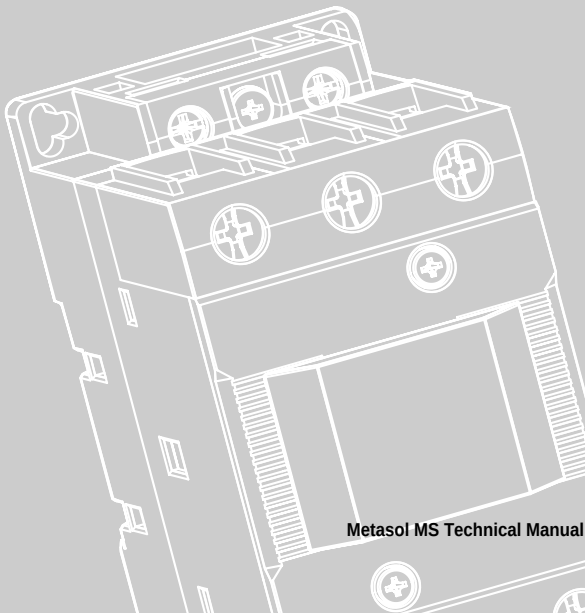
J. Motor Protection and Selection of Thermal Overload Relay



1. Motor Protection

1.1 Motor Protection General

The recent induction motor has been miniaturized with light-weight by improvement of insulation technology,it has a tendency of thermal margin reduction in terms of characteristic by supplying E class electric motor and using F class electric motor. Electric motor protection relay also needs to be adjusted with this thermal characteristic because of this. By the way, operational method of electric motor is widely applied to developed supply condition, variety to many different parts such as intermittent driving and variable load driving. Therefore, operational of proper protection relay is necessary for showing motor's performance and safe, proper driving of machines, facility. There are various types for protection type relay according to type operational of motor, but type of indirectly detecting motor's winding's temperature increase by line current is generally used. flush automatic temperature control device type which directly detects winding temperature is sometimes necessary, when this type is not required. Moreover, plugging by phase- reversal of disconnection driving is necessary to use jointly. Selecting proper protection relay by motor's protection condition is necessary, because sometimes reversal prevention by protection phase-reversal of disconnection driving. Table 1 shows tendency of schematic protection characteristic by parts to be protected about MT-□ □ /3K type TOR which reduce operating current when phase disconnection by adding MT type TOR, general thermal protection relay protecting overload restraint and differential amplifying device to this. It is necessary to select with preparing possible protection range and considering possibility of accident, required reliability and cost's efficiency about the detail application by wrriten statesment below.

Table 1. 3 Phase induction motor protection system and application protecting relay

Protection system \ Protecting relay			MT Type Thermal overload relay		Lagged type	Open phase type
			2 Element	3 Element		
Over-load	Stand-ard duty	Generalsquirrel-cage motor	◎	◎	○	◎
		Wound-rotor type motor	○	○	○	○
		Submersible type motor	△	△	×	△
	Interm-ittent driving	Generalsquirrel-cage motor	△	△	○	△
		Wound-rotor type motor	△	△	△	△
		Submersible type motor	△	△	△	△
Restraint		Generalsquirrel-cage motor	◎	◎	○	◎
		Wound-rotor type motor	△	△	△	△
		Submersible type motor	△	△	×	△
		Safety explosion-proof motor	△	△	△	△
Abnormal power distribution system		Phase disconnecting driving (preventing burning)	△	△	○	○
		3 phase unbalanced driving	×	×	×	×
		Short circuit	△	△	△	△
		Burning by over-short voltage	○	○	○	○
		Leak	×	×	×	×
		Grounding	△	△	△	△
		Phase reversal	×	×	×	×

Note) ◎:Completely protectable ○:Protectable except in special cases
△:Conditionally protectable ×:Not protectable

1.2 Operating Characteristic of Thermal Overload Relay

■ Characteristic of MT type TOR

TOR of magnetic switch is widely used as especially protecting device of squirrel cage type induction motor. The function is separating motor with overload and restrained condition from circuit by protecting motor from burning caused by over-current. TOR is the most widely used for motor protection, because valid protection characteristic can be acquired with similar operating characteristic to current-time characteristic about allowance temperature of motor's winding at low price, and generally safety for protection has relatively fast time limit characteristic.
Metasol type TOR's characteristic is as following.

