Final Report by Three-phase Induction Motor Evaluation Standards Subcommittee, Energy Efficiency Standards Subcommittee of the Advisory Committee for Natural Resources and Energy

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Ministry of Economy, Trade and Industry

The three-phase induction motor evaluation standards subcommittee deliberated on evaluation standards, etc. for manufacturers and importers of three-phase induction motors (hereinafter referred to as "manufacturers, etc.") for the purpose of improving the performance of these products (the deliberation included the scope, categories, target fiscal year, target standard values, measurement methods, etc. of three-phase induction motors covered by this report) and prepared this report as follows.

1. Target scope [See Attachment 1, Attachment Sheet 1 and Reference 2.]

Three-phase induction motors covered by this report are those which satisfy all of the following conditions from (1) to (7) based on the scope of three-phase induction motors specified by Japanese Industrial Standards JIS C 4034-30 "Rotating electrical machines - Part 30: Efficiency classes of single-speed, three-phase, cage-induction motors (IE code)" [excluding those which are completely integrated into other machines (for example, pumps, fans, compressors, etc.) and cannot be tested separately from such machines and those made solely for inverter driving (those whose base frequency is 50 Hz ±5% or 60 Hz ±5% are included in the scope).

1) Those whose rated frequency or base frequency is either 50 Hz±5% or 60 Hz±5% or compatible with both 50 Hz ±5% and 60 Hz ±5%
2) Those whose speed is single
3) Those whose rated voltage is 1,000 V or lower
4) Those whose rated output is 0.75 kW or higher and 375 kW or lower
5) Those whose number of poles is either 2 poles, 4 poles or 6 poles
6) Those whose duty type of use is either (a) or (b) below
   (a) Those which are continuously operated at a constant load for sufficient time to allow the motor to reach thermal equilibrium (abbreviation: S1)
   (b) Those which are repeatedly used for the time shorter than the time in which the motor reaches the thermal equilibrium, making the period of time when the motor operates at a constant load and the period of time when it is stopped one cycle (abbreviation: S3), where the rated cyclic duration factor is 80% or higher
7) Those driven by a commercial power supply (capable of continuous operating direct on-line)

However, those whose thermal class specified in JIS C 4003 "Electrical insulation – Thermal evaluation and designation" is 180 (H), 200 (N), 200 (R) or 250, those which are delta-star starting types, those which are designed for vessels and ocean structures (floating facilities for production, storage or loading of oil, oil platforms, etc.), those which are structured for the use in liquid, those which are explosion-proof types, those whose ratio of difference between the synchronous speed and the rotational speed of the rotor is 5% or higher in case of output 0.75 kW or higher and 110 kW or lower, or 3% or higher in case of output exceeding 110 kW and 375 kW or lower (High slip motors), those designed for gates of dams or flood gates (Water gate motors), those which cover their stators or rotors with metal materials (Canned motors), those used in an extremely low temperature environment (those designed to use ambient temperature lower than –20°C) and, of those made solely for inverter driving, those which are external fan cooling types are excluded from the scope.

2. Matters to be considered as evaluation standards for manufacturers, etc.

(1) Target fiscal year [See Attachment 2.]

The target fiscal year shall be FY2015.

(2) Categories for setting targets and target standard values [See Attachments 3 and 4.]

As regards three-phase induction motors to be shipped by manufacturers, etc. in the domestic market in the target fiscal year, the values obtained by calculating weighted averages of the energy consumption efficiency [%] of those products measured by the way stated in paragraph (3) below, i.e. weighted averages calculated for each category of the following table according to the number of units shipped by each business operator, considering the coefficients stated in the notes 1 to 4 below, shall not be below the target standard values. However, as regards motors using voltage and frequency corresponding to those of the domestic and overseas markets, this applies to the energy consumption efficiency of the voltage and frequency corresponding to those of the domestic market.

Table 1 Categories and Target Standard Values of Three-phase Induction Motors

Category	Rated frequency or base frequency	Rated output	Target standard value [%]
1	60 Hz	0.75 kW or higher, lower than 0.925 kW	85.5
2		0.925 kW or higher, lower than 1.85 kW	86.5
3		1.85 kW or higher, lower than 4.6 kW	89.5
4		4.6 kW or higher, lower than 9.25 kW	91.7
5		9.25 kW or higher, lower than 13 kW	92.4
6		13 kW or higher, lower than 16.75 kW	93.0
7		16.75 kW or higher, lower than 26 kW	93.6
8		26 kW or higher, lower than 33.5 kW	94.1
9		33.5 kW or higher, lower than 41 kW	94.5
10		41 kW or higher, lower than 50 kW	95.0
11		50 kW or higher, lower than 100 kW	95.4
12		100 kW or higher, lower than 130 kW	95.8
13		130 kW or higher, 375 kW or lower	96.2
14	50 Hz	0.75 kW	82.5
15		1.1 kW	84.1
16		1.5 kW	85.3

17	50 Hz	2.2 kW	86.7
18		3 kW	87.7
19		4 kW	88.6
20		5.5 kW	89.6
21		7.5 kW	90.4
22		11 kW	91.4
23		15 kW	92.1
24		18.5 kW	92.6
25		22 kW	93.0
26		30 kW	93.6
27		37 kW	93.9
28		45 kW	94.2
29		55 kW	94.6
30		75 kW	95.0
31		90 kW	95.2
32		110 kW	95.4
33		132 kW	95.6
34		160 kW	95.8
35		200 to 375 kW	96.0
36		Others	Note 2

Note 1. The evaluation is made using the values obtained by multiplying the energy consumption efficiency obtained by measurement by the coefficients a to f listed in Table 2 and Table 3, then rounding off the second place after the decimal point of those values thus obtained.

In case of output other than rated output listed in Table 2 (60 Hz), if the output in question is equal to or higher than the middle point between two of the rated output which are one class higher and lower than the output in question, the coefficients a to c of the higher rated output are used, and if the output in question is lower than said middle point, the coefficients a to c of the lower rated output are used.

Table 2 Coefficients of Each Output of 60 Hz

Rated output [kW]	2 poles	4 poles	6 poles
	Coefficient a	Coefficient b	Coefficient c
0.75	1.1104	1.0000	1.0364
1.1	1.0298	1.0000	0.9886
1.5	1.0117	1.0000	0.9774
2.2	1.0347	1.0000	1.0000
3.7	1.0113	1.0000	1.0000
5.5	1.0246	1.0000	1.0077
7.5	1.0166	1.0000	1.0077
11	1.0154	1.0000	1.0076
15	1.0220	1.0000	1.0142
18.5	1.0207	1.0000	1.0065
22	1.0207	1.0000	1.0065
30	1.0184	1.0000	1.0000
37	1.0161	1.0000	1.0043
45	1.0150	1.0000	1.0053
55	1.0192	1.0000	1.0095
75	1.0138	1.0000	1.0042
90	1.0042	1.0000	1.0042
110	1.0084	1.0000	1.0000
150	1.0084	1.0000	1.0042
185 to 375	1.0042	1.0000	1.0042

Table 3 Coefficients of Each Output of 50 Hz

Rated output [kW]	2 poles	4 poles	6 poles
	Coefficient d	Coefficient e	Coefficient f
0.75	1.0223	1.0000	1.0456
1.1	1.0169	1.0000	1.0383
1.5	1.0131	1.0000	1.0339
2.2	1.0093	1.0000	1.0285
3	1.0069	1.0000	1.0245
4	1.0057	1.0000	1.0207
5.5	1.0045	1.0000	1.0182
7.5	1.0033	1.0000	1.0146
11	1.0022	1.0000	1.0122
15	1.0022	1.0000	1.0099
18.5	1.0022	1.0000	1.0098
22	1.0032	1.0000	1.0087
30	1.0032	1.0000	1.0075
37	1.0021	1.0000	1.0064
45	1.0021	1.0000	1.0053
55	1.0032	1.0000	1.0053
75	1.0032	1.0000	1.0042
90	1.0021	1.0000	1.0032
110	1.0021	1.0000	1.0032
132	1.0021	1.0000	1.0021
160	1.0021	1.0000	1.0021
200 to 375	1.0021	1.0000	1.0021

Note 2. The target standard value (η: %) of category 36 listed in Table 1 shall be the value calculated by the following formula.

$$\eta = A\times(\log_{10}(P_N/P_C))^3 + B\times(\log_{10}(P_N/P_C))^2 + C\times\log_{10}(P_N/P_C) + D$$

Where, P_N [kW]: Rated output

P_C [kW]: 1 [kW] (for making P_N non dimensional)

A, B, C and D: Interpolation coefficients

A	B	C	D
0.0773	−1.8951	9.2984	83.7025

However, as regards those whose number of poles is 2 poles and 6 poles, the evaluation shall be made using the value calculated by multiplying the energy consumption efficiency obtained by measurement by coefficient g in case of 2 poles or coefficient h in case of 6 poles (rounding off the second place after the decimal point).

$$\text{Coefficient g} = \frac{A\times(\log_{10}(P_N/P_C))^3 + B\times(\log_{10}(P_N/P_C))^2 + C\times\log_{10}(P_N/P_C) + D}{A'\times(\log_{10}(P_N/P_C))^3 + B'\times(\log_{10}(P_N/P_C))^2 + C'\times\log_{10}(P_N/P_C) + D'}$$

Where, P_N [kW]: Rated output

P_C [kW]: 1 [kW] (for making P_N non dimensional)

A', B', C' and D': Interpolation coefficients

A'	B'	C'	D'
0.3569	−3.3076	11.6108	82.2503

$$\text{Coefficient h} = \frac{A\times(\log_{10}(P_N/P_C))^3 + B\times(\log_{10}(P_N/P_C))^2 + C\times\log_{10}(P_N/P_C) + D}{A''\times(\log_{10}(P_N/P_C))^3 + B''\times(\log_{10}(P_N/P_C))^2 + C''\times\log_{10}(P_N/P_C) + D''}$$

Where, P_N [kW]: Rated output

P_C [kW]: 1 [kW] (for making P_N non dimensional)

A", B", C" and D": Interpolation coefficients

A″	B″	C″	D″
0.1252	−2.6130	11.9963	80.4769

Note 3. If shipped including 3 ratings (6 ratings), as regards 200 V/60 Hz (400 V/60 Hz), the evaluation shall be made using the value obtained by multiplying the energy consumption efficiency obtained by measurement by each of the coefficients i to k listed in Table 4 and rounding off the second place after the decimal point.

The 3 ratings and 6 ratings are defined as follows.

3 ratings: 200 V/50 Hz, 200 V/60 Hz, 220 V/60 Hz or
400 V/50 Hz, 400 V/60 Hz, 440 V/60 Hz

6 ratings: 200 V/50 Hz, 200 V/60 Hz, 220 V/60 Hz, 400 V/50 Hz, 400 V/60 Hz, 440 V/60 Hz

Table 4 Coefficients of Each Rated Output of 3 Ratings (6 Ratings)

Rated output [kW]	2 poles	4 poles	6 poles
	Coefficient i	Coefficient j	Coefficient k
0.75	1.1325	1.0130	1.0452
1.1	1.0485	1.0188	1.0023
1.5	1.0298	1.0188	0.9908
2.2	1.0468	1.0147	1.0170
3.7	1.0229	1.0147	1.0170
5.5	1.0362	1.0099	1.0246
7.5	1.0246	1.0099	1.0246
11	1.0244	1.0109	1.0221
15	1.0310	1.0142	1.0288
18.5	1.0286	1.0119	1.0207
22	1.0286	1.0119	1.0207
30	1.0262	1.0107	1.0107
37	1.0227	1.0107	1.0150
45	1.0215	1.0106	1.0128
55	1.0258	1.0032	1.0171
75	1.0192	1.0032	1.0117
90	1.0095	1.0032	1.0117
110	1.0138	1.0042	1.0074
150	1.0126	1.0042	1.0116
185 to 375	1.0084	1.0042	1.0116

Note 4. As regards the number of units shipped by each business operator, if the shipment is made including 3 ratings (6 ratings) listed in Note 3, the quantity ratios listed in Table 5 shall be used to calculate the quantity of each rating. In the calculation, the first place after the decimal point is rounded off to obtain an integer value and, if it is necessary to adjust fractional quantity, the adjustment shall be made by the rating whose quantity ratio is highest.

