Global Leader

INDUCTION MOTOR APPLICATION GUIDE

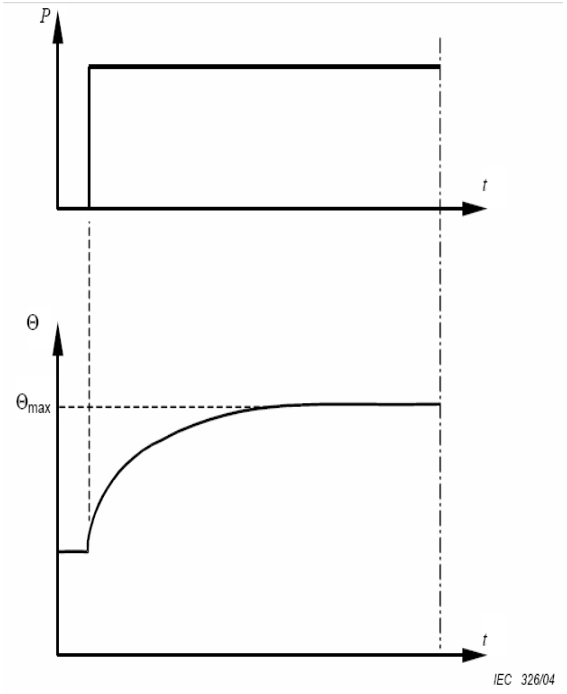
ROTATING MACHINERY DESIGN DEPT

HYUNDAI
HEAVY INDUSTRIES CO.,LTD.

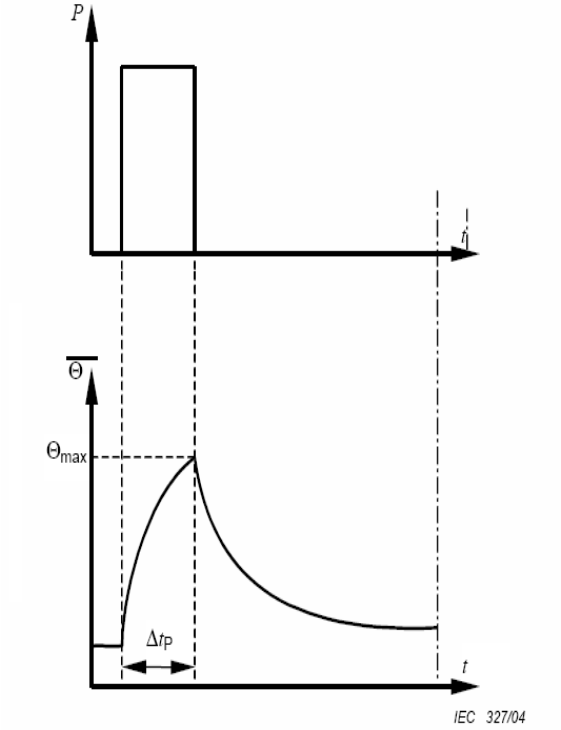
Contents

1. Duty cycle

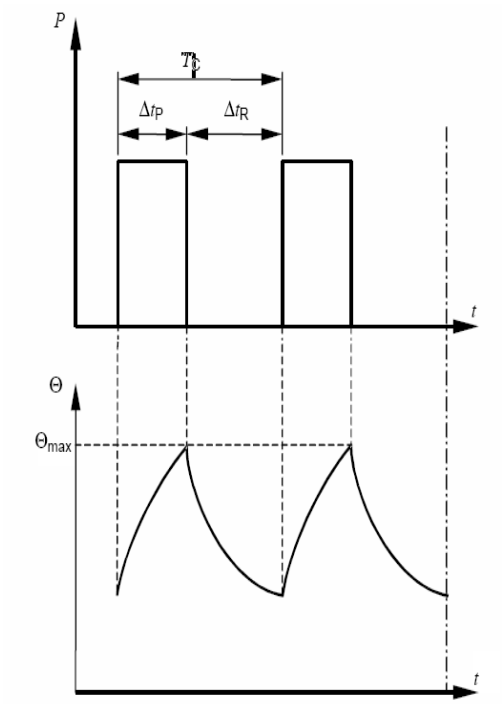
- The rating shall be informed by customer so that the size of motor can be decided correctly.
- If no designation is stated, rating for continuous applies.



