

Specification for Squirrel Cage Induction Motor

(Non Cryogenic)

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Project Name : SK E&S Liquid Hydrogen Refueling Station Project

Owner : SK E&S

Site : South Korea

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1. GENERAL

1.1 Scope

This specification covers the medium and low voltage, squirrel caged induction motors used for the rotating equipment to be installed at Liquid Hydrogen Refueling Station.

Special motors such as for electric fans, ventilators, air conditioners, machine tools, powered hand tools, sirens, testing of experimental equipment or controllers are excluded from the scope of this specification. Motor for cryogenic pumps shall be separately specified.

1.2 Units

Unless otherwise specified, international SI units shall be used for all drawings and documents to be submitted by the manufacturer.

1.3 Manufacture's drawing and documents

Drawing and documents shall be submitted according to the list of vendor document and schedule. Purchaser's approval for such drawings and documents shall not relieve manufacturer of his responsibility to meet all requirement of the purchase order.

2. STANDARDS AND REGULATIONS

Induction motors shall be designed, constructed, tested and performed in conformity with the following standards and regulation :

1) National Electrical Manufacturers Association (NEMA)

NEMA MG-1 (2016): Motors and generators

NEMA 250 (2018): Enclosures for Electrical Equipment (1000 Volts Maximum)

2) International Electro-technical Commission (IEC)

IEC 60034-1 (2017): Rotating electrical machines – Part 1: Rating and Performance

IEC 60034-5 (2020): Rotating electrical machines – Part 5 : Degrees of protection provided by the integral design of rotating electrical machines (IP code) – Classification

IEC 60034-8 (2014): Rotating electrical machines – Part 8: Terminal markings and direction of rotation

IEC 60034-9 (2007): Rotating electrical machines – Part 9: Noise limits

IEC 60034-12 (2016): Rotating electrical machines – Part 12: Starting performance of single-speed three-phase cage induction motors

IEC 60034-14 (2018): Rotating electrical machines – Part 14: Mechanical vibration of certain machines with shaft heights 56mm and higher – Measurement, evaluation and limits of vibration severity

IEC 60034-18-1 (2010): Rotating electrical machines – Part 18: Functional evaluation of insulation systems – General guidelines

IEC 60034-30-1 (2014): Rotating electrical machines – Part 30-1: Efficiency classes of line operated AC motors (IE code)

IEC 60044-1 (2003): Instrument Transformers – Part 1: Current Transformers

IEC 60079-0 (2017): Electrical apparatus for explosive gas atmospheres – Part 0: General requirements

IEC 60079-1 (2014): Electrical apparatus for explosive gas atmospheres – Part 1: Flameproof enclosures “d”

IEC 60079-2 (2014): Electrical apparatus for explosive gas atmospheres – Part 2: Equipment protection by pressurized enclosure “p”

IEC 60079-7 (2017): Electrical apparatus for explosive gas atmospheres – Part 7 : Increased safety “e”

IEC 60079-10-1 (2020): Electrical apparatus for explosive gas atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres

IEC 60079-11 (2011): Electrical apparatus for explosive gas atmospheres – Part 11: Equipment protection by intrinsic safety “i”

IEC 60079-14 (2013): Electrical apparatus for explosive gas atmospheres – Part 14: Electrical installations design, selection and erection

IEC 60079-15 (2017): Electrical apparatus for explosive gas atmospheres – Part 15: Type of protection “n”

IEC 60529 (2013): Degrees of protection provided by enclosures (IP Code)

3) American National Standards Institute (ANSI)

ANSI C50.41 (2012): Polyphase induction motors for power generating stations

4) API (American Petroleum Institute)

API RP 505 (2018): Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class 1, Zone 0, Zone 1 and Zone 2

5) The Institute of Electrical and Electronics Engineers, Inc. (IEEE)

IEEE 242 (2001): IEEE recommended practice for protection and coordination of industrial and commercial power systems

IEEE 112 (2017): IEEE Standard Test Procedure for Polyphase Induction Motors and Generators