Table 5 Quantity Ratio of Each Voltage and Frequency of 3 Ratings (6 Ratings)

Rated voltage	200 V		220 V
Rated frequency	50 Hz	60 Hz	
Quantity ratio	50%	30%	20%

Rated voltage	400 V		440 V
Rated frequency	50 Hz	60 Hz	
Quantity ratio	50%	30%	20%

Rated voltage	200 V		220 V	400 V		440 V
Rated frequency	50 Hz	60 Hz		50 Hz	60 Hz	
Quantity ratio	40%	25%	10%	10%	5%	10%

(3) Method for measuring energy consumption efficiency [See Attachment 5 and Attachment Sheet 2.]

The energy consumption efficiency of three-phase induction motors shall be measured as the ratio (%) of output (value obtained by subtracting total loss (*) from input) [W] against input [W] by the method specified in JIS C 4034-2-1 (the test method for “low” uncertainty) and calculated by the following formula.

Performance [%] = (Input [W] – Total loss [W])/Input [W]×100

* The total loss is obtained as the sum of fixed loss, load loss (the calculation method for the load loss by a load test) and stray load loss (the calculation method for the stray load loss by a load test conducting torque measurement).

(4) Items to be indicated, etc.

1) Items to be indicated

The items to be indicated are as follows.

i) Product name

ii) Rated output (kW)

iii) Number of poles

iv) Rated voltage (V)

v) Rated frequency or base frequency (Hz)

vi) Category of usage (S1 or S2 (Load hour rate; equal to or higher than 80%))

vii) Energy consumption efficiency (%: Rated performance at rated voltage and frequency)

viii) Efficiency class (IE code)

ix) Name of manufacturer, etc.

2) Matters to be complied with

<1> The energy consumption efficiency [%] shall be expressed by the number down to the first place after the decimal point.

<2> The efficiency class (IE code) said in viii) of the foregoing paragraph 1) shall be described for each rated voltage and frequency. However, if the efficiency class (IE code) at each rated voltage and frequency is common to all, it is acceptable to describe only one type.

<3> The indication of the items listed in the foregoing paragraph 1) shall be made on a visible place of a three-phase induction motor’s main body in a way that makes it difficult to erase the indication. They must also be described in catalogues indicating the performance of the product or in data provided for users by manufacturers, etc. when they choose products, on a visible place and in a way that makes it difficult to erase the indication.

3. Proposals for energy conservation

(1) Actions of Government

1) From viewpoint of promoting three-phase induction motors with excellent energy consumption efficiency, the government shall endeavor to implement necessary measures such as diffusion and publication, etc. of those products to promote actions of users (people who buy single unit of three-phase induction motor or machines incorporating three-phase induction motors) and manufacturers, etc.

(2) Actions of manufacturers, etc.

1) Manufacturers, etc. shall endeavor to promote the development of energy conservation technologies for three-phase induction motors to develop and manufacture or import products with excellent energy consumption efficiency.
2) From viewpoint of diffusing three-phase induction motors with excellent energy consumption efficiency, manufacturers, etc. shall endeavor to provide appropriate information for users to encourage them to choose three-phase induction motors with excellent energy conservation performance by indicating the energy consumption efficiency and presenting advantages by exchanging with high efficiency products including precaution for use, etc. at visible places of catalogues or operation manuals of target products as well as of data provided by manufacturers, etc. to help users choose products.

(3) Actions of manufacturers, etc. of machines incorporating three-phase induction motors

1) Manufacturers, etc. of machines incorporating three-phase induction motors shall endeavor to manufacture or import machines incorporating three-phase induction motors with excellent energy consumption efficiency.
2) From viewpoint of diffusing machines incorporating three-phase induction motors with excellent energy consumption efficiency, efforts shall be made to provide appropriate information for users to encourage them to choose machines incorporating three-phase induction motors with excellent energy conservation performance by indicating the energy consumption efficiency at visible places of catalogues or operation manuals of target products as well as of data provided by manufacturers, etc. to help users choose products.

(4) Actions of users

When purchasing “single three-phase induction motor” or “machines incorporating three-phase induction motors”, users shall endeavor to choose three-phase induction motors with excellent energy consumption efficiency or machines incorporating such three-phase induction motors and promote energy conservation by using them appropriately and efficiently.

Attachment 1

Target Scope of Three-phase Induction Motors

1. Basic idea

The scope to which the standards of this evaluation are applied shall be as follows as specifically designated from among "standard three-phase induction motors (classification code: 301223)" and "non-standard three-phase induction motors (70 W or higher) (classification code: 301224)" classified by Japan Standard Commodity Classification (as revised in June, 1990) based on the scope of three-phase induction motors (hereinafter referred to as motors) which is specified by Japanese Industrial Standards JIS C 4034-30 "Rotating electrical machines - Part 30: Efficiency classes of single-speed, three-phase, cage-induction motors (IE code)".

Three-phase squirrel-cage induction motors which satisfy all of the following conditions [*1]

1) Those whose rated frequency or base frequency (1) is 50 Hz±5% or 60 Hz±5% or compatible with both 50 Hz ±5% and 60 Hz ±5% (2)
2) Those whose speed is single (3)
3) Those whose rated voltage is 1,000 V or lower (4)
4) Those whose rated output is 0.75 kW or higher and 375 kW or lower
5) Those whose number of poles is either 2 poles, 4 poles or 6 poles
6) Those whose duty type of use is either (a) or (b) below
   (a) Those which are continuously operated at a constant load for sufficient time to allow the motor to reach thermal equilibrium (abbreviation: S1)
   (b) Those which are repeatedly used for the time shorter than the time in which the motor reaches the thermal equilibrium, making the period of time when the motor operates at a constant load and the period of time when it is stopped one cycle (abbreviation: S3), where rated cyclic duration factor is 80% or higher
7) Those driven by a commercial power supply (capable of continuous operating direct on-line)

However, the following types are excluded.

(A) Those which are completely integrated into other machines (for example, pumps, fans, compressors, etc.) and cannot be tested separately from such machines

(B) Those made solely (5) for inverter driving [*2]

[*1] Even if special flanges, feet and/or shafts are used, those motors are included in the scope.

[*2] Those whose base frequency is 50 Hz ±5% or 60 Hz ±5% are included in the scope.

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(1) The base frequency is the maximum rated frequency with which a motor can continuously generate the rated torque.

(2) In case of motors with multiple rated frequencies or base frequencies, those with one or more applicable rated frequencies or base frequencies

(3) Those which cannot change the number of poles

(4) In case of motors with multiple rated voltages, those with one or more applicable rated voltages

(5) Solely for inverter driving means those which cannot be driven by commercial electric power source, etc.

2. Motors excluded from the scope

Of target three-phase induction motors, the following motors are excluded from the scope.

As the principle of the exclusion, 1) those which are used for special applications, 2) those for which technical methods for measurement and evaluation have not been established and 3) those whose use ratio in the market is extremely low are excluded from the scope.

(1) Those whose thermal class specified by JIS C 4003 "Electrical insulation - Thermal evaluation and designation" is 180 (H), 200 (N), 220 (R) or 250

Although those are used in a high temperature condition such as electric furnaces, they are excluded from the scope because 1) they are used for special applications and 3) their use ratio in the market is extremely low.

* Number of units shipped (FY2008): 1,304 units (ratio to the total: 0.03%)

Number of units shipped (FY2009): 1,022 units (ratio to the total: 0.06%)

Reference: Excerpt from JIS C 4003 (2010)

5. Thermal class

The temperature of electric products is, in most cases, a main factor causing the deterioration of electrical insulation materials within electrical insulation systems. Therefore, the basic thermal class is useful and it has been recognized internationally too. If a thermal class is specified for an electrical insulation system, it means the recommended maximum continuous use temperature (°C) in case of appropriate combination of electrical insulation materials.

The thermal class of electrical insulation systems is specified based on the result of a functional test conducted according to use experience or 4.5. The thermal class of this electrical insulation system is specified based on the actual thermal durability index of the electrical insulation system or the relative thermal durability index of the electrical insulation system.

Even if a thermal class of an electrical insulation material is applied to an electrical insulation material based on the result of a test conducted according to use experience or 4.4, it does not mean that it is appropriate to use the thermal class of the electrical insulation material for the thermal class of the electrical insulation system or it does not automatically mean that the thermal class of the electrical insulation system part of which is formed by the electrical insulation material is equal to the thermal class of the electrical insulation material.

Table 1 below shows the designations of thermal classes.

Table 1 - Designations of Thermal Classes

Actual thermal durability index or relative thermal durability index °C		Thermal class °C	Specified letter [a]
≧90	<105	90	Y
≧105	<120	105	A
≧120	<130	120	E
≧130	<155	130	B
≧155	<180	155	F
≧180	<200	180	H
≧200	<220	200	N
≧220	<250	220	R
≧250 [b]	<275	250	–

Note

a) If necessary, a specified letter can be expressed using a bracket, like class 180 (H). If the space for the indication is small, like name plates, only a specified letter can be used for individual product standards.

b) The thermal class exceeding 250 increases by the unit of 25 and is specified accordingly.

(2) Those of delta-star starting system ([65])

Those motors are used for weaving machines which require excessive torque when starting, but they are excluded from the scope because 1) they are used for special applications and 3) their use ratio in the market is extremely low.

* Number of units shipped (FY2008): 2,518 units (ratio to the total: 0.06%)
Number of units shipped (FY2009): 1,910 units (ratio to the total: 0.11%)

(3) Those designed for vessels or ocean structures (floating facilities for production, storage or loading of oil, oil platforms, etc.)

Those motors are used as auxiliary driving power motors for pumps, air conditioning fans, cargo handling cranes, etc. used on vessels, but excluded from the scope because they are specially structured considering vibration, salt resistance, humidity resistance, etc. and 3) their use ratio in the market is extremely low.

* Number of units shipped (FY2008): 17,000 units (ratio to the total: 0.38%)
Number of units shipped (FY2009): 13,584 units (ratio to the total: 0.81%)

(4) Those which are structured for the use in liquid

Those motors are used for submerged pumps, disaster preventive pumps, dust collectors used for sewage treatment plants, etc., but excluded from the scope because 1) they are used for special applications, 2) technical methods for measurement and evaluation have not been established and 3) their use ratio in the market is extremely low.

* Number of units shipped (FY2008): 45,264 units (ratio to the total: 1.02%)
Number of units shipped (FY2009): 44,355 units (ratio to the total: 2.64%)

(5) Those which are explosion-proof types

Those motors are used in explosive atmosphere of oil refinery plants, etc., but excluded from the scope because 1) they are used for special applications and 3) their use ratio in the market is extremely low.

* Number of units shipped (FY2008): 33,855 units (ratio to the total: 0.76%)
Number of units shipped (FY2009): 26,558 units (ratio to the total: 1.58%)

[6] To weave fabric evenly, it is necessary to start weaving machines momentarily at predetermined revolution speed. Therefore, motors designed for delta starting transitioning to star operation are used to make the starting torque 1000% or greater of that at the time of rating operation, as opposed to the star-delta starting system designed for the purpose of suppressing the starting current.

(6) Those whose ratio of difference between the synchronous speed and the rotational speed of the rotor is either (a) or (b) of the following conditions

(a) Those whose output is 0.75 kW or higher and 110 kW or lower: 5% or above

(b) Those whose output is above 110 kW and 375 kW or lower: 3% or above

Those motors are used for crushers, etc. which need great torque, but excluded from the scope because 1) they are used for special applications and 3) their use ratio in the market is extremely low.

* Number of units shipped (FY2008): 5,818 units (ratio to the total: 0.13%)
Number of units shipped (FY2009): 3,020 units (ratio to the total: 0.18%)

(7) Those designed for the use in dams or dam's gates

Those motors are used as motors for dams or for the opening and closing of dam's gates, but excluded from the scope because 1) they are used for special applications and 3) their use ratio in the market is extremely low.

