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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
NASA-16225 (June 2004)  
NASA  
Superseding NASA-16225  
(July 2003)  
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SECTION TABLE OF CONTENTS

DIVISION 16 - ELECTRICAL

SECTION 16225

MOTORS

06/04

PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 GENERAL REQUIREMENTS
- 1.3 SUBMITTALS
- 1.4 DESIGN REQUIREMENTS

PART 2 PRODUCTS

- 2.1 EQUIPMENT
  - 2.1.1 Efficiency
- 2.2 MOTOR TYPES
- 2.3 SIZES OF MOTORS
  - 2.3.1 Motors
  - 2.3.2 Electrically Driven Equipment
- 2.4 VOLTAGE RATINGS
- 2.5 TEMPERATURE RATING AND INSULATION
- 2.6 MOTOR HOUSINGS
- 2.7 MOTOR ENCLOSURES
- 2.8 SERVICE FACTOR
- 2.9 FACTORY TESTS

PART 3 EXECUTION

- 3.1 INSTALLATION
- 3.2 ALIGNMENT
- 3.3 ELECTRICAL TESTS
- 3.4 VIBRATION TESTS
  - 3.4.1 Vibration Analyzer
  - 3.4.2 Vibration Data

-- End of Section Table of Contents --

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SECTION 16225

MOTORS  
06/04

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NOTE: Delete, revise, or add to the text in this section to cover project requirements. Notes are for designer information and will not appear in the final project specification.  
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This section covers alternating current fractional and integral horsepower wattage motors rated up to 250 hp 190 kilowatt when used on a 120-, 208- or 240-volt, single-or three-phase, 60-hertz power source and up to 300 hp 225 kilowatt when used on a 480-volt and 600-volt, three-phase, 60-hertz power source.

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PART 1 GENERAL

1.1 REFERENCES

\*\*\*\*\*  
NOTE: The following references should not be manually edited except to add new references. References not used in the text will automatically be deleted from this section of the project specification.  
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The publications listed below form a part of this section to the extent referenced:

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 11 (1990; R 2000) Load Ratings and Fatigue Life for Roller Bearings

ABMA 9 (1990; R 2000) Load Ratings and Fatigue Life for Ball Bearings

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE Std 112 (1996) Standard Test Procedure for Polyphase Induction Motors and Generators

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS (2003) Acceptance Testing Specifications

for Electrical Power Distribution  
Equipment Systems

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 1940-1 (2003) Mechanical Vibration - Balance  
Quality Requirements of Rigid Rotors -  
Part 1: Determination of Permissible  
Residual Unbalance

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (2002) Motors and Generators

U.S. DEPARTMENT OF ENERGY (DOE)

DOE CI-1 (2001) How to Buy a Premium  
Energy-Efficient Electric Motor

1.2 GENERAL REQUIREMENTS

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**NOTE: If Section 16003 GENERAL ELECTRICAL  
PROVISIONS is not included in the project  
specification, applicable requirements therefore  
should be inserted and the following paragraph  
deleted.**  
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Section 16003 GENERAL ELECTRICAL PROVISIONS applies to work specified in  
this section.

1.3 SUBMITTALS

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**NOTE: Review submittal description (SD) definitions  
in Section 01330 SUBMITTAL PROCEDURES and edit the  
following list to reflect only the submittals  
required for the project. Submittals should be kept  
to the minimum required for adequate quality  
control. Include a columnar list of appropriate  
products and tests beneath each submittal  
description.**  
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The following shall be submitted in accordance with Section 01330 SUBMITTAL  
PROCEDURES in sufficient detail to show full compliance with the  
specification:

SD-02 Shop Drawings

Outline drawings for Motors shall indicate overall physical  
features, dimensions, ratings, service requirements, and weights  
of equipment.

SD-03 Product Data

Equipment and performance data shall be submitted for Motors  
consisting of use life, system functional flows, safety features,

and mechanical automated details. Curves indicating tested and certified equipment response and performance characteristics shall also be submitted.