1. using a contact is possible to b contact for opening magnetic contactor and different voltage circuit for indicating operation by applying 1alb.
2. Every type of heater inserted phase when 2 element is standardized to 1/L1 phase 2/TI phase, 5/L3phase 6/T3 phase.
3. Scale indicates current value by applying RC scale(indicated by according to full load of motor).
4. It is possible to control within approximately ±20% range of heater title rating by controlling the front dial with plus or minus driver.
5. Manual trip is possible at front, Checking distribution is easy.
6. Heat has 2 element as a standard, but 3 element(possible for protection of phase disconnection) about every type of product can be possibly manufactured.
7. Compensating surrounding temperature
8. Manual, automatic reset transfer is possible
9. Every type has 3 pole structure, easy for distribution
10. TOR(Overload) for protection of phase disconnection can be manufactured(MT-□□/3K□)

■ Operating characteristic

Metasol series MT thermal overload relay's characteristic follows KS C, IEC standard.

Table 2. Operation at balance circuit (standard value)

Standard	Condition	Limit operation		Operation when overloaded	Operation when restrained	Surrounding temperature
		A(Cold Start)	B(A continuous)	C(Cold Start)	D(Cold Start)	
KS C IEC 60947 -4-1	Setting current multiplier	1.05	1.2	1.5	7.2	20℃
	Operating time	Not operating (2hours)	Within 2 hours	(10A) Less than 2 min.	(10A) 2<TP≦10sec	
				(10) Less than 4 min.	(10) 4<TP≦10sec	
				(20) Less than 8 min.	(20) 6<TP≦20sec	
				(30) Less than 12 min.	(30) 9<TP≦30sec	

Note 1) Tp indicates operating time when restrained.
Note 2) It is a Trip Class inside the brackets.

Table 3. Operation(standard) in an unbalanced circuit(phase disconnection)

Standard	Condition	With open phase protection function		Without openphase protection function		Surrounding temperature
		3 element(MT-□3K)		3 element(MT-□3K)		
		Notoperating	Operating	Notoperating	Operating	
		A(ColdStart)	B(Acontinuous)	A(ColdStart)	B(Acontinuous)	
KS C IEC 60947 -4-1	Setting current multiplier	2pole 1.0	2pole 1.15	3pole 1.0	2pole 1.32	20℃
		1pole 0.9	1pole 0		1pole 0	
	Operating-time	Not operating (2hours)	Within 2 hours	Not operating	Within 2 hours	

1. Motor Protection

1.3 Protection of Motors Overload and Restrained State.

Electric motor drives within determined rating range, it has any difficulty with practical operational, because it is used in less than winding insulator's rating temperature increase. But, it is heated with larger amount of current flowing than rated current, when it is restrained or with overload. It finally causes burning by accelerating insulator's deterioration by this. Therefore, it is fundamental to break motor from circuit before winding insulator reaches dangerous temperature. The allowable time that winding insulator reaches dangerous temperature about over current in protection by detecting current, it regulates operating characteristic of protecting device. This current-time characteristic is called thermal characteristic, and winding temperature from surrounding state is defined with cold start characteristic, and it from rated temperature increase is defined with hot start characteristic. current detecting type protection device should have this characteristic.

However, TOR, the most representing current detecting type protection device regulates operating characteristic standard with standard motor, because thermal characteristic of motor is different depending on protection structure per type, pole number of insulator. Standard TOR satisfies this characteristic of standard and simultaneously considers thermal characteristic of general standard motor, therefore it is possible for standard motor's overload restrained protection which drives with load continuously.