* Number of units shipped (FY2008): 160 units (ratio to the total: 0.004%)
Number of units shipped (FY2009): 137 units (ratio to the total: 0.01%)

(8) Those covering stators and rotors with metal materials (Canned motors)

Those motors are used for vacuum pumps, etc. which require high air tightness, but excluded from the scope because 1) they are used for special applications and (3) their use ratio in the market is extremely low.

* Number of units shipped (FY2008): 22 units (ratio to the total: 0.0005%)
Number of units shipped (FY2009): 25 units (ratio to the total: 0.001%)

(9) Those used in extremely low temperature environments

Those motors used in extremely low temperature environments whose ambient temperature is lower than –20°C are specially structured, for example attaching space heaters, etc., because the performance of bearing grease and insulation material deteriorates in such environments.

Those motors are excluded from the scope because 1) they are used for special applications and 2) and technical methods for measurement and evaluation have not been established.

(10) Motors made solely for inverter driving, those of external fan cooling types

Those motors are used for the load whose torque characteristics are constant such as conveyors, lifts. They drive cooling fans with different power supplies because, when operating at a low speed, if the motor outputs the same torque as that of the rating operation, the air volume from the motor's cooling fan decreases and overheats the motor.

Those motors are excluded from the scope because 2) technical methods for measurement and evaluation have not been established and 3) their use ratio in the market is extremely low.

* Number of units shipped (FY2008): 25,611 units (ratio to the total: 0.58%)
Number of units shipped (FY2009): 20,528 units (ratio to the total: 1.22%)

If above (1) to (10) are totaled, the number of those products shipped accounts for approximately 3.0% (FY2008) and approximately 6.6% (FY2009) of the total.

* The number of units shipped was quoted from the voluntary statistics of the Japan Electrical Manufacturers' Association

Meanwhile, in light of the intention of the law established for the purpose of securing effective use of fuel resources in the country, even if three-phase induction motors are shipped in the country (three-phase induction motors shipped overseas are excluded), if they are incorporated into other machines and those machines are exported overseas, they are excluded from the scope (those which indicate overseas voltage/frequency on name plates, etc. and those for which the fact that they are shipped overseas can be confirmed with their order sheets, overseas recognition marks, etc.).

Attachment 2

Target Fiscal Year, etc. of Three-phase Induction Motors

1. Target fiscal year

It is reasonable to make FY2015 the target fiscal year as it puts 5 years after the reference fiscal year 2010, considering the period needed for the development of elementary technologies, the period needed for the development of products, state of diffusion of products since then.

Meanwhile, unified performance classes (IE1: standard, IE2: high performance, IE3: premium performance) of three-phase induction motors have been specified by IEC (International Electrotechnical Commission), and based on this classification, regulations are being introduced in each country and three-phase induction motors are being traded in the worldwide market. As the regulation for three-phase induction motors is to be upgraded to IE3 in FY2015 in Europe, it is anticipated that the trend toward making high-performance three-phase induction motors is drastically accelerated in FY2015. From this viewpoint too, it is reasonable to make FY2015 the target fiscal year because it accords with the time when change is expected in Europe and Japanese manufacturers can change products and invest in equipment while maintaining their competitiveness not only in the country also in overseas markets.

2. Improvement in the target fiscal year

The improvement ratio of the energy consumption efficiency [%] in the target fiscal year is estimated to be 7.4% against the current target standard value based on the premise that the number of units shipped and the product composition of each category of FY2010 remain unchanged.

<Outline of estimation>

(1) The energy consumption efficiency per unit [%] calculated based on the three-phase induction motors actually shipped in the reference fiscal year (FY2010) making weighted averages with the number of units shipped:
Approximately 81.1 [%/unit]

(2) The energy consumption efficiency per unit [%] calculated based on the target standard values of three-phase induction motors expected to be shipped in the target fiscal year (FY2015) making weighted averages with the number of units shipped:
Approximately 87.1 [%/unit]

(3) Improvement ratio of energy consumption efficiency:

$$\frac{87.1\ [\%/\text{unit}] - 81.1\ [\%/\text{unit}]}{81.1\ [\%/\text{unit}]} \times 100 = \text{Approximately } 7.4\ [\%]$$

Attachment 3

Categories for Setting Targets for Three-phase Induction Motors

1. Basic idea

Three-phase induction motors shall be classified based on the principles referred to as “the basic idea concerning the development and revision of evaluation standards for manufacturers, etc. to be considered in relation to the improvement in performance of specific equipment” (the 10th Energy Efficiency Standards Subcommittee of the Advisory Committee for Natural Resources and Energy, revised on June 18, 2007) (hereinafter referred to as “the principles”).

“The basic idea concerning the development and revision of evaluation standards for manufacturers, etc. to be considered in relation to the improvement in performance of specific equipment”

- Extract –

Principle 2: Specific equipment is classified based on certain indices. The indices (basic indices) are those which are deeply related to energy consumption efficiency such as physical amount and functions, and they are determined considering coefficients which consumers use as criteria when choosing products (coefficients representing consumers’ needs).

Principle 3: Target standard values are determined by one value or functional formula for each category for which it is possible and appropriate to target at the same energy consumption efficiency.

Principle 4: When setting categories, additional functions are disregarded in principle. However, there may be a case in which, if the energy consumption efficiency of a product without an additional function is set as a target standard value, other products with the additional function may have to withdraw from the market because they cannot comply with the target standard value, despite the fact that the needs for the latter products are thought to be high in the market. If the probability of such case is high, then it is acceptable to make another category (sheet) for those products.

Principle 5: As regards products which are expensive but excellent in the energy consumption efficiency because of using advanced energy saving technologies, although it is possible to classify them into a separate category, it is desirable to treat them in the same category with others wherever possible so that manufacturers can actively sell the products with excellent energy consumption efficiency.

Principle 6: When setting a target standard value for a category, special products shall be excluded. However, availability of technologies employed in such special products shall be also reviewed when studying the future performance improvement possibly realized by technology development, etc.

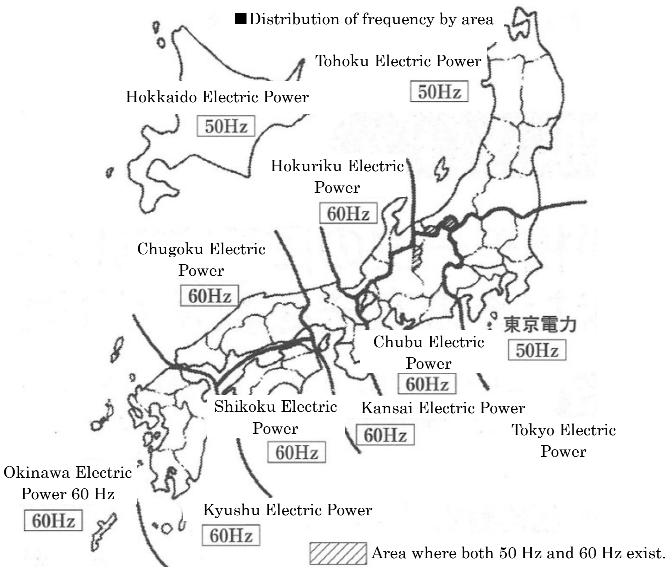
2. Specific classification method

Considering the fact that the characteristics of three-phase induction motors become different according to the frequency and the rated output and it affects their energy consumption efficiency [%], the motors are classified as follows.

(1) Classification by frequency

Japanese frequency is divided into 50 Hz in eastern Japan and 60 Hz in western Japan. As three-phase induction motors rotate at a speed proportional to the frequency, the revolution speed (the number of revolution per minute) of three-phase induction motors used in 50 Hz areas and that of three-phase induction motors used in 60 Hz areas are different.

Also, when a motor is revolving n times per second at torque [Nm], the output P [W] is calculated as



$P\,[W] = 2 \cdot \pi \cdot n \cdot T$, so, for example, if it is tried to generate the same output with motors with different number of revolution n, the torque becomes different too. (See Table 1.)

Based on this fact, the classification is made by frequency.

Table 1 Example of 37 kW Three-phase Induction Motor with 4 Poles

Power supply frequency [Hz]		50	60
Speed [min^{-1}]	Number of synchronous revolution	1500	1800
Torque [Nm]	Rated torque	242	201

(2) Classification by rated output

Three-phase induction motors are systems which convert electric energy to mechanical energy, so the rated output [kW] of three-phase induction motors as an index of the energy necessary for driving machines is a basic index for users choosing three-phase induction motors.

As three-phase induction motors are used by being incorporated into other machines such as pumps, fans, compressors, it is necessary to make their bodies compatible with current models. As a result, there are limits to the use of materials and the content of improvement such as cooling, and there are also limits to the improvement of performance depending on each output.

Based on those facts, the classification is made according to the rated output.

3. Summary of classifications

Based on the ideas stated in paragraphs 1 and 2 above, the categories for setting the target are made as per Table 2 below.

Table 2 Categories of Three-phase Induction Motors

Category	Frequency (Rated frequency or base frequency)	Rated output
1	60 Hz	0.75 kW or higher, lower than 0.925 kW
2		0.925 kW or higher, lower than 1.85 kW
3		1.85 kW or higher, lower than 4.6 kW
4		4.6 kW or higher, lower than 9.25 kW
5		9.25 kW or higher, lower than 13 kW
6		13 kW or higher, lower than 16.75 kW
7		16.75 kW or higher, lower than 26 kW
8		26 kW or higher, lower than 33.5 kW
9		33.5 kW or higher, lower than 41 kW
10		41 kW or higher, lower than 50 kW
11		50 kW or higher, lower than 100 kW
12		100 kW or higher, lower than 130 kW
13		130 kW or higher, 375 kW or lower
14	50 Hz	0.75 kW
15		1.1 kW
16		1.5 kW
17		2.2 kW
18		3 kW
19		4 kW
20		5.5 kW
21		7.5 kW
22		11 kW
23		15 kW
24		18.5 kW
25		22 kW
26		30 kW
27		37 kW
28		45 kW
29		55 kW
30		75 kW
31		90 kW
32		110 kW

33	50 Hz	132 kW
34		160 kW
35		200 to 375 kW
36		Others

4. Supplement to classifications

The method of classifying three-phase induction motors by their frequency and rated output accords with IEC or JIS. (* IEC or JIS further classifies them by the number of poles. The reason that the classification of this document did not do so is clarified in paragraph 4 of Attachment 4.)

Both IEC and JIS make the classification according to each rated output, and the performance value of rated output other than that specified by IEC or JIS is addressed differently according to the frequency, i.e. either 60 Hz or 50 Hz, as described below.

Specifically, in case of 60 Hz, an performance value of rated output other than that specified by IEC or JIS is determined by its position, i.e. whether it is equal to or higher than the middle point between rated output in front of it and rated output behind it or lower than the middle point, and the performance value up to the middle point between one rated output and the next rated output is supposed to be constant.

* For example, if rated output other than specified one is between 0.75 kW and 1.1 kW, the performance value is supposed to be constant between the point equal to or higher than 0.75 kW and the point lower than 0.925 kW (the middle point between 0.75 kW and 1.1 kW).

Meanwhile, in case of 50 Hz, the performance value of rated output other than that specified by IEC or JIS is primarily determined by putting a value in a formula, which becomes different according to output.

Considering the nature mentioned above, the classification of 60 Hz is made by giving margin to the rated output, that of 50 Hz is made for each class of rated output and a new classification is made for others which do not belong to the foregoing classifications.