Submit Manufacturer's Catalog Data in accordance with paragraph entitled, "Equipment," of this section

For Electric Motors rated over [7.5] [10] [15] [20 hp] [25] and those specified to meet a special vibration class in accordance with NEMA MG 1 indicate number of:

- Rotor Bars
- Stator Slots
- Rotational Speed
- Cooling Fan Blades
- Bearing Manufacturer
- Bearing Style
- Bearing Type
- Balls/Elements
- Commutator Bars
- Commutator Brushes
- SCR Firing Frequencies (for variable speed motors)

#### SD-07 Certificates

Certificates shall be submitted for the following tests showing conformance with the referenced standards contained in this section. Certified copies of previous test reports on identical motors may be submitted in lieu of factory test reports.

- Factory Test Results
- Efficiency
- Power-Factor
- Service Factor
- Temperature Rating
- Noise
- Full-Load
- Locked-Rotor
- Insulation Resistance
- Winding Resistance
- High-Potential Tests

#### SD-08 Manufacturer's Instructions

Manufacturer's Instructions shall be submitted for Motors including special provisions required to install equipment components and system packages. Special notices shall detail impedances, hazards and safety precautions.

### 1.4 DESIGN REQUIREMENTS

The following motor design data shall be provided prior to final turnover-number of motor rotor bars, Stator slots, rotational speed; number of cooling fan blades; RPM of motor; bearing manufacturer, bearing type, bearing style and number of balls/elements; number of commutator bars and commutator brushes; and SCR firing frequencies.

PART 2 PRODUCTS

2.1 EQUIPMENT

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**NOTE: For most general purpose motors the vibration levels listed in NEMA MG 1 and ISO 1940-1, Grade G6.3 are acceptable, however, industry has shown a marked increase in bearing life when initial vibration levels are reduced to under .10 in/sec peak-to-peak. This is 30 percent less than NEMA MG 1 and ISO 19401 G6.3 allows. ISO 1940-1, G2.5 would be appropriate on critical motors, high cost motors, and special application motors.**  
\*\*\*\*\*

Submit manufacturer's catalog data for motors and enclosures.

Design, fabrication, testing, and performance of motors shall be in accordance with NEMA MG 1 and ISO 1940-1 and shall meet or exceed the requirements as specified herein.

Testing and performance of polyphase induction motors shall be in accordance with IEEE Std 112, Method B.

Efficiency labeling shall be in accordance with NEMA MG 1.

Allowable balance limits shall be in accordance with ISO 1940-1, Table 1

2.1.1 Efficiency

Motors shall have efficiencies in accordance with the recommended levels specified in DOE CI-1.

Metric motor sizes shall be converted to English units by multiplying the kilowatt rating by 1.34 to determine the horsepower equivalent. The result shall be compared to the motor sizes listed in DOE CI-1 and the closest size listed to the horsepower equivalent shall be used for determining efficiencies.

2.2 MOTOR TYPES

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**NOTE: Energy efficient induction motors are required when the projected annual operating hours are greater than 2,000 and motors are rated 5 to 250 hp 3.7 to 185 kilowatt.**  
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[Motor shall be marked to show the index letter, which shall be the letter shown or a letter that indicates a higher efficiency.]

Motors shall be of the following types:

1/3 HP 250 watt rating and smaller, single phase - capacitor start

1/2 HP 375 watt and larger, three-phase - induction squirrel-cage type, NEMA Design B, having normal starting torque and low starting current

Motors shall be designed for across-the-line starting and shall be designed with torque characteristics to carry the specified rated starting load.

Motors shall have factory-sealed ball bearings with an L-10 rated life of not less than [30,000] [50,000] [80,000] [\_\_\_\_\_] hours in accordance with ABMA 9 or ABMA 11.