S1:Continuous



S2:Short time



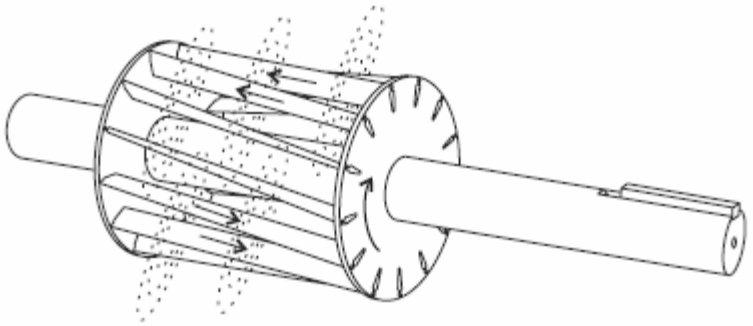
S3:Periodic

For example

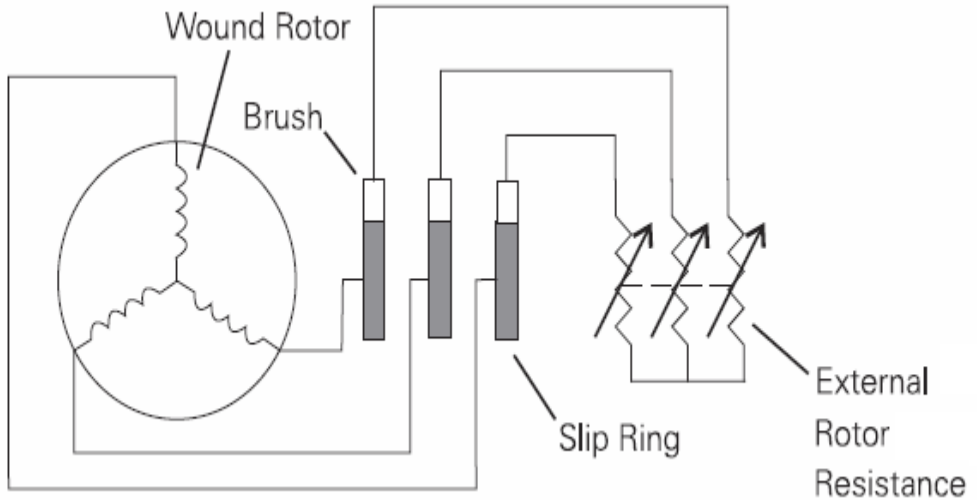
Ratings	Duty type	Motor size
1000kW	S1-Continuous	450fr
1000kW	S2-30min.	400fr

2. Rotor

- There are two kinds of rotor types in 3-phase induction motor.
- In case of wound rotor motor, the external rotor resistance is optional item.



Squirrel Cage Rotor



Wound Rotor

Features of each rotor type

	Squirrel Cage rotor	Wound rotor
Speed control	No ('Yes' with inverter)	Yes
Starting performance	Low starting toque High starting current	High starting torque Low starting current
Maintenance	Good	Bad
Cost	Low	High

3. Insulation class

- The insulation class is the thermal class of insulation system applied for winding insulation.
- HHI's standard insulation class is F class
- The higher insulation class like H class is non-standard of HHI.

Insulation class table

	Class B	Class F	Class H
Temperature limit	130 deg.C	155 deg.C	180 deg.C

4. Temperature rise & Ambient temperature

- Temperature rise of winding can be determined by resistance method or by embedded temperature detector.

Temperature rise table

	Class B	Class F	Class H
Resistance method	80 deg.C	105 deg.C	125 deg.C
Embedded temperature detector	90 deg.C	115 deg.C	135 deg.C

Amb.:40 deg.C

- The motor size is determined depending **not** on the **temperature** value **but** on the **temperature rise** value. So, If the ambient temperature increase, then the temperature rise shall decrease by the same degree.

	Class B		
Ambient	Temperature rise	Temperature	Motor size
40 deg.C	80 deg.C	120 deg.C	Smaller
50 deg.C	70 deg.C	120 deg.C	Larger

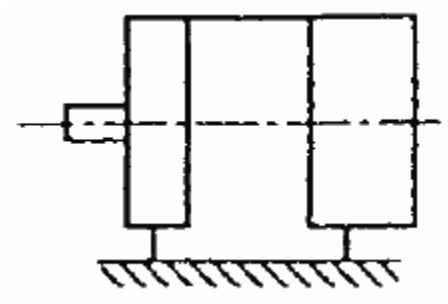
- So, even with the same temperature class, the motor sizes can be different depending on the ambient temperature.
- In case of water cooled type, 25 deg.C of cooling water match 40 deg.C of cooling air.