IEEE 522 (2004): IEEE Guide for Testing Turn Insulation of Form-Wound Stator Coils for Alternating-Current Electric Machines

IEEE C57.13 (2008) : IEEE Standard Requirements for Instrument Transformer

6) Korean Industrial Standards (KS)

KS C 4202 (2020): Low voltage three-phase squirrel-cage induction motors for general purpose

KS C 4203 (2018): High voltage three-phase squirrel-cage induction motors for general purpose

3. GENERAL CONDITIONS OF USE

3.1 Supply conditions

3.1.1 Squirrel cage electric induction motors designed to be supplied with :

- 1) Low voltage for up to 149.2kW (200HP) motors : 440V, 3Ph, 60Hz
- 2) Medium voltage for motors above 149.2kW (200HP) : 6.6kV, 3Ph, 60Hz
- 3) Space heater, if applied : 220V, 1Ph, 60Hz

3.1.2 Each motor shall supply its power rating and normal torque without exceeding the overheating limits specified in the standards. These conditions remain mandatory :

- 1) Plus or minus 10 percent of rated voltage with rated frequency.
- 2) Plus or minus 5 percent of rated frequency with rated voltage.
- 3) A combined Variation in voltage and frequency of plus or minus 10 percent (sum of absolute value) of the rated values, provided the frequency variation does not exceed plus or minus 3 percent of rated frequency.
- 4) Motors shall be capable of direct full voltage starting or autotransformer starting or soft starter starting.

3.2 Service conditions

Motors are required to run in continuous operation for periods of several months. They shall also be capable of starting after being shut down for a month. Service conditions shall take into account climatic conditions, unless otherwise specified.

3.3 Installation conditions

In all cases, motor enclosure shall be suitable for service at the location where the motor is installed. The explosion proof protection shall be suitably provided as per the hazardous area classification indicated on data sheet.

3.4 Climatic and environment conditions (HOLD)

3.4.1 Air temperature

- | | |
|------------|-----------|
| 1) Highest | : 38.8°C |
| 2) Lowest | : -13.5°C |
| 3) Mean | : 14.5°C |

- 3.4.2 Atmospheric pressure average : 101.57kPa.a
- 3.4.3 Wind mean velocity : 2.2m/sec
- 3.4.4 Design velocity : 45 m/sec @ 10m elevation, 10minutes average
- 3.4.5 Outdoor design conditions relative humidity: 2 to 90%
- 3.4.6 Altitude : +3.16m, from sea level
- 3.4.7 Ambient conditions : salt laden air

4. GENERAL CONSTRUCTION REQUIREMENTS

The general requirements for construction are applicable to all types of enclosure. Special requirements are indicated in Section 5.

4.1 Casing structure

4.1.1 Frame

Frames are made of cast iron or welded steel plate. Small frames may be made of pressure cast aluminium. A grounding terminal is provided on the frame.

4.1.2 Cooling Disposition

Generally, cooling fluid used is ambient air. A self-contained cooling method i.e. ventilated ribbed frame or tube type frame forming air-air exchanger, shall be preferred.

If special cooling method is applied, it shall be approved by Owner and/or Purchaser before manufacturing.

4.2 Bearings

4.2.1 Bearings for all motors 149.2 kW (200HP) or less, shall be antifriction ball type. Motors above 149.2 (200HP) to 373 kW (500HP) may use antifriction ball or sleeve bearings at manufacturer's option. Bearings for all motors above 373 kW (500HP) will be sleeve bearings.

4.2.2 All motors that are supplied with ball or roller bearings shall have the appropriate AFBMA number stamped on a corrosion proof name plate attached to the motor. The design of these bearing shall be based on AFBMA standard and shall have a design life of not less than 100,000hours based on the bearing manufacture's rating tables for anticipated loading conditions.

4.2.3 Bearing temperature rise shall be limited to a 40°C rise over a 40°C ambient for either self or forced lubricated bearing. For motors 1119 kW (1500HP) or higher, the temperature shall be measured by RTD or thermo couple in the bearing metal on each drive and non drive side.

4.2.4 The bearing ends of outdoor type motors shall be designed and constructed to prevent water creeping along the shaft not to motor housing.