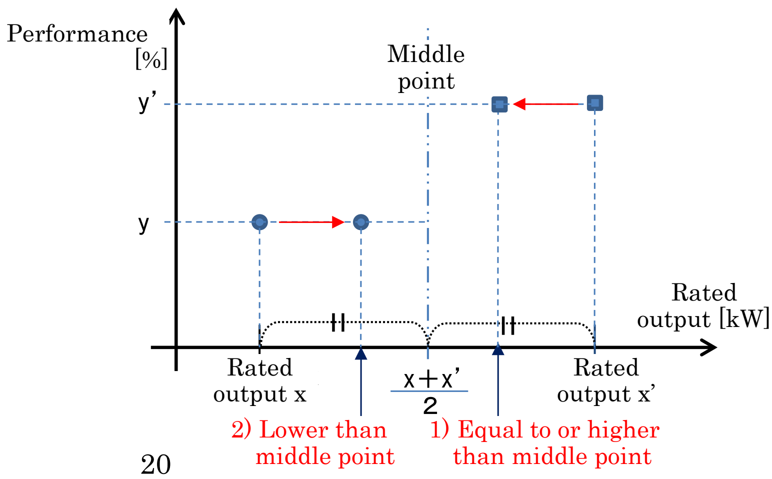
[Reference JIS C 4034-30: 2011]

60 Hz 5.4.1.2 (Excerpt)

The nominal performance value of 60 Hz rated output other than specified one is determined as follows.

- Between two continuous output ratings, the nominal performance of the rated output which is equal to or higher than the middle point shall be the higher one of two classes of nominal performance.
- Between two continuous output ratings, the nominal performance of the rated output which is lower than the middle point shall be the lower one of two classes of nominal performance.

Image of 60 Hz



[Reference JIS C 4034-30: 2011]
50 Hz 5.4.1.1 (Excerpt)

The nominal performance value of rated output (P_N) other than specified one is calculated using formula (1).

η (performance) = $A \times (\log_{10}(P_N/P_C))^3 + B \times (\log_{10}(P_N/P_C))^2 + C \times \log_{10}(P_N/P_C) + D$... (1)

Where, A, B, C and D: Interpolation coefficient Pc [kW]: 1 [kW]

IE code	Interpolation coefficient	2 poles	4 poles	6 poles
IE3	A	0.3569	0.0773	0.1252
	B	–3.3076	–1.8951	–2.6130
	C	11.6108	9.2984	11.9963
	D	82.2503	83.7025	80.4769

Attachment 4

Target Standard Values for Three-phase Induction Motors

1. Basic idea

Target standard values are set based on the idea of Top Runner method. The specific ideas are as follows.

1) Target standard values shall be set for every category that has been defined appropriately.
2) As for categories where technological advances in the future are expected to improve the performance of products, target standard values shall allow for improvement as much as possible.
3) Target standard values shall not conflict with each other among categories.

2. Specific technologies for improving energy consumption efficiency

To improve the performance of three-phase induction motors, it is important to reduce the loss occurring when converting electric energy to mechanical energy.

The loss is classified mainly into fixed loss (iron loss and machine loss), load loss (primary copper loss and secondary copper loss) and stray load loss and they are closely related to each other, so it is necessary to reduce each type of loss with a good balance. There are specific examples of the reduction as follows.

(a) Improvement of material for magnetic steel sheet

The magnetic steel sheet constituting the iron core shall be changed to the type with less iron loss [W/kg].

(b) Improvement of stator side and rotor side

Although it is possible to reduce the iron loss with the improvement (a), this method conversely lowers the magnetic flux density, reduces the magnetic flux in the motor, increases the current for compensating for the reduction of the magnetic flux and increases copper loss or stray load loss, so it is also necessary to improve the stator side and the rotor side.

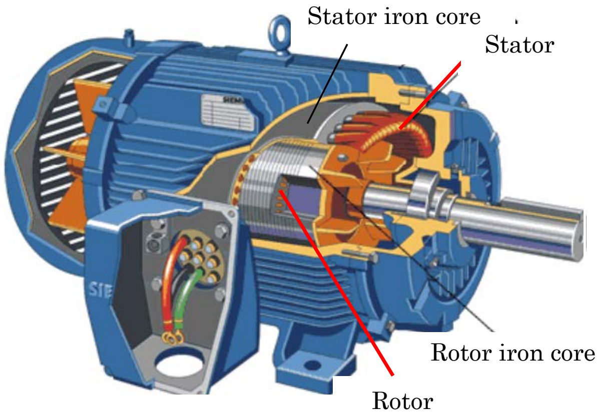


Figure 1: Structural Drawing of Three-phase Induction Motor

Examples of improvement of stator side

- Increase of conductor's cross-section area: Change of the iron core shape so that it can contain more conductors (coils)
- Shortening of winding edge length: Reduction of resistance by making the winding length shorter
- Improvement of winding's occupancy ratio: Increase of coil volume in the iron core slot

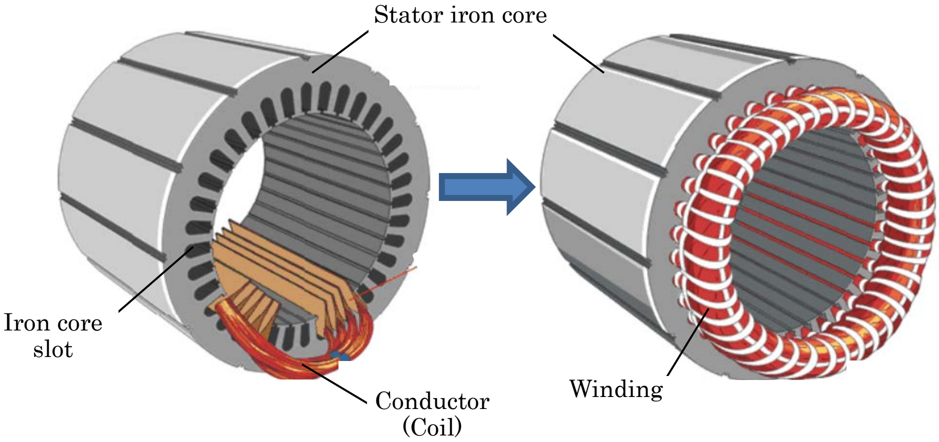


Figure 2: Structural Drawing of Stator

Examples of improvement of rotor side

- Increase of conductor's cross-section area: Change of iron core shape so that it can increase the occupancy ratio of the conductor (the cage portion), increase of the aluminum filling ratio of the cage portion
- Insulation and thermal treatment of rotor's grooves: Enhancement of insulation between the conductor and the iron core

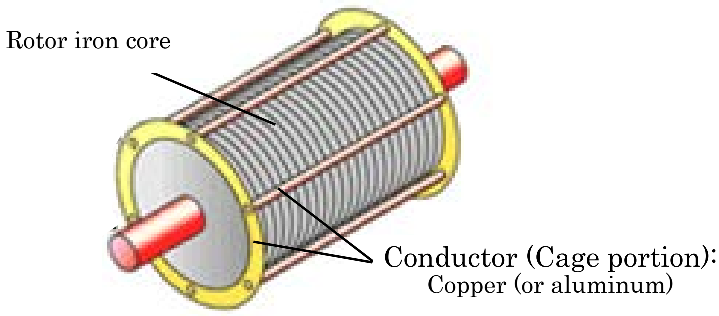


Figure 3: Structural Drawing of Rotor

3. Specific target standard values

According to the category of three-phase induction motors, Top Runner values were obtained from actually measured values of the energy consumption efficiency [%] of each class of the rated output in FY2010 as a reference year to study the target standard values.

The majority of three-phase induction motors in the country are currently IE1 and high-performance types are few. (Reference 1: Current State of Three-phase Induction Motors (the first committee explanation data))

IE1 to IE3 and Top Runner values are shown in Figure 4 to Figure 9 below. If these results are summarized based on the characteristics of 4 poles using the ratios of the performance values of IE1, IE2 and IE3 (converting 2 poles to 4 poles and converting 6 poles to 4 poles), Figure 4 to Figure 6 are consolidated into Figure 10 and Figure 7 to Figure 9 are consolidated into Figure 11.

Based on the results above and the technical improvements stated in paragraph 2 above, the highest performance classes (IE3) among the regulations implemented by each country for its three-phase induction motors were set as the target standard values (as per Table 1. As regards Note 1 to Note 4, details are stated in paragraph 4).

As a result, improvement 0.6% over the Top Runner value (6.2% over IE1) is expected for 60 Hz and improvement 0.8% over the Top Runner value (8.8% over IE1) is expected for 50 Hz.

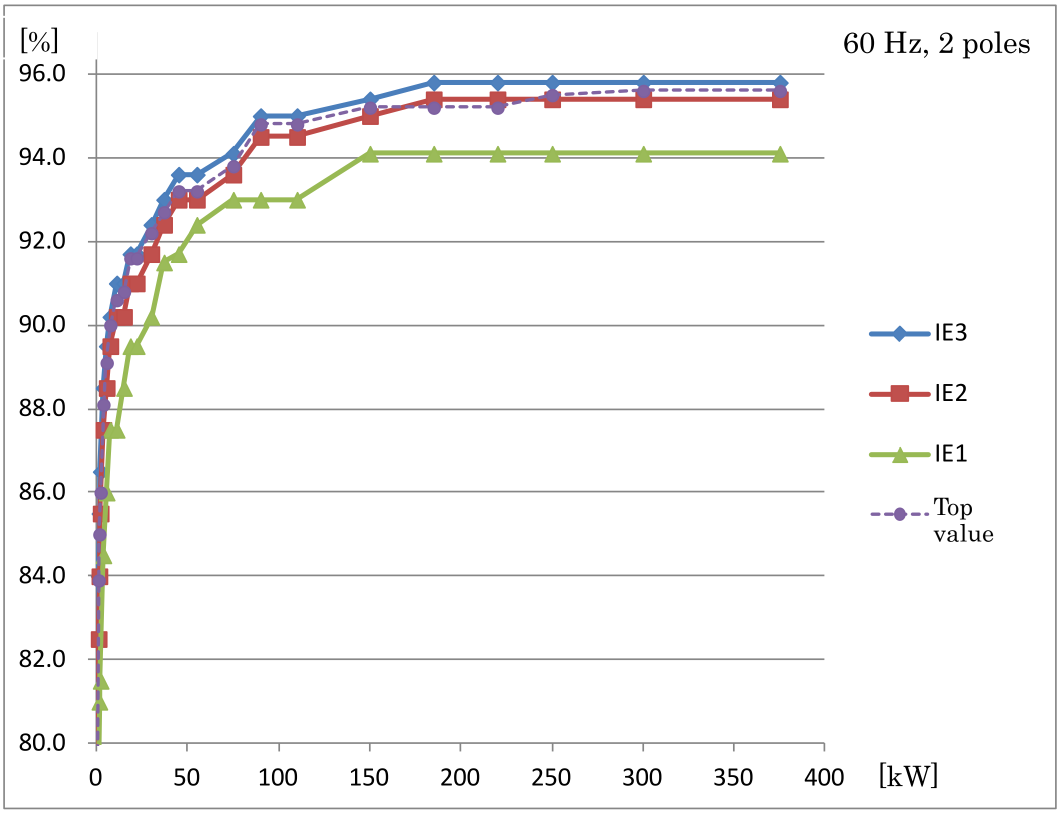


Figure 4: Energy Consumption Efficiency at Rated Output of 60 Hz (2 Poles)