- **De-rating Factor for Cooling Air Inlet Temperature**

No.	Type Factor / Ambient Temp.	IC411,IC611 Cooling	IC01 Cooling
1	40℃	1.0	1.0
2	45℃	0.95	0.96
3	50℃	0.9	0.91
4	55℃	0.84	0.86
5	60℃	0.78	0.81

5. Construction

- Horizontal Constructions



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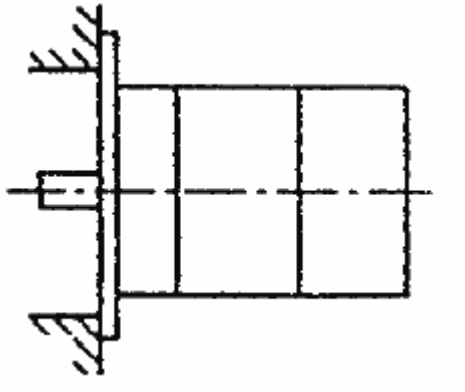

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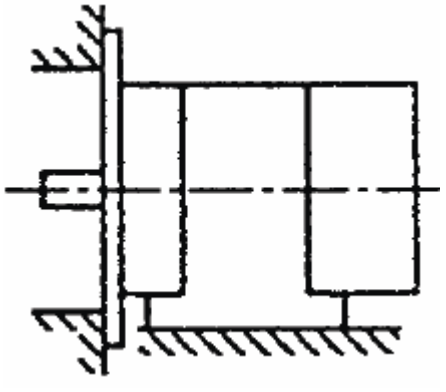

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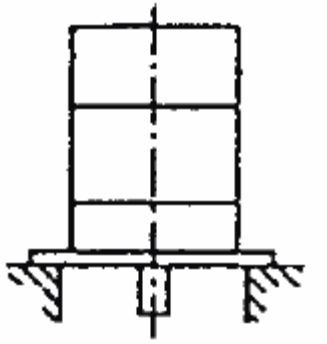
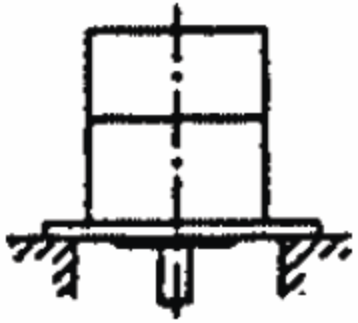
- Vertical Constructions



V1: Flange is a part of endshield



V10: Flange is a part of frame

6. Environment

- First of all, the enclosure should be selected considering the environment.
- This is an information for additional precaution. (Ex, dust filter, space heater, anti-absorption treatment etc.)

7. Altitude

- The motor temperature can be affected by the altitude where the motor is installed.
- Upto 1000m, the former thermal criteria is applied.
- Above 1000m, the reduction of cooling effect due to the lower air density is generally compensated by the reduction of max. ambient temperature.
- However, for the detail design, there need the information both about altitude and max. ambient temperature.

##. **De-rating Factor for site altitude**

No.	Type Factor / Site Altitude	IC411,IC611 Cooling	IC01 Cooling
1	0m < S.A. ≤ 1,000m	1.0	1.0
2	1,000m < S.A. ≤ 1,500m	0.96	0.96
3	1,500m < S.A. ≤ 2,000m	0.92	0.93
4	2,000m < S.A. ≤ 2,500m	0.88	0.90
5	2,500m < S.A. ≤ 3,000m	0.84	0.86
6	3,000m < S.A. ≤ 3,500m	0.80	0.83
7	3,500m < S.A. ≤ 4,000m	0.76	0.80

8. Enclosure

- Open Drip-proof(IP23)

  -.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

  -.Because of direct cooling, the motor size is small.

- NEMA Weather protected type II(IPW24)

  -.Its ventilating passage so arranged that high velocity air born particle can not enter inside motor.

  -. Additional air housing on ODP motor.

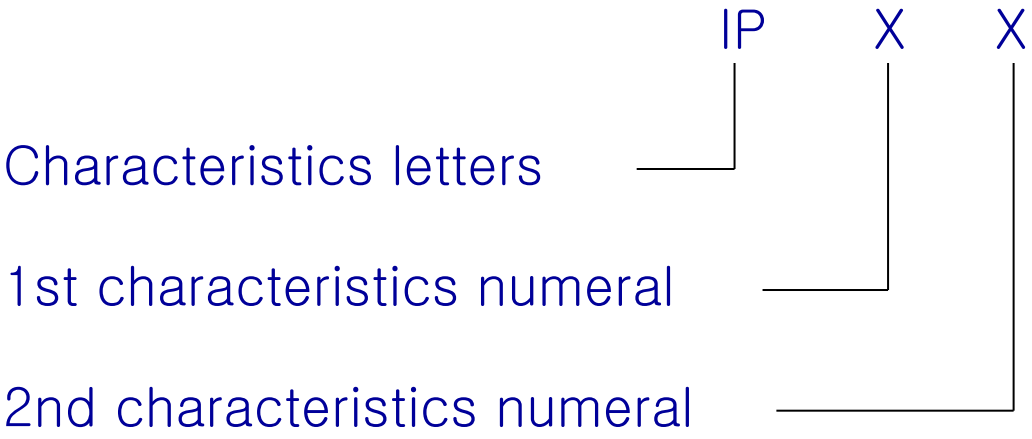
- Totally Enclosed Fan Coold(IP44, IP54, IP55, IP56)

  -.Totally enclosed machine equipped for self exterior cooling.