4.2.5 The rotor end play of horizontal-shaft motors provided with sleeve bearings shall be according to NEMA MG 1-20.29, unless otherwise specified.

4.2.6 Bearings for vertical-shaft motors shall be designed to carry not only the thrust of the rotor but also thrust of the load

4.2.7 One or both bearings shall be insulated to prevent flow of shaft current, unless otherwise protected by other means.

4.3 Bearing lubrication

Antifriction bearings shall be lubricated by grease, with readily accessible grease inlet and outlet plugs provided in the housings to allow regreasing from the exterior while motor is in service. Ring oil lubrication systems may be furnished for severe duty applications of ball and roller bearing combinations.

4.4 Shaft

Shafts are made of steel and to be designed to withstand without deformation stresses due to permanent or transient operating loads in the specified conditions of use. The shaft voltage shall not exceed 0.3V when measured between shaft and casing of motors operated with no load at rated voltage and rated frequency.

4.5 Rotor

Rotor shall be squirrel cage laminated. After fabrication, the entire rotor assembly shall be coated with a suitable corrosion resistant finish.

4.6 Magnetic circuit

Magnetic circuit consists of insulated plates tightly bolted together so as to withstand mechanical stresses in the specified conditions of use.

4.7 Resistance Temperature Detectors

Resistance temperature detectors(Platinum) rated 100 ohms at 0°C, shall be provided in the motor slots, if applied or by request of Purchaser. RTD leads shall be routed in protected metallic conduit to a terminal block in a connection box separated with the main power terminal box. The conduit and connection box shall be provided by Manufacturer.

4.8 Stator windings

Stator windings are made of copper carefully with material in conformity with the insulation of class F and the rating of machines shall be based on a class B temperature rise for all parts of the machine windings when operating at rated power, rated voltage, rated frequency and having due regard for the environmental conditions specified in 3.4. The stator winding and end turns shall be adequately braced to withstand repeated full voltage starting. Windings shall be treated with the global impregnation method (vacuum, then pressure).

4.9 Earthing

Each motor in NEMA frame size shall be equipped with earthing terminations suitable for the mounting of M10-grounding bolts on the motor casing to allow connection of earthing conductor. Earthing points shall be protected against corrosion and designed to ensure that effective electrical and mechanical connections can be made. At least two separate grounding points at diagonally opposite ends on the motor casing shall be provided for medium voltage motors or motors over 100kW, while one grounding point for low voltage motors shall be furnished. The earthing symbol or legend shall identify this device. The Supplier's certified drawings shall show the location and type of grounding provisions for each frame size for Purchaser's approval.

4.10 Ventilation

External fans are made of corrosion resisting material to be efficiently protected against corrosion. Fan covers are designed with the same degree of mechanical strength as the frame. External fans are installed at the opposite end to the coupling and shall blow air towards the coupling.

Motors with low speed resulted by speed control etc. may be equipped with forced ventilation by means of a motor-fan set. In this case, the principle and the design of auxiliary equipment of forced ventilation system, are subject to approval of Purchaser's.

4.11 Terminal boxes

4.11.1 Terminal boxes are amply dimensioned larger than ANSI C50.41 type II terminal housing and have the protection degree of watertight type 4 enclosures specification in NEMA standard 250 and mechanical strength, as the frame : they can be oriented to all directions in every 90°.

4.11.2 Terminal boxes are equipped with seal female pipe thread for connecting the conduit or packing cable gland. Besides the connection terminals, they shall be equipped with one grounding terminal.

4.11.3 Terminal boxes shall be provided with drain holes having removable threaded plug and shall have gasket cover secured by non-corroding bolts or screws.

4.11.4 For medium voltage motors, connections to platinum probes and heating resistors shall be made through separate terminal boxes.

4.11.5 When space heater, temperature detectors and thermocouples are included, each separate terminal boxes shall be have provision for conduit connection of not less than 22mm NPT thread size.