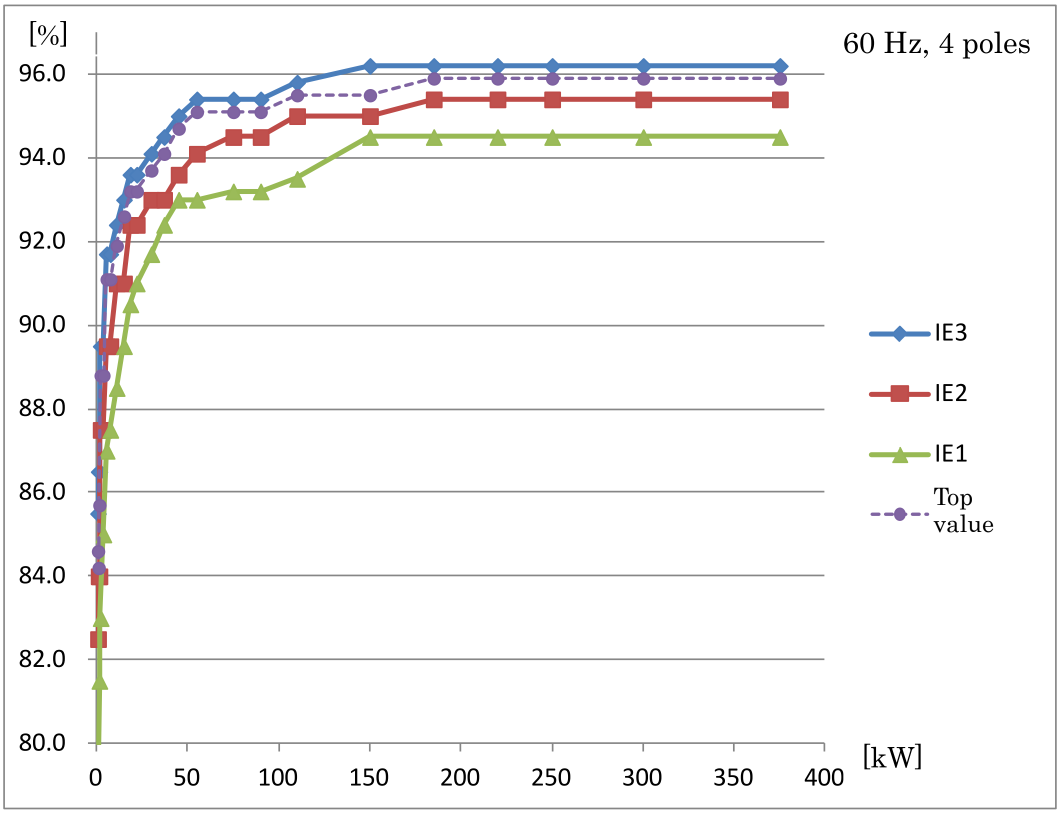


Figure 5: Energy Consumption Efficiency at Rated Output of 60 Hz (4 Poles)

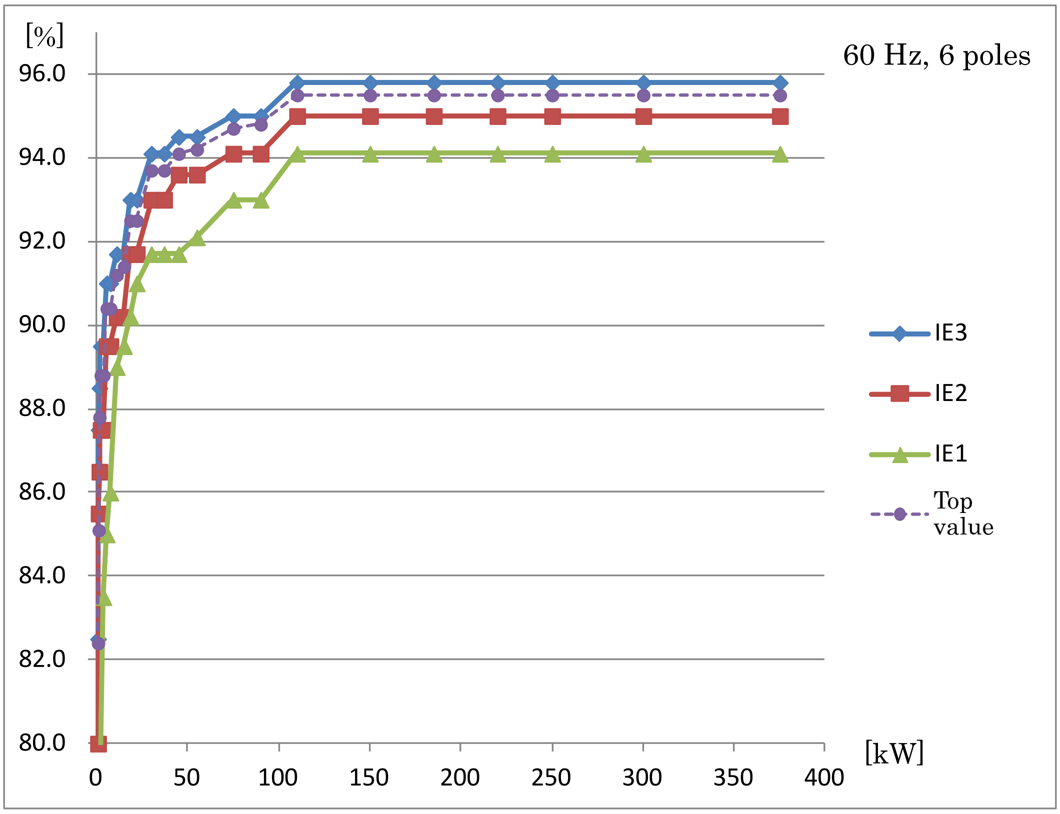


Figure 6: Energy Consumption Efficiency at Rated Output of 60 Hz (6 Poles)

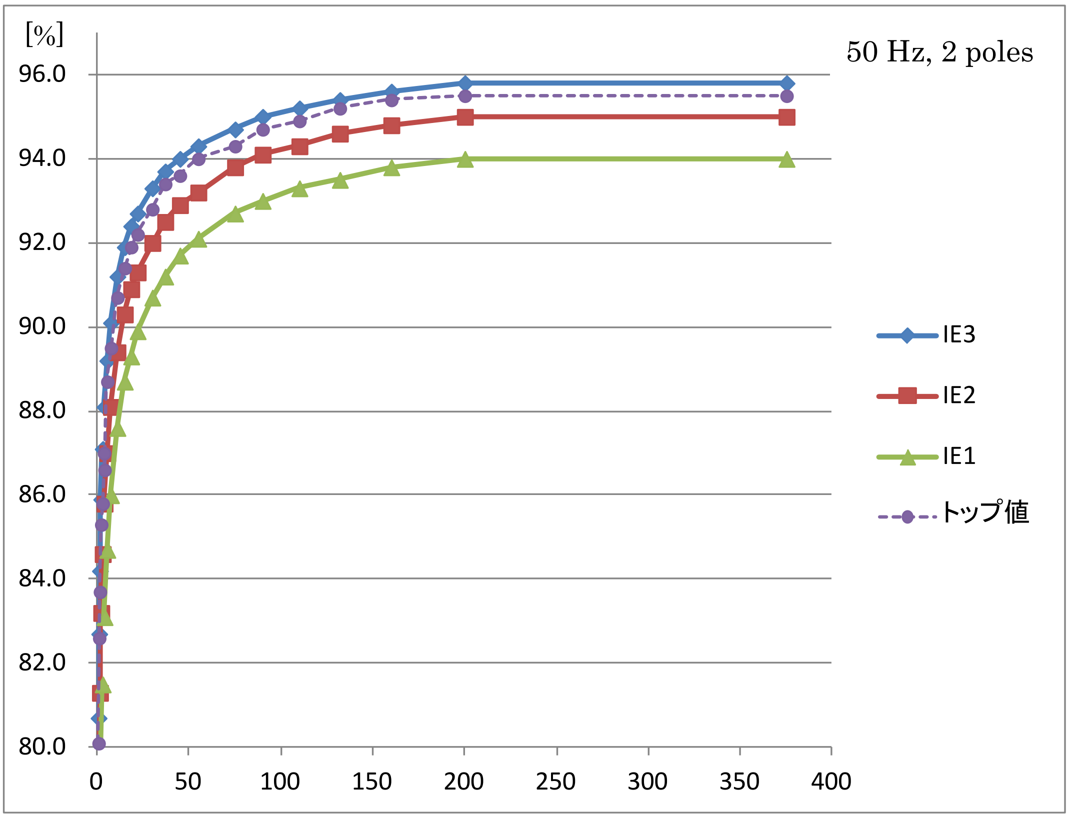


Figure 7: Energy Consumption Efficiency at Rated Output of 50 Hz (2 Poles)

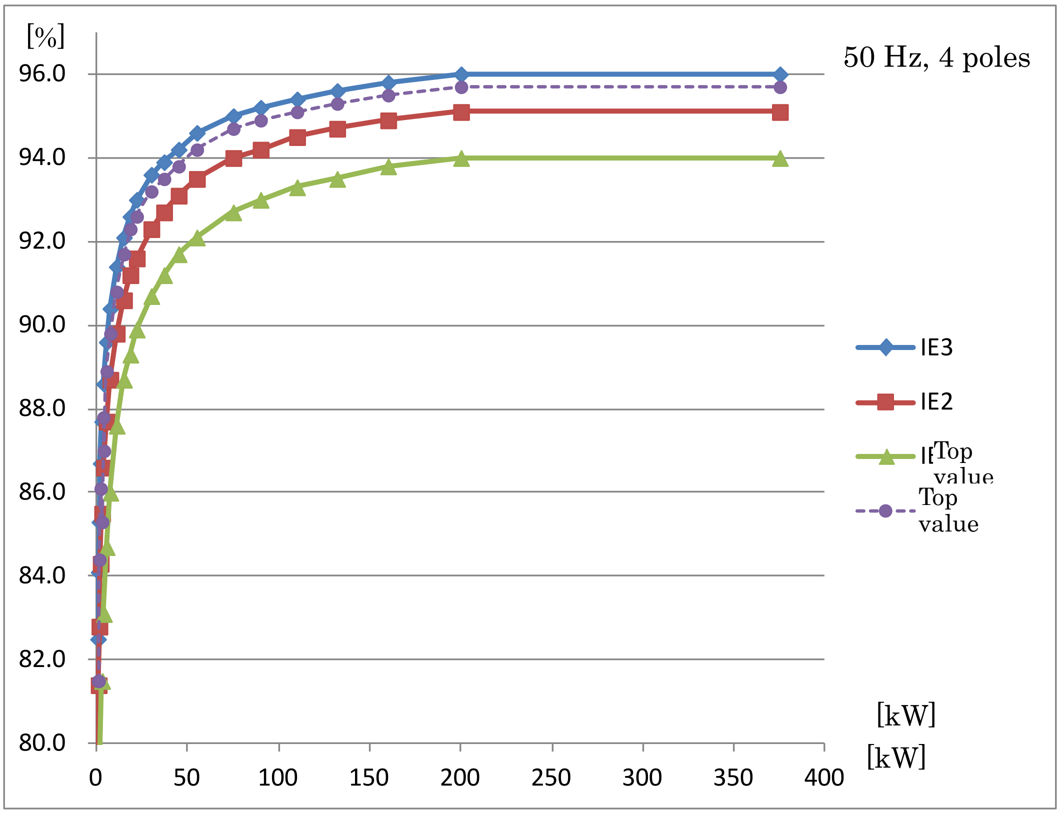


Figure 8: Energy Consumption Efficiency at Rated Output of 50 Hz (4 Poles)

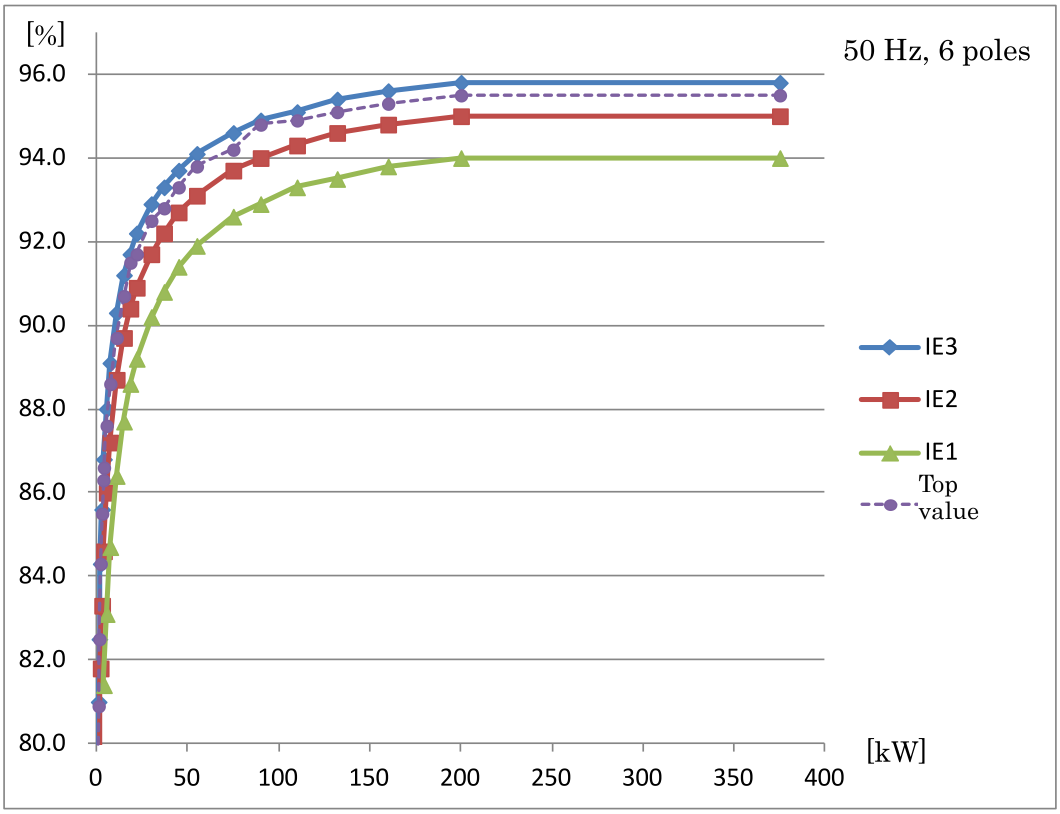


Figure 9: Energy Consumption Efficiency at Rated Output of 50 Hz (6 Poles)