  -. Because of indirect cooling, the motor size is large.

9. Degree of protection

Example of designation



- The first characteristic numeral indicates the degree of protection provided by the enclosure to persons and to the parts of the machine inside the enclosure.
- The second characteristic numeral indicates the degree of protection provided by the enclosure with respect to harmful effects due to ingress of water.

Degree of protection indicated by the first characteristic numeral

First characteristics numeral	Degree of Protection
	Definition
0	No special protection
1	Accidental or inadvertent contact with or approach to live and moving parts inside the enclosure by a large surface of the human body, such as a hand (but no protection against deliberate access). Ingress of solid objects exceeding 50 mm in diameter
2	Contact with or approach to live or moving parts inside the enclosure by fingers or similar objects not exceeding 80 mm in length. Ingress of solid objects exceeding 12 mm in diameter
4	Contact with or approach to live or moving parts inside the enclosure by wires or strips of thickness greater than 1 mm. Ingress of solid objects exceeding 1 mm in diameter
5	Contact with or approach to live or moving parts inside the enclosure. Ingress of dust is not totally prevented but dust does not enter in sufficient quantity to interfere with satisfactory operation of the machine

Degree of protection indicated by the second characteristic numeral

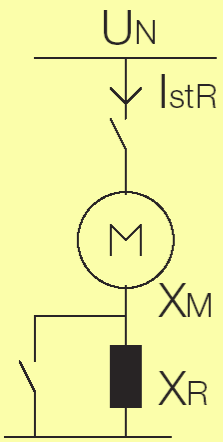
Second characteristics numeral	Degree of Protection
	Definition
0	No special protection
1	Dripping water (vertically falling drops) shall have no harmful effect
2	Vertically dripping water shall no harmful effect when the machine is tilted at any angle up to 15° from its normal position
3	Water falling as a spray at an angle up to 60° from the vertical shall have no harmful effect
4	Water splashing against the machine from any direction shall have no harmful effect
5	Water projected by a nozzle against the machine from any direction shall have no harmful effect
6	Water from heavy seas or water projected in powerful jets shall not enter the machine in harmful quantities

10. Starting method

- The purpose of starting methods is to reduce the starting current to an acceptable level.

	Reactor	Autotransformer
Starting current	~ Voltage tap	~ (Voltage tap)^2
Starting torque	~ (Voltage tap)^2	~ (Voltage tap)^2