4.11.6 A terminal box of sturdy construction shall be provided with ample space (in case of MV motor, inner space of terminal box : minimum 500mm required between terminals and bottom hole) for

connecting the cable(s) and constructed in such a way that the cable can be connected without a requirement for pulling the cable through a fixed opening in the box.

4.11.7 The size and type for entry hole of terminal box for MV/LV motor is as follows to connect the power cable(s). And terminal lugs shall be manufactured with this consideration too. The size and type for entry hole of terminal box of MV/LV motor will be provided later according to the cable size calculation.

4.11.8 Gland plates and glands to be used for single core cables shall be made of nonmagnetic materials.

4.11.9 Terminal box bottom side should be fabricated to installed inlet and outlet conduit

4.12 Differential and surge protection

4.12.1 Motors over 1000kW (1340HP) shall be provided with differential and surge protection device. Manufacturer shall provide all wiring or bus work necessary for motor connections. A separate terminal box on or within the motor enclosure for mounting the equipment shall be provided.

4.12.2 CT's shall be provided for self-balancing type differential protection. The CT's shall be equipped in the motor terminal boxes so that the motor leads U1 and U2 pass through one CT, leads V1 and V2 through the second CT and W1 and W2 through the third CT, U2, V2, and W2 are then connected together for the "Wye" point.

4.12.3 Current transformer shall be dry or molded (complete coating of thermosetting synthetic resin) type which so rated and designed that they shall not sustain any damage due to through fault.

4.12.4 Current transformers for differential protection shall be Class PX in accordance with IEC 60044 or X Class in accordance with ANSI(IEEE std. C57.13)

Manufactures shall submit, for differential current transformers, the following information:

- Rated primary current
- Rated turn ratio (maximum error 25%)
- Rated knee point Voltage
- Maximum exciting current at the rated knee point and/or at a stated percentage
- Maximum resistance of secondary winding at a temp. of 75 °C
- Rated resistive burden
- Magnetizing (excitation) curve
- Error (rotation and phase displacement)

4.12.5 Current transformer shall be dry or molded (complete coating of thermosetting synthetic resin) type which so rated and designed that they shall not sustain any damage due to through fault. Also, CT shall be sized to carry full load current continuously and which so rated and designed that they shall not sustain any damage due to through fault.

4.13 Bolting

Internal, external bolting which is not protected by the global impregnation shall be of stainless steel, complying with the climatic conditions of 3.4.

4.14 Identification and name plates

Nameplates shall be clearly stamped with information as described in Part 20 of NEMA MG 1-20.25 and in addition the following :

- Direction of rotation
- Motor weight
- Connection diagram
- Temperature class according to IEC 60079
- Zone classification according to IEC 60079

Rating nameplates of each motor shall be fixed bearing all information.

Separate name plate indicating Item No. each motor with the dimension of 50 x 30mm shall be fixed near the rating plate.

Motors installed in hazardous areas are equipped with the regular nameplates required for explosion proof equipments.

All identification or regular nameplate shall be made of non-corrosive stainless steel with not less than the minimum information called for the NEMA standard MG-10.38 or KS.

4.15 Space heater

Medium voltage motors as well as motors to be installed at humidity atmosphere shall be equipped with space heater which is to be operated when motors are stop, in order to prevent moisture condensation. The temperature of these space heater is to be in the limit of temperature required for the explosion proof class of the motor. The heater shall be controlled by the thermostat or similar device to be protected from over heat. The heater control system consist of power contactor shall be equipped inside local panel without purchaser's external control device.

4.16 External protection

Motors in principle shall be of totally enclosed fan cooled type. Weather protected type II is to be applicable in case the motor will be installed at out door location.

The enclosures shall protect the motor bearings against the entrance of dust and moist air. The air intake filters shall be galvanized steel frames.

4.17 Explosion proof enclosure

Motors to be installed at explosive hazardous area shall be of flame proof or pressurized explosion protection type and shall be conformity with the IEC 60079. For motors to be installed at hazardous area, the appropriate type can be used with the prior approval of purchaser's.

The temperature indicated on casing shall be lower than the spontaneous ignition temperature of the surrounding hazardous atmosphere depending on the proposed installation. Explosion-proof type motors are selected for the specified hazardous gas group which will be indicated on the data sheet.

