZARDOUS - DIVISION 1(U.L. Listed)

FAN COVER (TEFC):

Constructed of plastic, steel, aluminum or cast iron depending on exact frame and type.

CORRO-DUTY® NEMA frame motors have cast iron fan cover. CORRO-DUTY® and TITAN® motors (449 frame & up) have either steel or cast iron fan covers.

(2) FRAME MATERIAL:

NEMA®† frame motors: 180 through 447

Type:	AV, AU, AV4,	=	Aluminum
	RV, RU, RV4, CTV	=	Cast iron
	TV, TU, TV4, TV9	=	Aluminum (180 - 280 frames)*
		=	Cast iron (320 - 440 frames)
	LV, LU, LV4, LV9	=	Cast iron
	NV, NU, NV4, NV9	=	Cast iron

*Note: CORRO-DUTY® option has cast-iron frame



CONSTRUCTION FEATURES (continued)

TYPICAL ENCLOSURE MATERIAL

TITAN® Motor Frames

FRAME	<u>WPI</u> HU RU HV RV HV4 RV4	<u>WPII</u> HU RU HV RV HV4 RV4	<u>TEFC</u> JU JV JV4	<u>XP</u> EU EV EV4
449	CAST IRON	CAST IRON	CAST IRON	---
5008	CAST IRON	CAST IRON	CAST IRON	CAST IRON
5012	CAST IRON	CAST IRON	---	---
5807	---	---	CAST IRON	CAST IRON
5809	---	---	CAST IRON	CAST IRON
5811	---	---	CAST IRON	CAST IRON
5812	---	---	CAST IRON	CAST IRON
5813	CAST IRON	CAST IRON	---	---
6812	---	---	CAST IRON	---
6808, 6810	FAB STEEL	FAB STEEL	---	---
6813	CAST IRON	CAST IRON	---	---
8000	FAB STEEL	FAB STEEL	---	---
9600	FAB STEEL	FAB STEEL	---	---



† All marks shown within this document are properties of their respective owners.

CONSTRUCTION FEATURES (continued)

INSULATION: Class F (NEMA^{®†} frame WPI stock motors are nameplated for Class B temperature rise).

Low voltage motors (600 volts and less) 600 HP and lower are random wound, Class F insulation.

Low voltage motors 601 HP and up and all medium voltage motors (above 600 Volts) are form wound, Class F insulation. Some slow speed motors with lower HP than 601 may require form wound designs.

OUTLET BOX: NEMA^{®†} frame motors:

Aluminum or steel. CORRO-DUTY[®] option has cast-iron outlet box.

TITAN[®] large frame motors:

- (1) Obtain "AF" dimension from dimension print of product in question.
- (2) Find matching "AF" in the "Conduit Box" section of the Accessories and Modifications.
- (3) Read across to "Type Construction" column.
- (4) Cast iron is standard on hazardous location.
- (5) Cast iron or steel is standard on CORRO-DUTY[®] motors.

ROTOR BARS: Aluminum. Copper bar option available on TITAN[®] large frame motors.

SHAFTS: AISI 1045 steel. Optional high-tensile steel.

STANDARD SERVICE FACTOR: WPI & WPII = 1.15, 1.00 on medium voltage, 12-pole and slower
TEFC & Hazardous Location - 1.0

THRUST BEARING LOCATION:

TYPE	THRUST BEARING
NEMA^{®†} FRAME MOTORS NORMAL THRUST: AV, RV, LV, NV TV, CTV, CEV IN-LINE: TV9, LV9, NV9 HIGH-THRUST: AU TV-4, TU, LU, NU (180-360 FRAME) RU, RV-4 TV-4, TU, LU, LV-4, NU, NV-4 (400 - 440 FRAME)	LOWER BEARING UPPER BEARING LOWER BEARING LOWER BEARING LOWER BEARING UPPER BEARING UPPER BEARING
TITAN[®] LARGE FRAME MOTORS NORMAL THRUST 5000 AND 5800 TYPES EV, JV ALL OTHERS	LOWER BEARING UPPER BEARING