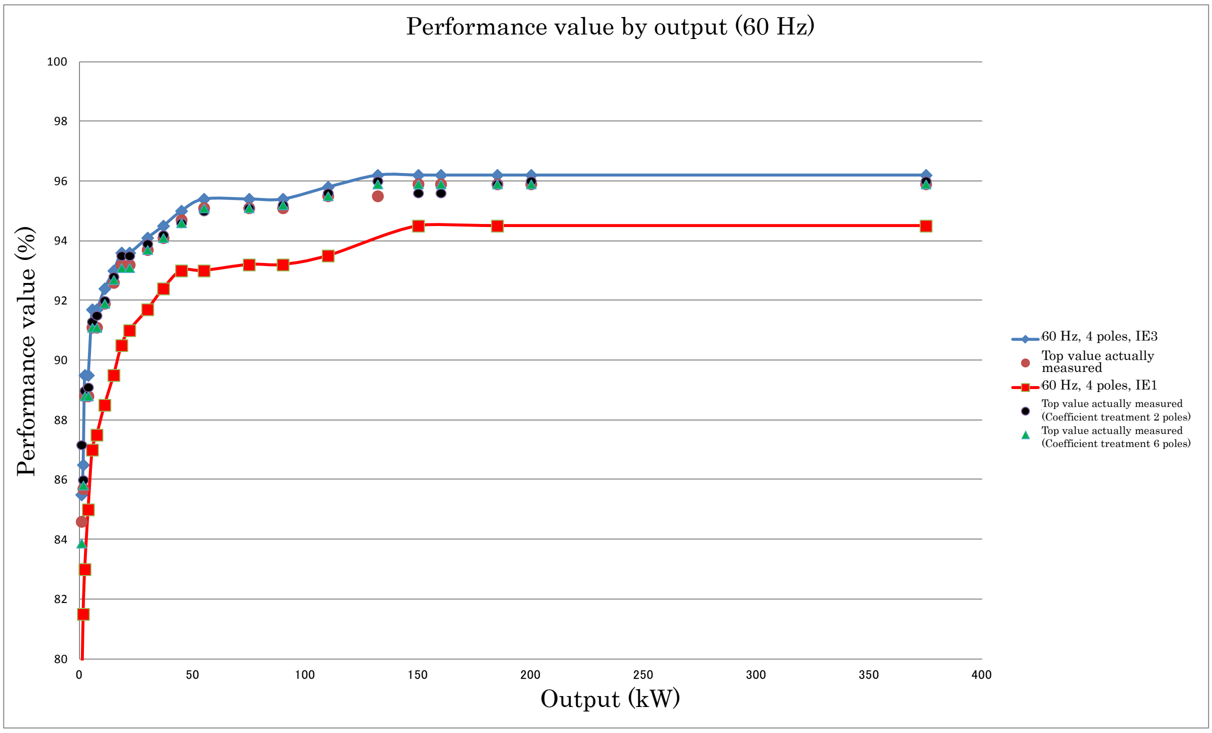


Figure 10: Energy Consumption Efficiency at Rated Output of 60 Hz

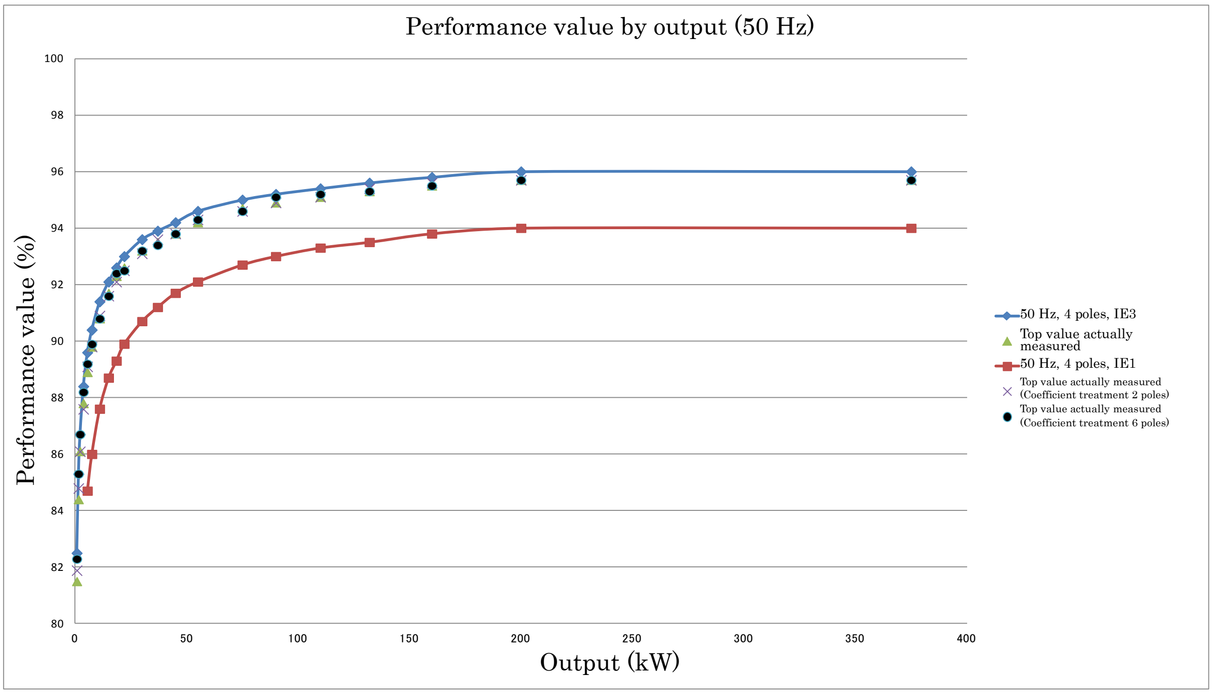


Figure 11: Energy Consumption Efficiency at Rated Output of 50 Hz

Table 1 Standard Energy Consumption Efficiency of Three-phase Induction Motors

Category	Rated frequency or base frequency	Rated output	Target standard value [%]
1	60 Hz	0.75 kW or higher, lower than 0.925 kW	85.5
2		0.925 kW or higher, lower than 1.85 kW	86.5
3		1.85 kW or higher, lower than 4.6 kW	89.5
4		4.6 kW or higher, lower than 9.25 kW	91.7
5		9.25 kW or higher, lower than 13 kW	92.4
6		13 kW or higher, lower than 16.75 kW	93.0
7		16.75 kW or higher, lower than 26 kW	93.6
8		26 kW or higher, lower than 33.5 kW	94.1
9		33.5 kW or higher, lower than 41 kW	94.5
10		41 kW or higher, lower than 50 kW	95.0
11		50 kW or higher, lower than 100 kW	95.4
12		100 kW or higher, lower than 130 kW	95.8
13		130 kW or higher, 375 kW or lower	96.2
14	50 Hz	0.75 kW	82.5
15		1.1 kW	84.1
16		1.5 kW	85.3
17		2.2 kW	86.7
18		3 kW	87.7
19		4 kW	88.6
20		5.5 kW	89.6
21		7.5 kW	90.4
22		11 kW	91.4
23		15 kW	92.1
24		18.5 kW	92.6
25		22 kW	93.0
26		30 kW	93.6
27		37 kW	93.9
28		45 kW	94.2
29		55 kW	94.6
30		75 kW	95.0
31		90 kW	95.2
32		110 kW	95.4
33		132 kW	95.6

34	50 Hz	160 kW	95.8
35		200 to 375 kW	96.0
36		Others	Note 2

Note 1. The evaluation is made using the values obtained by multiplying the energy consumption efficiency obtained by measurement by the coefficients a to f listed in Table 2 and Table 3, then rounding off the second place after the decimal point of those values thus obtained.

In case of output other than rated output listed in Table 2 (60 Hz), if the output in question is equal to or higher than the middle point between two of the rated output which are one class higher and lower than the output in question, the coefficients a to c of the higher rated output are used, and if the output in question is lower than said middle point, the coefficients a to c of the lower rated output are used.

Table 2 Coefficients of Each Output of 60 Hz

Rated output	2 poles	4 poles	6 poles
[kW]	Coefficient a	Coefficient b	Coefficient c
0.75	1.1104	1.0000	1.0364
1.1	1.0298	1.0000	0.9886
1.5	1.0117	1.0000	0.9774
2.2	1.0347	1.0000	1.0000
3.7	1.0113	1.0000	1.0000
5.5	1.0246	1.0000	1.0077
7.5	1.0166	1.0000	1.0077
11	1.0154	1.0000	1.0076
15	1.0220	1.0000	1.0142
18.5	1.0207	1.0000	1.0065
22	1.0207	1.0000	1.0065
30	1.0184	1.0000	1.0000
37	1.0161	1.0000	1.0043
45	1.0150	1.0000	1.0053
55	1.0192	1.0000	1.0095
75	1.0138	1.0000	1.0042
90	1.0042	1.0000	1.0042
110	1.0084	1.0000	1.0000
150	1.0084	1.0000	1.0042
185 to 375	1.0042	1.0000	1.0042

Table 3 Coefficients of Each Output of 50 Hz

Rated output	2 poles	4 poles	6 poles
[kW]	Coefficient d	Coefficient e	Coefficient f
0.75	1.0223	1.0000	1.0456
1.1	1.0169	1.0000	1.0383
1.5	1.0131	1.0000	1.0339
2.2	1.0093	1.0000	1.0285
3	1.0069	1.0000	1.0245
4	1.0057	1.0000	1.0207
5.5	1.0045	1.0000	1.0182
7.5	1.0033	1.0000	1.0146
11	1.0022	1.0000	1.0122
15	1.0022	1.0000	1.0099
18.5	1.0022	1.0000	1.0098
22	1.0032	1.0000	1.0087
30	1.0032	1.0000	1.0075
37	1.0021	1.0000	1.0064
45	1.0021	1.0000	1.0053
55	1.0032	1.0000	1.0053
75	1.0032	1.0000	1.0042
90	1.0021	1.0000	1.0032
110	1.0021	1.0000	1.0032
132	1.0021	1.0000	1.0021
160	1.0021	1.0000	1.0021
200 to 375	1.0021	1.0000	1.0021

Note 2. The target standard value (η: %) of category 36 listed in Table 1 shall be the value calculated by the following formula.

$$\eta = A\times(\log_{10}(P_N/P_C))^3 + B\times(\log_{10}(P_N/P_C))^2 + C\times\log_{10}(P_N/P_C) + D$$

Where, P_N [kW]: Rated output

P_C [kW]: 1 [kW] (for making P_N non dimensional)

A, B, C and D: Interpolation coefficients

A	B	C	D
0.0773	−1.8951	9.2984	83.7025

However, as regards those whose number of poles is 2 poles and 6 poles, the evaluation shall be made using the value calculated by multiplying the energy consumption efficiency obtained by measurement by coefficient g in case of 2 poles or coefficient h in case of 6 poles (rounding off the second place after the decimal point).

$$\text{Coefficient } g = \frac{A \times (\log_{10}(P_N/P_C))^3 + B \times (\log_{10}(P_N/P_C))^2 + C \times \log_{10}(P_N/P_C) + D}{A' \times (\log_{10}(P_N/P_C))^3 + B' \times (\log_{10}(P_N/P_C))^2 + C' \times \log_{10}(P_N/P_C) + D'}$$

Where, P_N [kW]: Rated output

P_C [kW]: 1 [kW] (for making P_N non dimensional)

A', B', C' and D': Interpolation coefficients

A'	B'	C'	D'
0.3569	−3.3076	11.6108	82.2503

$$\text{Coefficient } h = \frac{A \times (\log_{10}(P_N/P_C))^3 + B \times (\log_{10}(P_N/P_C))^2 + C \times \log_{10}(P_N/P_C) + D}{A'' \times (\log_{10}(P_N/P_C))^3 + B'' \times (\log_{10}(P_N/P_C))^2 + C'' \times \log_{10}(P_N/P_C) + D''}$$

Where, P_N [kW]: Rated output

P_C [kW]: 1 [kW] (for making P_N non dimensional)

A", B", C" and D": Interpolation coefficients

A″	B″	C″	D″
0.1252	−2.6130	11.9963	80.4769

Note 3. If shipped including 3 ratings (6 ratings), as regards 200 V/60 Hz (400 V/60 Hz), the evaluation shall be made using the value obtained by multiplying the energy consumption efficiency obtained by measurement by each of the coefficient i to k listed in Table 4 and rounding off the second place after the decimal point.