Manufacturer should submit the certification and inspection report to KOSHA or KGS for approval to purchaser before FAT.

4.18 Protection degree of Motor enclosure

The motor located in non-hazardous outdoor area shall be IP55(Minimum). Outdoor electric motors which are installed in dealing with the sea water(seawater intake, supply and deluge area) shall be water proof (water tight type: IP55). Also, if they are located in hazardous area, the installation method shall meet the term 4.17.

4.19 Inspection for safety certification

The safety certification shall be obtained from KOSHA, KGS or KTL under article 34 of Korea industrial safety health law.

4.20 Lifting device and base

4.20.1 Lifting device

Lifting device shall be provided on all motors at balance point. Drilled and tapped holes in the enclosure case shall be dead-ended or permanently sealed. All motors shall have eye bolts, lifting lugs or extension pieces for hoisting. The IP rating of the motor shall be maintained regardless of any such eye bolts or lugs. Drawings shall be furnished by manufacture for information in construction of a motor lifting device and location of lifting points.

4.20.2 Base

Motors shall be provided with a base, anchor and other devices necessary for adjustment. The motor base and adjusting screws shall be made of anticorrosive material.

5. REQUIRED CHARACTERISTICS

The technical requirements and ratings of the motors shall comply with IEC 60034.

5.1 Starting, acceleration and operation

- 5.1.1 Motor shall operate satisfactorily during starting, voltage dips of short duration and automatic transfer from a normal to a reserve power supply in accordance with ANSI C50.41 section 15.
- 5.1.2 Motors shall be capable of starting from rest and accelerating the load with 80% of motor name plate voltage applied to the motor terminals. When this requirement makes necessary the use of an increased size of motor, the Supplier shall state so in his proposal.
- 5.1.3 Squirrel cage induction motors shall be NEMA design B with normal starting torque unless other characteristics are required by the driven equipment. The locked rotor current of all motors shall not exceed 6 times full-load current when tested at rated voltage and frequency.
- 5.1.4 Unless other characteristics are required by the driven equipment, single phase motor shall be split-phase or capacitor start with locked rotor kVA Code G or H.

5.2 Noise level

Maximum permissible noise level is the value defined, by IEC 60034- 9.

By extension, the maximum value shall be taken into account. Without power limitation, for the rpm considered.

5.3 Vibration

- 5.3.1 Balancing of rotating parts shall correspond to the maximum permissible total vibration amplitude defined by IEC 60034-14
- 5.3.2 By extension, maximum values shall be maintained for power rating higher than those indicated by IEC Rules.
- 5.3.3 Motors shall be capable of overspeed operation, under emergency conditions, accordance with NEMA standard MG 1-20.13

5.4 Motor Efficiency

For low-voltage 3-phase induction motors, the motor efficiency shall be applied IE3 (Premium Efficiency) as minimum in accordance with IEC 60034-30 referred to Attachment #3.

5.5 Torque

- 5.5.1 For motors up to and including 500kW and having the speed higher than 1500rpm
 - Locked rotor torque shall be at least equal to full load torque.

- Pull-up torque during starting shall be at least equal to full load torque.
- Breakdown torque should be at least equal to twice the full load torque.

5.5.2 For motors of larger than 500kW or with the speed lower than 1500rpm, values of locked rotor torque, pull-up torque and breakdown torque shall be adapted depending on load torque of the driven machine and on permissible voltage drop in the system.

5.6 Number of starts

The motor shall be designed and manufactured in accordance with NEMA MG1-20.12 requirements for successive starts, to start and accelerate the driven load as defined on the driven load speed-torque curve.

5.7 Locked rotor

All the motors shall be capable of enduring the required locked rotor current for the specific start up duration as per the speed- torque characteristics of the connected load. Minimum duration which motors will be capable of withstanding full voltage with locked rotor is (when starting hot) :

- 4 seconds for low voltage motors
- 6 seconds for medium voltage motors

5.8 Other characteristics

Taking into account that above required characteristics have priority, motors shall have:

- Lowest possible starting current surges.
- Highest possible power factors
- Highest possible efficiencies as per section 5.4.