Reactor



U_N = Rated net voltage

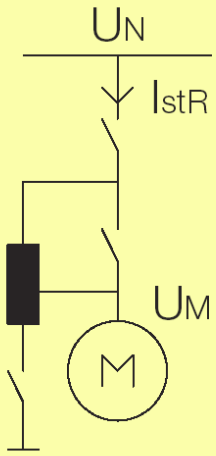
I_{st} = Start current at full voltage

I_{stR} = Start current at red. voltage

X_M = Motor reactance

X_R = Reactor reactance

Autotransformer



U_N = Rated net voltage

I_{st} = Start current at full voltage

I_{stR} = Start current at red. voltage

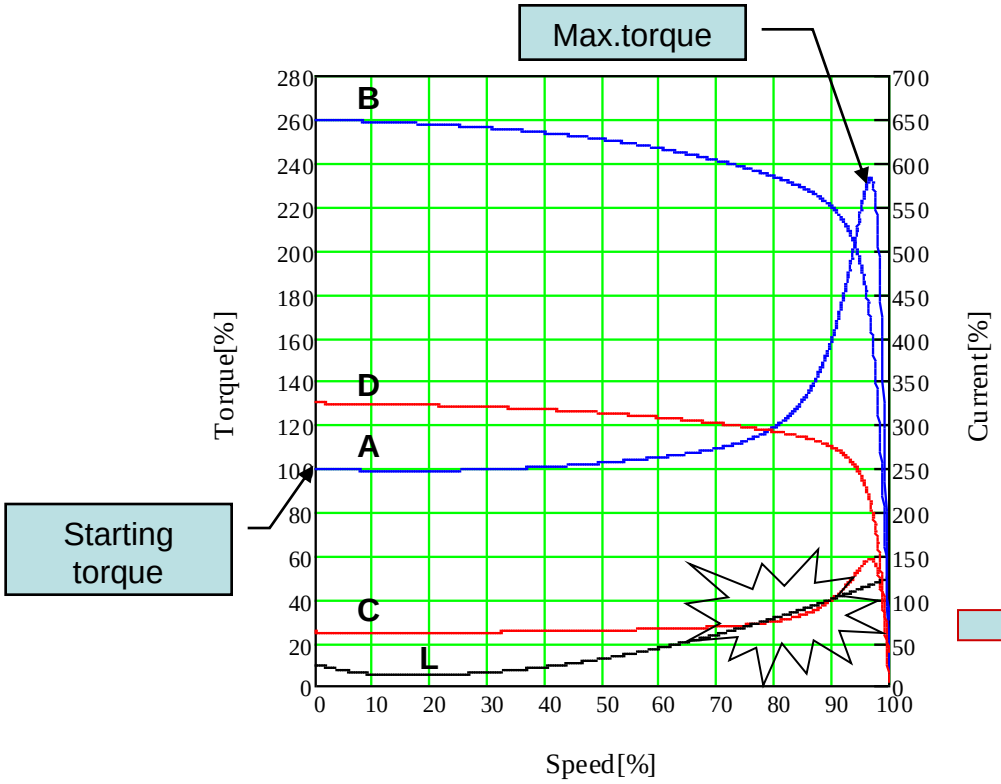
U_M = Motor voltage

- To get a proper starting current level, if the voltage tap is set too low, it is not easy to get an proper acceleration torque.

	DOL	Auto T/R 80% tap	Auto T/R 50% tap
Starting current	1000 A	640 A	250 A
Starting torque	100 %	64 %	25 %

- With 25% starting torque, the motor may not accelerate the load, so the starting torque of the motor should be higher. It can be done by enlarge motor size generally.
- So, the unreasonablely low voltage tap can make the motor size bigger.

Speed-torque & current curve



A: Speed vs torque curve at 100% voltage

B: Speed vs current curve at 100% voltage

C: Speed vs torque curve at 50% voltage

D: Speed vs current curve at 50% voltage

L: Speed vs load torque curve

The acceleration at 75% speed is impossible with 50% voltage tap.

- If the load torque curve is provided, the acceleration characteristics can be checked with the given voltage tap.

11. Starting duty

1) Starting a motor cause a great stress on motor mechanically, electrically, and thermally. So, If possible, the frequent starts of motor should not be allowed.

2) NEMA MG1 give a criteria as below

   - Two Starts in succession with the motor initially at an ambient temperature.(Cold condition)
   - One Start with the motor initially at a full load temperature.(Hot condition)
   - It should be recognized that the number of starts should be kept a minimum since the life of the motor is affected by the number of starts.

12. Load inertia

$$t_{acc} := \frac{2 \cdot \pi \cdot f}{pole} \cdot \int_{0\%}^{100\%} \frac{J}{T} \, d(n)$$

J: Inertia moment

T: Acceleration Torque

1) The higher load inertia➔ the longer starting time

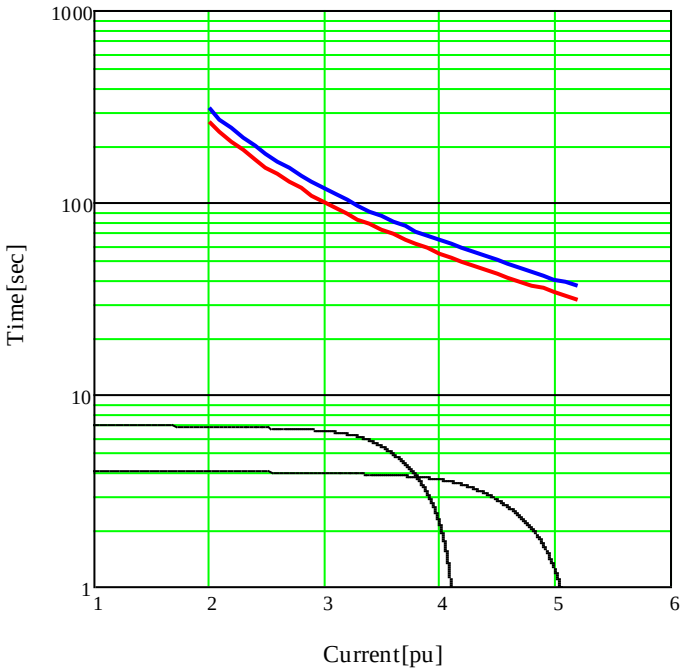
➔ the higher temperature during starting.

➔ the lower starting duty.