2.3 SIZES OF MOTORS

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**NOTE: When part load operation is required, specify efficiency and power factor at 1/2 and 3/4 as well as full load.**

**Horsepower Wattage ratings indicated are minimum sizes for guidance only and do not limit the motor size.**

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2.3.1 Motors

Motors shall be of a sufficient size for the duty to be performed and shall not exceed the full-load rating when the driven equipment is operating at specified capacity under the most severe loading conditions.

2.3.2 Electrically Driven Equipment

When electrically driven equipment differs from that indicated, adjustments shall be made to the motor size, wiring and conduit systems, disconnect devices, and circuit protection to accommodate the equipment actually installed, at no additional cost to the Government. Control and protective devices shall be in accordance with Section 16286 OVERCURRENT PROTECTIVE DEVICES."

2.4 VOLTAGE RATINGS

Motors shall have the following minimum voltage ratings:

<u>MOTOR SIZE</u>		<u>SERVICE</u>	<u>MOTOR VOLTAGE RATING</u>
<u>MOTOR TYPE</u>	<u>HORSEPOWER</u>		
Fractional horsepower, single-phase	1/3 and smaller	120/208-volt, 3-phase, 4-wire	115-volt, 60-hertz
Fractional and integral horsepower, 3-phase	1/2 and larger	120/208-volt, 3-phase, 4-wire	200-volt, 3-phase 60-hertz
Fractional and integral horsepower, 3-phase	1/2 and larger	480-volt, 3-phase, 3-wire	230/460-volt, 3-phase, 60-hertz
<u>MOTOR SIZE</u>		<u>SERVICE</u>	<u>MOTOR VOLTAGE RATING</u>
<u>MOTOR TYPE</u>	<u>WATTAGE RATING</u>		
Single-phase	250 and	120/208-volt,	115-volt,

<u>MOTOR TYPE</u>	<u>MOTOR SIZE</u>		<u>SERVICE</u>	<u>MOTOR</u>
	<u>WATTAGE</u>	<u>RATING</u>		<u>VOLTAGE RATING</u>
	smaller		3-phase, 4-wire	60-hertz
3-phase	375 and larger		120/208-volt, 3-phase, 4-wire	200-volt, 3-phase 60-hertz
3-phase	375 and larger		480-volt, 3-phase, 3-wire	230/460-volt, 3-phase, 60-hertz

2.5 TEMPERATURE RATING AND INSULATION

Motors shall be designed for continuous operation at the rated full load in an ambient temperature of [104 degrees F] [40 degrees C] [\_\_\_\_\_].

Insulation level shall be at least Class [B] [F] [\_].

2.6 MOTOR HOUSINGS

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**NOTE: For motors in outdoor applications and indoor applications in a harsh environment refer to Section 09960 HIGH PERFORMANCE COATINGS.**  
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The motor housing shall have a smooth surface in the vertical, horizontal, and axial directions at each bearing housing for attaching a magnet mounted accelerometer in order to monitor the motor vibration. The surface shall be on the bearing housing. The axial surface will be as close to the motor centerline as possible. The surface will have a finish of 63 micro-inch minimum. Diameter of finished surface shall be 2 inch 50 millimeter minimum and must be corrosion resistant. As an option sound disks can be used to meet the smooth surface requirement. Disk shall have a minimum thickness of 3/8 inch 9 millimeters.

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**NOTE: Good frequency response (required for accurate vibration data) is more related to placing the accelerometer magnet on a clean surface with a lubricant between the magnet and the surface than a highly polished surface. When using a stud mounted accelerometer, mounted directly to the disk or finished surface, minimum surface finish is 32 micro-inch.**  
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**NOTE: When using stud mounted accelerometers specify the hole size per the accelerometer's manufacturers instructions. Most threaded accelerometers use 1/4-28 or 10-32 thread size.**  
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**NOTE: Surface must be level to prevent**  
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accelerometer magnet from rocking.