The 3 ratings and 6 ratings are defined as follows.

3 ratings: 200 V/50 Hz, 200 V/60 Hz, 220 V/60 Hz or
400 V/50 Hz, 400 V/60 Hz, 440 V/60 Hz

6 ratings: 200 V/50 Hz, 200 V/60 Hz, 220 V/60 Hz, 400 V/50 Hz, 400 V/60 Hz, 440 V/60 Hz

Table 4 Coefficient of Each Rated Output of 3 Ratings (6 Ratings)

Rated output [kW]	2 poles	4 poles	6 poles
	Coefficient i	Coefficient j	Coefficient k
0.75	1.1325	1.0130	1.0452
1.1	1.0485	1.0188	1.0023
1.5	1.0298	1.0188	0.9908
2.2	1.0468	1.0147	1.0170
3.7	1.0229	1.0147	1.0170
5.5	1.0362	1.0099	1.0246
7.5	1.0246	1.0099	1.0246
11	1.0244	1.0109	1.0221
15	1.0310	1.0142	1.0288
18.5	1.0286	1.0119	1.0207
22	1.0286	1.0119	1.0207
30	1.0262	1.0107	1.0107
37	1.0227	1.0107	1.0150
45	1.0215	1.0106	1.0128
55	1.0258	1.0032	1.0171
75	1.0192	1.0032	1.0117
90	1.0095	1.0032	1.0117
110	1.0138	1.0042	1.0074
150	1.0126	1.0042	1.0116
185 to 375	1.0084	1.0042	1.0116

Note 4. As regards the number of units shipped by each business operator, if the shipment is made including 3 ratings (6 ratings) listed in Note 3, the quantity ratios listed in Table 5 shall be used to calculate the quantity of each rating. In the calculation, the first place after the decimal point is rounded off to obtain an integer value and, if it is necessary to adjust fractional quantity, the adjustment shall be made with the rating whose quantity ratio is highest.

Table 5 Quantity Ratio of Each Voltage and Frequency of 3 Ratings (6 Ratings)

Rated voltage	200 V		220 V
Rated frequency	50 Hz	60 Hz	
Quantity ratio	50%	30%	20%

Rated voltage	400 V		440 V
Rated frequency	50 Hz	60 Hz	
Quantity ratio	50%	30%	20%

Rated voltage	200 V		220 V	400 V		440 V
Rated frequency	50 Hz	60 Hz		50 Hz	60 Hz	
Quantity ratio	40%	25%	10%	10%	5%	10%

4. Correction coefficients related to the setting of target standard values

(1) Correction coefficients based on the number of poles (Idea of Note 1 of Table 1)

The number of poles of the target three-phase induction motors is 2 poles, 4 poles and 6 poles but, as Table 6 shows, of approximately 100 million motors so far diffused in the country, those with 4 poles account for approximately 65%.

When setting a target standard value for each category, it is desirable to widen the scope of each category as much as possible in light of promoting energy conservation to the maximum, so, using 4 poles as the base (making the correction coefficient 1), and by setting a correction coefficient for each energy consumption efficiency of 2 poles and 6 poles, 2 poles, 4 poles and 6 poles are evaluated in the same category.

The correction coefficients are calculated as shown in Table 7 and Table 8 using the performance ratio of IE3 specified by the international standard IEC 60034-30 and Japanese Industrial Standards JIS C 4034-30.

Table 6 Quantity and Ratio of 2 Poles, 4 Poles and 6 Poles Diffused in the Country

	2 poles	4 poles	6 poles	Total
Quantity [Units]	27,981,200	62,294,954	5,998,316	96,274,470
Ratio [%]	29.1	64.7	6.2	100

* Source: Excerpted from survey report on energy consumption equipment (Business commissioned by Agency for Natural Resources and Energy in 2010)

Table 7 Calculation Basis of Coefficient for Each Rated Output of 60 Hz

Rated output [kW]	[60 Hz] IE3 performance value and ratio				
	2 poles [%]	4 poles/2 poles (coefficient a)	4 poles [%]	4 poles/6 poles (coefficient c)	6 poles [%]
0.75	77.0	1.1104	85.5	1.0364	82.5
1.1	84.0	1.0298	86.5	0.9886	87.5
1.5	85.5	1.0117	86.5	0.9774	88.5
2.2	86.5	1.0347	89.5	1.0000	89.5
3.7	88.5	1.0113	89.5	1.0000	89.5
5.5	89.5	1.0246	91.7	1.0077	91.0
7.5	90.2	1.0166	91.7	1.0077	91.0
11	91.0	1.0154	92.4	1.0076	91.7
15	91.0	1.0220	93.0	1.0142	91.7
18.5	91.7	1.0207	93.6	1.0065	93.0
22	91.7	1.0207	93.6	1.0065	93.0
30	92.4	1.0184	94.1	1.0000	94.1
37	93.0	1.0161	94.5	1.0043	94.1
45	93.6	1.0150	95.0	1.0053	94.5
55	93.6	1.0192	95.4	1.0095	94.5
75	94.1	1.0138	95.4	1.0042	95.0
90	95.0	1.0042	95.4	1.0042	95.0
110	95.0	1.0084	95.8	1.0000	95.8
150	95.4	1.0084	96.2	1.0042	95.8
185 to 375	95.8	1.0042	96.2	1.0042	95.8

Table 8 Calculation Basis of Coefficient for Each Rated Output of 50 Hz

Rated output [kW]	[50 Hz] IE3 performance value and ratio				
	2 poles [%]	4 poles/2 poles (coefficient d)	4 poles [%]	4 poles/6 poles (coefficient f)	6 poles [%]
0.75	80.7	1.0223	82.5	1.0456	78.9
1.1	82.7	1.0169	84.1	1.0383	81.0
1.5	84.2	1.0131	85.3	1.0339	82.5
2.2	85.9	1.0093	86.7	1.0285	84.3
3	87.1	1.0069	87.7	1.0245	85.6
4	88.1	1.0057	88.6	1.0207	86.8
5.5	89.2	1.0045	89.6	1.0182	88.0
7.5	90.1	1.0033	90.4	1.0146	89.1
11	91.2	1.0022	91.4	1.0122	90.3
15	91.9	1.0022	92.1	1.0099	91.2
18.5	92.4	1.0022	92.6	1.0098	91.7
22	92.7	1.0032	93.0	1.0087	92.2
30	93.3	1.0032	93.6	1.0075	92.9
37	93.7	1.0021	93.9	1.0064	93.3
45	94.0	1.0021	94.2	1.0053	93.7
55	94.3	1.0032	94.6	1.0053	94.1
75	94.7	1.0032	95.0	1.0042	94.6
90	95.0	1.0021	95.2	1.0032	94.9
110	95.2	1.0021	95.4	1.0032	95.1
132	95.4	1.0021	95.6	1.0021	95.4
160	95.6	1.0021	95.8	1.0021	95.6
200 to 375	95.8	1.0021	96.0	1.0021	95.8

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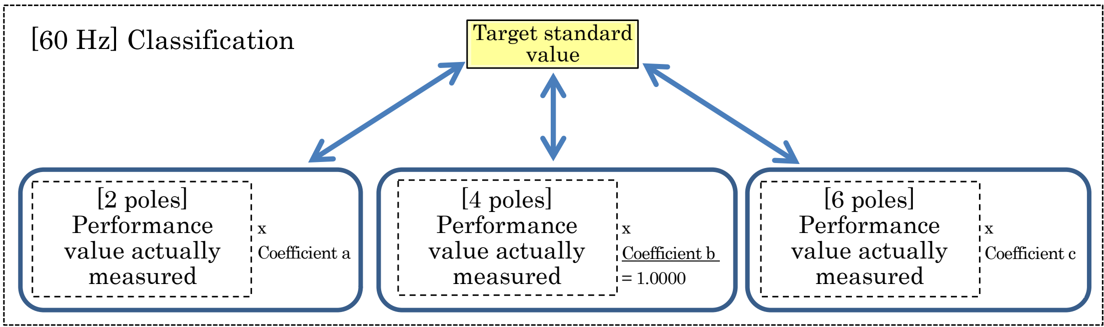

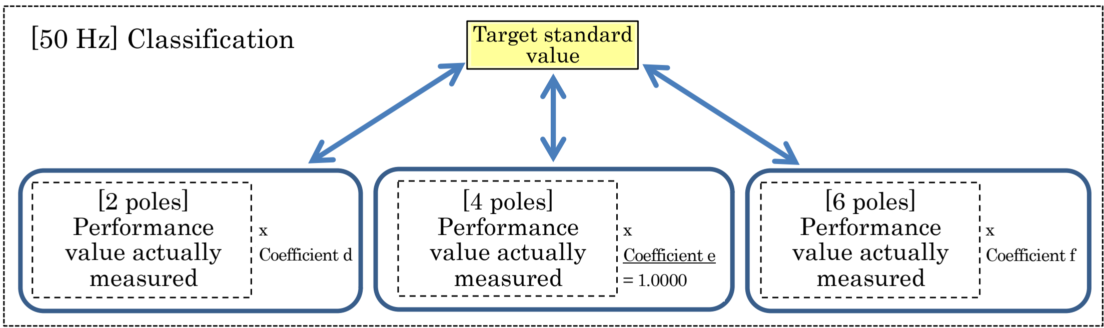

(2) Idea of Category 36 (Idea of Note 2 of Table 1)

The performance value [%] of rated output other than the representative output shall be calculated by the method specified by the international standard IEC 60034-30 and Japanese Industrial Standards JIS C 4034-30.

[Reference JIS C 4034-30: 2011]

50 Hz 5.4.1.1 (Excerpt)

The nominal performance value of rated output other (P_N) than specified one is calculated using formula (1).

$$\eta \text{ (Performance)} = A \times (\log_{10}(P_N/P_C))^3 + B \times (\log_{10}(P_N/P_C))^2 + C \times \log_{10}(P_N/P_C) + D \quad \dots (1)$$

Where, A, B, C and D: Interpolation coefficient Pc [kW]: 1 [kW]

IE code	Interpolation coefficient	2 poles	4 poles	6 poles
IE3	A	0.3569	0.0773	0.1252
	B	–3.3076	–1.8951	–2.6130
	C	11.6108	9.2984	11.9963
	D	82.2503	83.7025	80.4769

The “target standard value α” is calculated by putting the rated output value and the interpolation coefficients (A to D) of 4 poles into the formula described in the frame above (hereinafter called “Formula 1”).