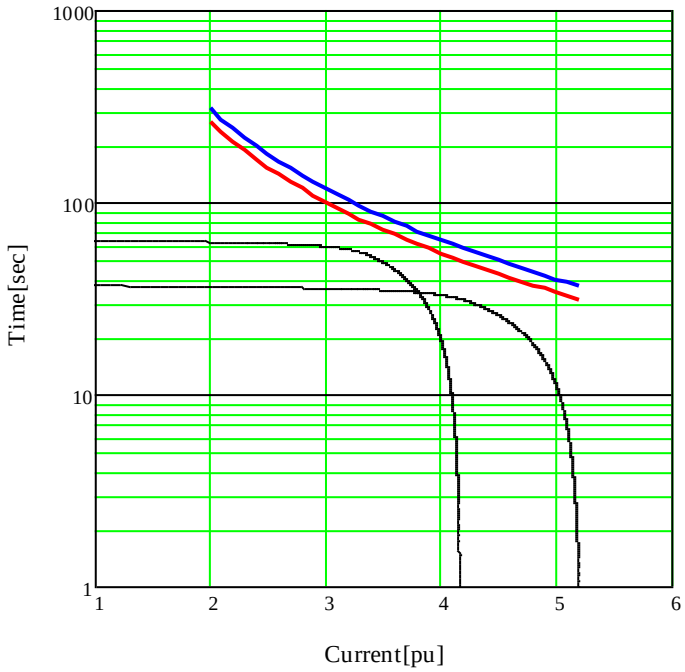
- In case of high inertia load, the motor size should be enlarged to dissipate the heat generated during starting.

Thermal limit & Time current curve

- With the same motor, we can have the different curves depending on the loads.



Pump



Fan

13. Coupling method

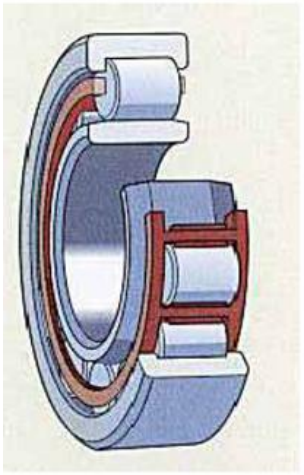
- Hydraulic coupling

  -. If hydraulic coupling is used, the inertia of load do not effected on motor during starting.

  -. So, if hydraulic coupling is adopted to high inertia load, then the motor can be sized like standard inertia motor.

14. Bearing types

- HHI's standard bearing types are stated on HHI motor catalog.
- If the bearing type change from anti-friction bearing to sleeve bearing, the additional cost shall be requested.
- The sleeve bearing applied on HHI motor catalog is the forced cooled type. So, if the self cooled type is necessary, the non-standard motor may be applied.



Anti-friction bearing

Sleeve bearing

15. Test and Inspection

- The applicable test standards are

  -. NEMA MG1, API 541, IEC 60034, JEC 2137, IEEE 112 etc.

- HHI's standard inspection plan is non-witness routine test with one motor temperature rise test.
- Standard test items

  -. Dimensional inspection

  -. No load test & Locked rotor test

  -. Determination of characteristics (Efficiency, power factor, torque..)

  -. Noise test & Vibration test

  -. Heat run test (Temperature rise test)

  -. Insulation resistance test & High voltage test

- Optional items are

  -. Insulation diagnosis (PD, Tan-delta, etc.)

  -. Water immersion test

  -. Terminal box fault level test

- According to the limit of test facility of HHI, the below matters are usually deviated like followings.

  -. Actual loading test ➔Equivalent loading test according to IEC, IEEE 112

  -. Efficiency and power factor measurement ➔ Measurement for calculation by equivalent circuit method according to IEEE 112, JEC 2137, IEC 60034-2

  -. Starting current and starting torque measurement ➔ Measurement for calculation by Locked rotor test according to IEEE 112

16. Accessories

- Temperature detectors (RTD, Thermocouple)
  - -. WTD(Winding temperature detector)
  - -. BTD(Bearing temperature detector)

- Others
  - -. Differential CTs
  - -. Surge capacitor, Lighting arrestor
  - -. Air differential pressure switch
  - -. Proximity sensor (Shaft vibration), Velometer (Housing vibration)
  - -. Zero-speed switch, Reverse rotation sensor
  - -. PD coupler
  - -. Leakage detector

17. Fill-in sheet for inquiry

HYUNDAI HEAVY INDUSTRIES CO.,LTD.

Information for Motor RFQ

Project Name : _____

Customer Name : _____

Bid Due Date : _____

Output (kW)	Phase	Speed	Voltage (V)	Frequency (Hz)	Quantity	Service Factor	Application	Motor Delivery

APPLICABLE STANDARD (CODES) ☐ IEC ☐ NEMA ☐ IEEE ☐ API ☐ BS ☐ Special (Specify) :

* Notes

1. The asterisk(*) marks shown on below information are our (Hyundai) standard.
2. The asterisk(**) marks must fill up. We can not figure out the motor type and price without these information.