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Surface shall be level within 1 degree or .001 inch 0.0254 millimeters.

The smooth surface shall be identified(using a label or plate) "Vibration data collection point - Do Not Paint"

2.7 MOTOR ENCLOSURES

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**NOTE: Motors with full enclosures require a way to effectively collect vibration data.**

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[Motors installed in indoor, clean, dry, nonhazardous locations shall have open-type drip-proof enclosures. Enclosures shall have a hinged access cover at each vibration collection point. Cover must be large enough to enable the placement of a magnet/accelerometer data collection instrument.]

[Motors installed in indoor, wet, nonhazardous locations shall have open splash-proof enclosures. Enclosures shall have a hinged access cover at each vibration collection point. Cover must be large enough to enable the placement of a magnet/accelerometer data collection instrument.]

[Motors installed in indoor, nonhazardous locations where it is necessary to protect the motor from dirt, moisture, chemical fumes, or other harmful ingredients in the surrounding atmosphere shall be the totally enclosed type, with either of the following:

[Totally enclosed, not fan-cooled, enclosures not equipped for cooling by means external to the enclosing parts. Enclosures shall have a hinged access cover at each vibration collection point. Cover must be large enough to enable the placement of a magnet/accelerometer data collection instrument.]

[Totally enclosed fan-cooled enclosures for exterior cooling by means of a fan or fans integral with the machine but external to the enclosing parts. Enclosures shall have a hinged access cover at each vibration collection point. Cover must be large enough to enable the placement of a magnet/accelerometer data collection instrument.]]

[Motors installed in outdoor, nonhazardous locations shall have waterproof enclosures.]

[Motors installed in hazardous locations for Classification I, [Division 1] or [Division 2] shall meet or exceed the minimum requirements of NFPA 70, Article 501.8. Type of enclosure shall be approved by the Contracting Officer prior to fabrication for the class and group of hazard in which the motors are located.]

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**NOTE: For motors installed in locations where weatherproof/waterproof enclosures are required specify accelerometers and data collection boxes consistent with other accelerometers and data collectors used at the facility.**

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Motors with weatherproof/waterproof enclosures shall have permanent accelerometers installed in the horizontal, vertical, and axial directions. The enclosure shall have a penetration installed to enable the accelerometer cables to be routed to outside the enclosure. A data collection box shall be mounted to the outside of the motor enclosure in a location that is easily accessible. Data collection box shall be rated NEMA 4R.

## 2.8 SERVICE FACTOR

Service factor of general purpose and other open ac motors shall be in accordance with NEMA MG 1.

Totally enclosed ac motors shall have a service factor of [1.15] [\_\_\_\_\_].

## 2.9 FACTORY TESTS

Factory test all motors in accordance with the requirements of NEMA MG 1. Polyphase induction motors shall be factory-tested in accordance with IEEE Std 112, Method B. Tests shall consist of measurements of voltage, frequency, speed, and current under no-load conditions; voltage, frequency, and current under locked-rotor conditions; and efficiency, noise, power factor, and thermal protection. Routine tests on wound-rotor induction motors shall include the measurement of wound-rotor open-circuit voltage across the slip rings under locked-rotor conditions. Electrical tests shall consist of winding resistance, insulation resistance, and high-potential tests. Submit certified copies of factory test results for approval prior to shipment from the factory. Previous test reports on identical motors are not acceptable for these tests.

## PART 3 EXECUTION

### 3.1 INSTALLATION

Motors shall be installed, aligned, and connected in accordance with the equipment manufacturer's instructions.

Motors shall be bolt mounted. Motor feet shall be coplanar within 0.001 inch 0.0254 millimeters. Base mounting points shall be accessible and adjustable to enable machine alignment. Motors over [7.5] [10] [15] [20] [25] hp shall have alignment jack bolts installed to enable alignment.

Alignment of motors shall be rechecked and adjusted as required after the motor has been in operation for not less than [48] [\_\_\_\_\_] hours.