5.9 Painting

More than two coat of painting shall be given with anti-rust paint. All the surface to be painted should be thoroughly cleaned up mil scale, rust and foreign materials, color of the finishing coat shall be Munsell No. N 7.5. The manufacturer shall supply the sufficient quantity of touch-up paint.

5.10 Motor service factor

Motor Shall be complied with the provisions of the standard NEMA MG 1-12.51 incase the specification of the motor are not mentioned by client. The service factor shall be utilized for special situations where loading will exceed full-load rating in short-time emergency condition and not for continuous operation. (minimum standard 1.0 service factor)

5.11 Motor starting

5.11.1 The starting current at full voltage shall not exceed 700% of rated current for LV motors, 600% of rated current for MV motors.

5.11.2 During motor starting, the voltage level at the motor terminals should be maintained minimum 80% of rated voltage.

5.12 Insulation

5.12.1 Motor windings shall be suitably treated so that the insulation is moisture resistant and adequate for exposure to severe atmospheric conditions. Motor shall have fully sealed insulation system as described in NEMA Standard MG1-1.27.2

5.12.2 The stator insulation shall be vacuum pressure impregnated after the stator has been wound, wedged, connected and the bracing system installed.

5.12.3 The strand insulation and turn insulation shall be designed to withstand excessive switching surges caused by open-close operation of vacuum circuit breaker. The stator winding insulation shall be designed to withstand an electrical impulse voltage within the envelope defined in Fig. 1 of IEEE 522.

6. Motor Data

The following motor design data shall included:

- 1) Nameplate data as per section 4.14.
- 2) Locked-rotor, pull-up and breakdown torques (speed vs. torque curves)
- 3) Efficiency at $\frac{1}{2}$, $\frac{3}{4}$, and full load
- 4) Power factor at locked-rotor, no load, $\frac{1}{2}$, $\frac{3}{4}$, and full load
- 5) Current at locked-rotor, no load, $\frac{1}{2}$, $\frac{3}{4}$, and full load
- 6) Sub-transient reactance, X"d
- 7) Open-circuit time constant
- 8) Acceleration time based on specific load condition at 100% Vn and at 80% Vn
- 9) Motor LRA and PF at 100%Vn and at 80%Vn
- 10) Motor curves: Motor and Load Speed-Torque, Motor Speed-Current, Speed-Power Factor,
- 11) Time-Current & Thermal Limit Curve at 100% Vn and at 80% Vn
- 12) Hot and cold safe stall time at 100% Vn and at 80% Vn
- 13) Maximum number of starts per hour and minimum time between starts at motor cold & at motor hot
- 14) Motor cool time constant when motor running and when motor stopped
- 15) Winding RTD type, recommended RTD trip and alarm temperature settings
Bearing RTD type, recommended RTD trip and alarm temperature settings

- 16) Maximum and recommended Power Factor Correction Capacitor rating
- 17) Rotor inertia GD2 in N.m2 or WK2 in lb.ft2
- 18) Bearing reference data including part numbers
- 19) Cooling data and lubrication requirements if applicable
- 20) Installation, maintenance and operating instructions, including drawings, illustrations, complete parts lists
- 21) Winding data sufficient to permit coil manufacture
- 22) Rotor removal method
- 23) Expected sound power level at no-load

7. TESTS AND VERIFICATIONS

Test shall be in accordance to those described by NEMA MG 1-20, ANSI/IEEE std. 112 and IEEE 522. Motors are accepted if the results of the series tests are in conformity with the characteristics indicated in the specifications within the tolerance limits.

There are three types of tests :

7.1 Manufacturer tests

These are the tests carried out on the different types of motors which the manufacturer performs on prototypes or during fabrication, for which he provides an "As built" certificate or test report.