1. DUTY
☐ Continuous *
☐ Time rated (specify) _____

** **2. ROTOR**
☐ Squirrel cage ☐ Wound

3. INSULATION CLASS
☐ Class B ☐ Class F *
☐ Special (specify) _____

4. TEMPERATURE RISE (By resistance method)
☐ Class B * ☐ Class F
☐ Special (specify) _____

** **5. TYPE OF MOUNTING**
☐ B3/ Horizontal-Foot ☐ V1, V10 / Vertical
☐ Special (Specify) _____

6. ENVIRONMENT
☐ High Humidity ☐ Dusty ☐ Tropical
☐ Special (Specify) _____

7. AMBIENT TEMPERATURE
☐ Max. 40 ºC *
☐ Special (specify) _____

8. ALTITUDE
☐ standard (Less than 1000m A.S.L.) *
☐ Special (specify) _____

** **9. AREA CLASSIFICATION**
☐ Non-Hazardous Area *
☐ Hazardous Area
☐ Class I, Zone 1 / Class I, Division 1
☐ Class I, Zone 2 / Class I, Division 2
☐ Gas Group, Ignition Temp. _____
☐ Special (specify) _____

19. MOTOR ROTATION (Viewed from Drive End)
☐ C.W. * ☐ C.C.W.
☐ Bi-directional

20. LOCATION OF MAIN TERMINAL BOX (Viewed from Drive End)
☐ Right * ☐ Left
☐ Special (Specify) _____

21. LOCATION OF AUX. TERMINAL BOX (Viewed from Drive End
☐ Right ☐ Left *
☐ Special (Specify) _____

** **22. BEARING TYPE**
☐ Anti-friction Bearing ☐ Split Sleeve Bearing
☐ Tilting Pad Bearing
☐ Special (Specify) _____

23. BEARING LUBRICATION TYPE
☐ Grease Lubricated ☐ Self Cooled Oil Lubricated
☐ Forced Feed Oil Lubricated
☐ Special (Specify) _____

24. CABLE ENTRY OPENING
☐ Blind Steel Plate ☐ Threaded
☐ Cable Gland Type
☐ Special (Specify) _____

25. PAINTING COLOR
☐ Munsell No : 7.5 BG 6/1.5, Light Grey *
☐ Special (Specify) _____

26. TEST AND INSPECTION
☐ Un-witnessed Routine Test *

** **10. ENCLOSURE**
- ☐ TEFC (IC411)
- ☐ TEAAC (IC511)
- ☐ TEAAC (IC611)
- ☐ TEWAC (IC81W)
- ☐ WPI (IC01)
- ☐ WPII (IC01)
- ☐ ODP (IC01)
- ☐ Explosion Proof
  - ☐ Ex-nA ☐ Ex-d ☐ Ex-p ☐ Ex-e
  - ☐ Certification _____
- ☐ Special (specify) _____

11. PROTECTION DEGREE
- ☐ IP54 ☐ IP55 ☐ IP23
- ☐ IPW23 ☐ IPW24
- ☐ Special (specify) _____

12. LOCATION
- ☐ Indoor ☐ Outdoor
- ☐ Special (specify) _____

** **13. STARTING METHOD**
- ☐ Full voltage (Direct on line) * ☐ Star-Delta
- ☐ Secondary rheostat (for wound)
- ☐ Reduce Voltage (% Tap.) _____
- ☐ V.V.V.F. (Speed Range) _____
  - ☐ Current Source (Maker) _____
  - ☐ Voltage Source (Maker) _____
- ☐ Soft Starter

14. STARTING DUTY
- ☐ Not Exceeding NEMA MG 1-20.43 (Cold : 2, Hot : 1) *
- ☐ Special (specify) _____

15. MAX. INRUSH CURRENT
- ☐ 650% * ☐ 600% ☐ 550%
- ☐ Special (specify) _____

** **16. LOAD INERTIA (Referred to Motor Shaft)**
- ☐ Not Exceeding NEMA MG 1-20.42 *
- ☐ Actual WK2 (lb-ft2) _____
- ☐ Actual GD2 (kg-m2) _____
- ☐ Speed-torque curve of load attached
  - ☐ Starting Condition - Valve Closed
  - ☐ Starting Condition - Valve Open

17. SHAFT EXTENSION ☐ Single * ☐ Double

18. COUPLING METHOD ☐ Direct Connected * ☐ Belt

☐ Special (specify) _____

** **27. EXTERNAL THRUST (VERTICAL MOTOR ONLY)**
- ☐ No Thrust
- ☐ Normal Down Thrust (Kg or LBS) _____
- ☐ Max. Down Thrust (Kg or LBS) _____
- ☐ Momentary Up Thrust (Kg or LBS) _____

(HHI's standard is to withstand the thrust of the rotor and coupling of motor only.)