### 3.2 ALIGNMENT

Before attempting alignment, the contractor will demonstrate that the load does not have any load/force imposed by the piping system. Minimum alignment values (below) are for motor and load at normal running temperatures. Values must be compensated for thermal growth. Limited movement of the motor or load (commonly known as bolt-bound) must be corrected to ensure alignment capability. Hold down bolts shall not be undercut in order to perform adjustment.

Shims shall be commercially die-cut, without seams or folds, and be made of corrosion resistant stainless steel. No more than four shims shall be used at any single point.

Motor and load shall be aligned to the following minimum specifications:

Speed(RPM)	Close-Coupled Offset (mils)	Close-Coupled Angle(mils/in.)	Spool Piece Angle (mils/in. @ coupling pt.)
600	6.0	2.0	3.0
900	5.0	1.5	2.0
1200	4.0	1.0	1.5
1800	3.0	0.5	1.0
3600	1.5	0.4	0.5
7200	1.0	0.3	0.4

[Motor/load alignment shall be performed under the direction of the manufacturer's representative.]

Final alignment settings shall be provided as part of the final test data.

### 3.3 ELECTRICAL TESTS

Perform continuity test on all phases.

Perform insulation resistance and polarization index test on each phase of motor. Insulation tests on 480-volt and 600-volt motors shall be conducted using a 1000-volt insulation test set. Insulation tests on motors rated less than 480-volts shall be conducted using 500-volt insulation test set.

Test data shall include the location and identification of motors and megohm readings versus time. Test data shall be recorded at 15, 30, 45 seconds, and in 1 minute increments thereafter up to 10 minutes. Megohm readings shall not be less than 25 megohms for each phase and each phase reading shall be within 10 percent of the other two.

Perform inspections and test procedures on all motors in accordance with NETA ATS 7.15.1 for rotating machinery, AC motors.

Calculate the polarization index of each phase by dividing the 10 minute reading by the 1 minute reading. The polarization index shall be greater than 1.25. Any values lower shall be rejected and the motor returned to the factory.

### 3.4 VIBRATION TESTS

#### 3.4.1 Vibration Analyzer

Contractor shall use an Fast Fourier Transformer (FFT) analyzer to measure vibration levels. It shall have the following characteristics: A dynamic range greater than 70 dB; a minimum of 400 line resolution; a frequency response range of 5 Hz-10 KHz(300-600000 cpm); the capacity to perform ensemble averaging, the capability to use a Hanning window; auto-ranging frequency amplitude; a minimum amplitude accuracy over the selected frequency range of plus or minus 20 percent or plus or minus 1.5 dB.

An accelerometer, either stud-mounted or mounted using a rare earth, low mass magnet and sound disk(or finished surface) shall be used with the FFT analyzer to collect data. The mass of the accelerometer and its mounting shall have minimal influence on the frequency response of the system over the selected measurement range.

### 3.4.2 Vibration Data

Vibration data shall be collected in the axial, vertical, and horizontal direction for each motor bearing.

Two narrowband spectra for each data collection point shall be obtained in the following manner: For all machines regardless of operating speed, a 5 to 500 Hz spectrum with a minimum of 400 lines of resolution shall be obtained. An additional spectrum of 5 to 2500 or 5 to 5000 Hz shall be acquired for machines operating at or below 1800 RPM or greater than 1800 RPM, respectively.

Vibration limits shall conform to the following:

<u>Frequency Range (CPM)</u>	<u>Vibration limit (inch/sec)</u>
0.3xRPM to 0.8xRPM	0.04
0.8xRPM to 1.2xRPM	0.75
1.2xRPM to 3.5xRPM	0.04
3.5xRPM to 120,000cpm	0.03

Final test reports shall be provided to the Contracting Officer. Reports shall have a cover letter/sheet clearly marked with the System name, Date, and the words "Final Test Reports - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

-- End of Section --