7.2 Shop acceptance tests

Shop acceptance tests are witnessed by a owner and/or purchaser or its representatives. They are normally restricted to :

- 1) Visual inspection
- 2) Dielectric tests, high potential test
- 3) Stator winding resistance measurements
- 4) Measurement of no-load operating point
- 5) Measurement of locked rotor current
- 6) Temperature rise test

Additional tests may be required, in this case they will be indicated In the purchase order.

A test report shall be made of these acceptance tests.

Temperature rise and power factor and efficiency at 1/2, 3/4 and 4/4 load tests can be carried out on a selected motor as sampling in a serial of motors at the request of purchaser's inspector.

7.3 Field tests

Before being placed in service each motor shall be checked, if possible not coupled to driven machine, for :

- 1) Insulation,
- 2) Direction of rotation

7.4 Routine Test

Each motor shall be given a routine (commercial) test to demonstrate that the motor is free from mechanical and electrical defects. Test methods and reporting shall follow ANSI/IEEE std.112, and NEMA MG-1-20.26. Testing shall include :

- 1) Measurement of no-load current (each phase)
- 2) Measurement of nominal no-load speed
- 3) Determination of locked-rotor current
- 4) High-potential test
- 5) Measurement of winding DC resistance
- 6) Measurement of vibration
- 7) Bearing inspection as per API std.541, section 4.3.2.1.j

7.5 Complete Test

Unless otherwise specified, motors rated 1000hp and larger shall be given the following tests. Where it can be demonstrated to the satisfaction of Purchasor's representative that an identical motor design has previously been built and tested, these tests may be omitted. Where a number of identical motors are supplied, and when approved by the Purchasor's representative, testing shall be done on one motor only. These tests shall include :

- 1) Determination of efficiency and power factor at $\frac{1}{2}$, $\frac{3}{4}$, and full load
- 2) Determination of locked-rotor power factor
- 3) Determination of full-load current and slip
- 4) Determination of locked-rotor and breakdown torque
- 5) Temperature at motor full load
- 6) Bearing temperature rise at motor full load
- 7) Vibration readings during load test

Performance shall be determined by methods stated in ANSI/IEEE std. 112, except Efficiency Test Method A. The method used in determining efficiency shall be stated in the test report. Heat run test shall be conducted in accordance with section 6 of ANSI/IEEE std.112. Actual loading method (e.g., method B(dynamometer method), method C(pump-back method) and method E (input measurement method) shall be used for making the heat run test. Other loading methods (e.g., dual-frequency

method, forward Stall Test and Reduced Voltage Rated Current method) shall be approved at time of purchase order by the Purchaser's representative. The testing shall continue until four equal subsequent temperature readings are obtained over a one hour period after the motor stator has reached full load operation temperature.

7.6 Stator Test

When specified, surge comparison test shall be made of turn insulation in the fully wound stator just prior to making up coil-to-coil connections per IEEE std. 522. Peak voltage shall not exceed the motor rated RMS voltage. When specified, winding immersion test shall be performed per NEMA MG-1-20.18 for motor stators equipped with sealed insulation systems.

8. LIMITS OF SUPPLY

The responsibility of the manufacturer of the motor covers the complete machines in proper working order. Unless otherwise specified in the provisions of the specification, supply of a motor is limited to :

- 1) Terminal boxes included,
- 2) Bare shaft end equipped with shaft key, bolt and washer.

Specification may also include auxiliary equipment under the responsibility of the manufacturer and in the limit of his supplies, such as :

- 1) Lubrication system
- 2) Air filters and ventilation and/or pressurizing equipment
- 3) Mounting slides
- 4) Thermal sensor equipped with junction box
- 5) Space heater
- 6) Complete accessories of control and regulation for pressurized enclosure of motor
- 7) Lifting device and base
- 8) Drain hole
- 9) Accessory terminal boxes
- 10) Ground terminal lug
- 11) Name plate
- 12) CT for Self-balancing protection 87 relay, above 1000kW motor

9. MANUFACTURER GUARANTEE

The following characteristics are in the scope of guarantee of the manufacturer:

- 1) Power
- 2) Torque
- 3) Efficiency
- 4) Power factor
- 5) Speed
- 6) Starting current
- 7) Noise level
- 8) Vibration limit