27. WINDING TEMPERATURE DETECTORS
- ☐ Not required
- ☐ Required. Quantity per phase _____
  - ☐ PT 100 ohm, Single ☐ PT 100 ohm, Dual
  - ☐ PTC
  - ☐ Special (Specify) _____
    - ☐ 4 - 20 mA transmitters(Type) _____

29. BEARING TEMPERATURE DETECTORS
- ☐ Not required
- ☐ Required. Quantity per bearing _____
  - ☐ PT 100 ohm, Single ☐ PT 100 ohm, Dual
  - ☐ Thermocouples (Type) _____
  - ☐ Dial type Indicators
    - ☐ Without Contact ☐ With Contact
  - ☐ Special (Specify) _____
    - ☐ 4 - 20 mA transmitters(Type) _____

30. ANTI-CONDENSATION HEATER
- ☐ Not required
- ☐ Required (Phase, Volts) _____

** **31. COOLING WATER (For TEWAC Motor)**
- ☐ Fresh Water ☐ Sea Water
- ☐ Water Inlet Temp.(Max.) _____

32. REQUIRED SPARE PARTS
- ☐ Bearing (Anti-friction) ☐ Sleeve Bearing Shell
- ☐ Special (Specify) _____

34. APPLICABLE CUSTOMER'S SPEC. ☐ YES ☐ NO

Attached : _____

35. SPECIAL REQUIREMENTS _____

18. HHI's Data Sheet

HYUNDAI HEAVY INDUSTRIES CO.,LTD.

AC INDUCTION MOTOR DATA SHEET

Model No.or RFQ No.	1207-167-00	Item No.		Rev. No.	[0]
Project Name		Project No.		Quantity	2 set

GENERAL SPECIFICATION

Frame Size		710
Type		HRQ3 717-6
Enclosure(Protection)		TEAAC (IP55)
Method of Cooling		IC611
Rated Frequency		50 Hz
Number of Phases		3
Insulation Class		■ F ☐ B ☐ H
Temp. Rise at full load (by resistance method)		
	at 1.0 S.F	80℃
Motor Location		■ Indoor ☐ Outdoor
Altitude		Less than 1000 meter
Relative Humidity		Less than 70 %
Ambient Temp.		-15 ~ 40 ℃ (Max.)
Duty Type		Continuous (S1)
Service Factor		1.0
Mounting		■ B3 ☐ B5 ☐ V1 ☐ V10
Bearing	Type	Split sleeve
	DE/N-DE	Sleeve / Sleeve
	Lubricant	Forced feed oil lub.
External Thrust		Not applicable

PERFORMANCE DATA

Rated Output		4163 kW
Number of Poles		6
Rotor Type		Squirrel Cage
Starting Method*		■ D.O.L ☐ Y-△
Rated Voltage		6000 V
Current	Full Load	472.2 A
	Locked-rotor**	600 %
Efficiency		
	50% Load	95.5 %
	75% Load	96.2 %
	100% Load	96.4 %
Power Factor(p.u)		
	50% Load	0.78
	75% Load	0.86
	100% Load	0.88
Speed at Full Load		992 r.p.m
Torque		
	Full Load	4,087.5 kg·m
	Locked-rotor**	70 %
	Breakdown**	220 %

External Thrust		Not applicable	
Coupling Method		■ Direct	☐ V-Belt
Shaft Extension		■ Single	☐ Double
Terminal Box	Main	■ Steel	☐ Cast Iron
	Aux.	■ Yes	☐ No
	Location	Refer to Outline Drawing	
Application		Fan	
Area classification		Non-hazardous	
Type of Ex-Protection		N/A	
Applicable Standard		IEC, IEEE	

	Breakdown**	220 %
Moment of Inertia (J)		
	Load	4,510 kg.m^2
	Motor	372 kg.m^2
Sound Pressure Level (No-load & mean value at 1m from motor)		80 dB(A)
Vibration		1.8 mm/sec.(rms)
Permissible number of consecutive starts	Cold	3 times
	Hot	2 times
Paint	Munsell No.	7.5BG 6/1.5

ACCESSORIES

(1) Winding Temp. Detector (Pt 100 ohm, Single) : 2EA / Phase

(2) Bearing Temp. Detector (Pt 100 ohm, Dual) : 1EA / Beairng

(3) Space heater

(4) Current transformer(installed on the neutral terminal box) x 3ea/motor

SUBMITTAL DRAWING

Outline Dimension Drawing	\ Motor Weight(Approx.)	
B3	RP4-26393	24000 kg

SPARE PARTS

REMARK

Date	DSND	CHKD	CHKD	APPD
2013-01-09	B.G. Kim		B.G.Kim	D.K.LEE

Thanks for your attention.