Here, if the number of poles is 4 poles, the evaluation is made between “target standard value α” and the “performance value actually measured”, and, if the number of poles is 2 poles and 6 poles, the evaluation is made between “target standard value α” and the “value calculated by multiplying the performance value actually measured by the correction coefficient”. Each correction coefficient (g and h) is as follows.

2 poles

$$\text{Coefficient } g = \frac{\text{Value obtained by putting the rated output and the interpolation coefficients (A to D) of 4 poles into Formula (1)}}{\text{Value obtained by putting the rated output and the interpolation coefficients (A to D) of 2 poles into Formula (1)}}$$

6 poles

$$\text{Coefficient } h = \frac{\text{Value obtained by putting the rated output and the interpolation coefficients (A to D) of 4 poles into Formula (1)}}{\text{Value obtained by putting the rated output and the interpolation coefficients (A to D) of 6 poles into Formula (1)}}$$

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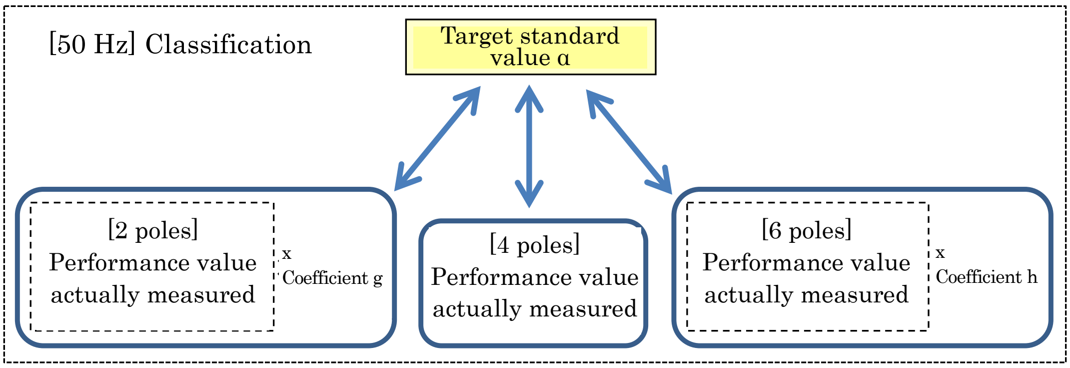

(3) About correction coefficients by 3 ratings (6 ratings) (Idea of Note 3 of Table 1)

Since Japanese frequency is divided into 50 Hz in eastern Japan and 60 Hz in western Japan, motors and machines incorporating motors are manufactured as products compatible with both 200 (400) V/50 Hz and 200 (400) V/60 Hz. However, as the performances of torque of 200 (400) V/60 Hz is inferior to that of 200 (400) V/50 Hz and it is difficult for 200 (400) V/60 Hz to have the same performance as that of 200 (400) V/50 Hz, three-phase induction motors with 3 ratings (200 V/50 Hz, 200 V/60 Hz, and 220 V/60 Hz or 400 V/50 Hz, 400 V/60 Hz and 440 V/60 Hz) adding 220 (440) V/60 Hz which realizes the performance closer to that of 200 (400) V/50 Hz or 6 ratings (200 V/50 Hz, 200 V/60 Hz, 220 V/60 Hz, 400 V/50 Hz, 400 V/60 Hz and 440 V/60 Hz) have been introduced.

Here, if the same performance value as that of 220 V/60 Hz (440 V/60 Hz) is sought from 200 V/60 Hz (400 V/60 Hz), the voltage drops, increasing the loss, and it becomes necessary to take measures such as making the body bigger in order to satisfy a equivalent performance value, which seriously affects the market.

Therefore, as regards the performance value of 200 V/60 Hz (400 V/60 Hz) of three-phase induction motors shipped including 3 ratings (6 ratings), the evaluation shall be made between the "values obtained by multiplying the performance values actually measured by the correction coefficients listed in Table 4 of Note 3 above" and the "target standard values" of Table 1.

To set specific correction coefficients i, j and k (Table 4 of Note 3), firstly, the ratios (value obtained by dividing the energy consumption efficiency of 200 V/60 Hz by that of 220 V/60 Hz) of 220 V/60 Hz and 200 V/60 Hz of typical three-phase induction motors with 3 ratings complying with IE2 shipped in the domestic market were calculated (however, if the performance value of 200 V/60 Hz is lower than the nominal performance of IE2, the ratio of IE2/IE3 was taken).

Then, each correction performance value (fields II, III and IV of Table 9 in the next page) was obtained by multiplying the above mentioned values by the performance values of 2 poles, 4 poles and 6 poles of IE3.

Based on the calculation above, the correction coefficients (i, j and k) by 3 ratings (6 ratings) were made to be the values obtained by dividing the target standard values of 60 Hz (field I of Table 9) by the correction performance values (fields II, III and IV of Table 9) respectively.

Table 9 Calculation of Coefficient of Each Rated Output by 3 Ratings (6 Ratings)

Rated output		2 poles		4 poles		6 poles	
[kW]	[60 Hz] Target standard value: I [%]	Correction performance value: II [%]	Coefficient i (= I/II)	Correction performance value: III [%]	Coefficient j (= I/III)	Correction performance value: IV [%]	Coefficient k (= I/IV)
0.75	85.5	75.5	1.1325	84.4	1.0130	81.8	1.0452
1.1	86.5	82.5	1.0485	84.9	1.0188	86.3	1.0023
1.5	86.5	84.0	1.0298	84.9	1.0188	87.3	0.9908
2.2	89.5	85.5	1.0468	88.2	1.0147	88.0	1.0170
3.7	89.5	87.5	1.0229	88.2	1.0147	88.0	1.0170
5.5	91.7	88.5	1.0362	90.8	1.0099	89.5	1.0246
7.5	91.7	89.5	1.0246	90.8	1.0099	89.5	1.0246
11	92.4	90.2	1.0244	91.4	1.0109	90.4	1.0221
15	93.0	90.2	1.0310	91.7	1.0142	90.4	1.0288
18.5	93.6	91.0	1.0286	92.5	1.0119	91.7	1.0207
22	93.6	91.0	1.0286	92.5	1.0119	91.7	1.0207
30	94.1	91.7	1.0262	93.1	1.0107	93.1	1.0107
37	94.5	92.4	1.0227	93.5	1.0107	93.1	1.0150
45	95.0	93.0	1.0215	94.0	1.0106	93.8	1.0128
55	95.4	93.0	1.0258	95.1	1.0032	93.8	1.0171
75	95.4	93.6	1.0192	95.1	1.0032	94.3	1.0117
90	95.4	94.5	1.0095	95.1	1.0032	94.3	1.0117
110	95.8	94.5	1.0138	95.4	1.0042	95.1	1.0074
150	96.2	95.0	1.0126	95.8	1.0042	95.1	1.0116
185 to 375	96.2	95.4	1.0084	95.8	1.0042	95.1	1.0116

(4) About number of units shipped if shipped as 3 ratings (6 ratings) as listed in Note 3 (Ideas of Note 4 of Table 1)

In case of three-phase induction motors having 3 ratings or 6 ratings, each unit has multiple levels of energy consumption efficiency.

Meanwhile, when evaluating target standard values, it is required that the value making the weighted average of the energy consumption efficiency measured as set forth in Attachment 5 with the number of units shipped by each business operator in each category, considering the matters stated in Notes 1 to 4 (P31 to P34), does not become lower than the target standard value, so it is necessary to know the number of units of each rating from the number of three-phase induction motors shipped.

Therefore, based on the result of the survey on the actual use by end users, which was obtained in the business commissioned in 2010, the quantity ratios were obtained as per Table 10 and, using these ratios, the number of units shipped for each rating was calculated.

Table 10 Quantity Ratios of Each Voltage and Frequency of 3 Ratings (6 Ratings)

Rated voltage	200 V		220 V
Rated frequency	50 Hz	60 Hz	
Quantity ratio	50%	30%	20%

Rated voltage	400 V		440 V
Rated frequency	50 Hz	60 Hz	
Quantity ratio	50%	30%	20%

Rated voltage	200 V		220 V	400 V		440 V
Rated frequency	50 Hz	60 Hz		50 Hz	60 Hz	
Quantity ratio	40%	25%	10%	10%	5%	10%

Attachment 5

Energy Consumption Efficiency of Three-phase Induction Motors and its Measuring Method

1. Basic idea

The energy consumption efficiency of three-phase induction motors and its measuring method shall be the performance obtained by the method specified by Japanese Industrial Standards JIS C 4034-2-1 "Rotating electrical machines - Part 2-1: Methods for determining losses and efficiency from tests of single-speed, three-phase, cage-induction motors" (hereinafter called JIS C 4034-2-1).

2. Specific energy consumption efficiency and its measuring method

(1) Energy consumption efficiency

The energy consumption efficiency of three-phase induction motors shall be the ratio (%) of output (W) against input (W) and it is calculated by the following formula inputting the input P_1 (W) and the total loss P_T (W) obtained by the rated load test conducted according to the rated load temperature test [6.4.4.1].

$$\text{Efficiency (\%)} = (P_1 - P_T)/P_1 \times 100$$

Where, the total loss P_T is obtained as the sum of fixed loss [8.2.2.3], load loss [8.2.2.4.1 (calculation method for load loss in the load test)] and stray load loss [8.2.2.5.1 (calculation method for stray load loss in the load test which measures torque)].

* The number in [ ] corresponds to the item number of JIS C 4034-2-1.

(2) Method for measuring energy consumption efficiency

The method of measuring three-phase induction motors shall be the test method with "low" uncertainty using commercial power supply specified by JIS C 4034-2-1.

However, the performance test for motors with auxiliary mechanisms specified by 5.1.3 of Japanese Industrial Standards JIS C 4034-30 "Rotating electrical machines - Part 30: Efficiency classes of single-speed, three-phase, cage-induction motors (IE code)" shall be conducted without attaching the auxiliary mechanisms unless they are indispensable for the structure of the motor to be tested. As regards motors made solely for inverter driving, the measurement shall be conducted without driving inverters using commercial power supply.

Attachment 6

Three-phase Induction Motor Evaluation Standards Subcommittee, Energy Efficiency Standards Subcommittee of the Advisory Committee for Natural Resources and Energy Meeting History

First Subcommittee Meeting (December 13, 2011)

- Disclosure of the Three-phase Induction Motor Evaluation Standards Subcommittee
- Current status of three-phase induction motors
- Scope of three-phase induction motors
- Energy consumption efficiency of three-phase induction motors and its measuring method
- Others

Second Subcommittee Meeting (January 28, 2013)

- Classification for setting target for three-phase induction motors
- Target fiscal year and target standard values for three-phase induction motors
- Interim report
- Others

Attachment 7

Three-phase Induction Motor Evaluation Standards Subcommittee,
Energy Efficiency Standards Subcommittee of the Advisory Committee for Natural Resources and Energy
List of Members

Chairman: Ryuichi Yokoyama	Professor, Graduate School of Environment and Energy Engineering, Faculty of Science and Engineering, Waseda University
Members: Masayuki Ushikubo	Section Manager, Technical Department, Japan Machine Tool Builders' Association
Takeshi Obata	Chairman, High Efficiency Motor Promotion Committee, The Japan Electrical Manufacturers' Association
Masaharu Kira	General Manager, Industrial Machinery Department 1 and Technical Department, The Japan Society of Industrial Machinery Manufacturers
Hidetoshi Sagawa	Counselor, Technical Department, The Japan Refrigeration and Air Conditioning Industry Association
Akira Chiba	Professor, Graduate School of Engineering, Tokyo Institute of Technology School of Engineering
Takahiro Tsurusaki	Chief Executive Researcher, Jyukankyo Research Institute Inc.
Yoichi Hanji	Senior Advisor, The Energy Conservation Center, Japan
Koichi Yasuoka	Professor, Graduate School of Engineering, Tokyo Institute of Technology School of Engineering
Hiroshi Yoshimiya	Chief Engineer, Senior Expert of Audit Division, Nikken Sekkei Ltd.