Electric motor's state which TOR mainly protects are overload and rotor restrained state at normal circuit composition. This state can protect by matching the setting current of TOR with motor's full load current. Fig. 51. shows the relation between current-time characteristic(thermal characteristic) about winding temperature increase and MT type TOR'S operating characteristic.

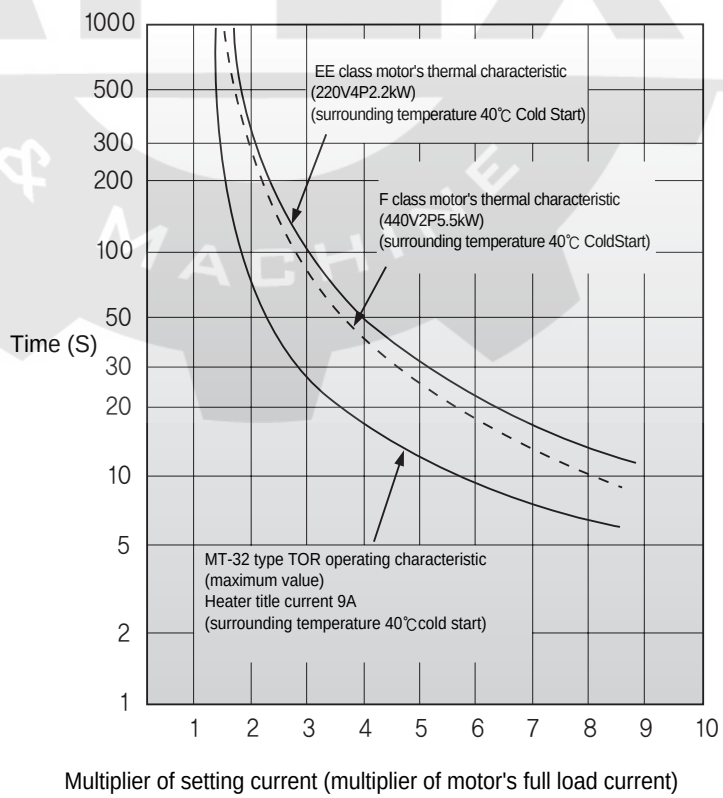


Fig. 51. Electric motor's thermal characteristic and operating characteristic of MT thermal overload relay

1.4 Three Phase Motor's Disconnection Accident Protection

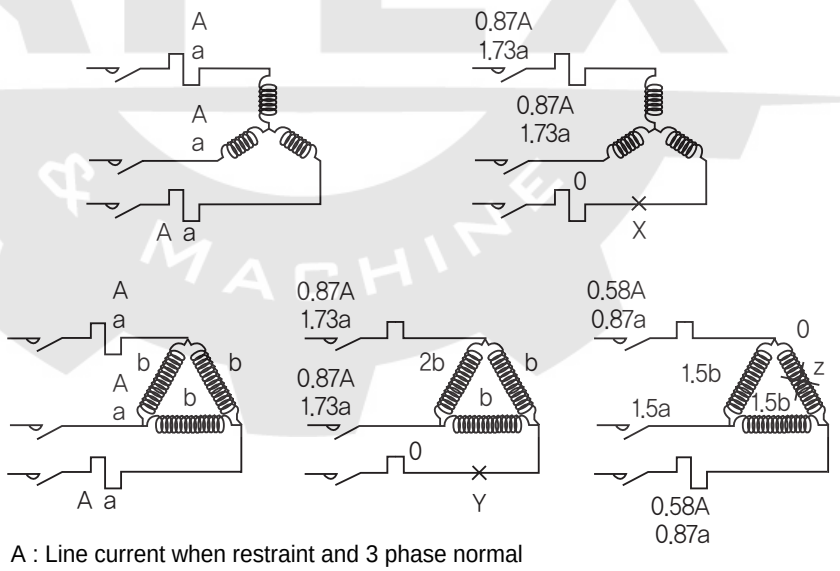
Phase disconnection accidents happen when 1 phase fuses in a 3 phase circuit. Starting with phase disconnection can protect the motor from burning by operating the TOR with a single phase restraining current flow. The electric motor stops and keeps driving with a single phase restrained state and single phase, then the single phase's current value also changes by load state, the TOR operates like the following:

- Motor stop's singles phase restrained state → TOR operates
- Motor's singles phase continuous driving (more than operating current) → TOR operating
- Motor's singles phase continuous driving (less than operating current) →TOR not operating → stop → restraining restarting single phase → operating

It is mostly possible to protect for single phase overload or single phase restraint. However, preparation for any cases is required, because there are situation which cannot be prevented.
Here are an example case in phase disconnection accident of 3 phase motor;

1. Direct phase disconnection of motor's input
2. Delta connection motor's internal phase disconnection
3. Primary phase disconnection of power transformer

Accident types in number 1, 2 are shown in fig. 52. assuming that the circuit opens at XYZ point. Power from the figure's values are assumed to be constant during driving, current indicates calculated current value with classification by reverse ratio.



A : Line current when restraint and 3 phase normal
a : Line current when full load and 3 phase normal
B : Phase current when restraint and 3 phase normal
b : Phase current when full load and 3 phase normal

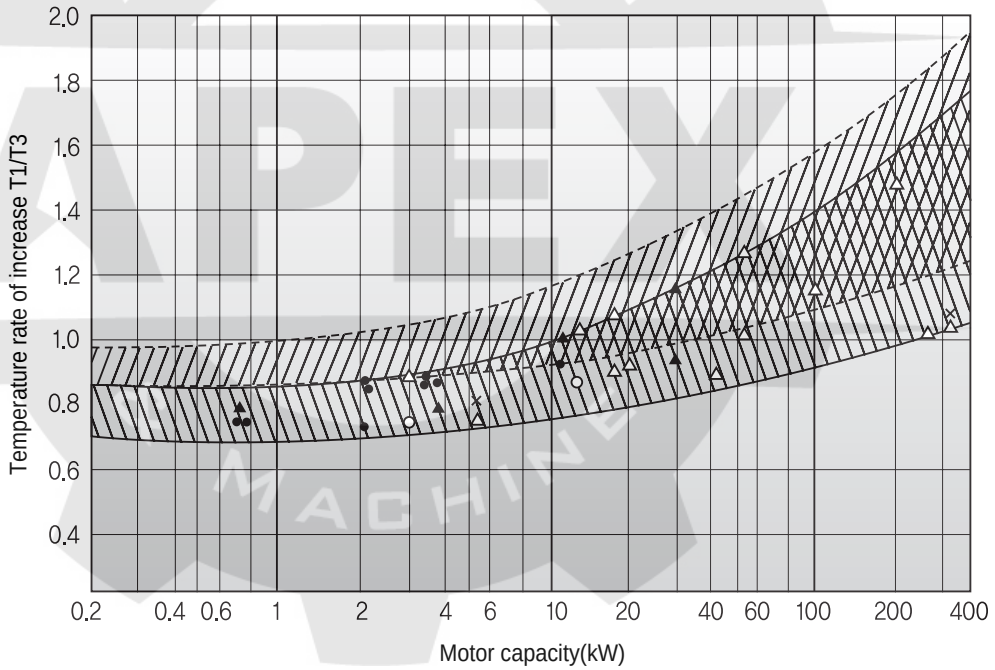
Fig. 52. Flowing current at motor's winding and protecting relay about every phase disconnection accident of 3 phase

1. Motor Protection

1.4 Three Phase Motor's Phase Disconnection Accident Protection

■ Direct phase disconnec -tion of motor's input

The most problematic thing is the case of delta phase disconnection's motor, there flows current possible for burning deterioration by motor's winding, although phase current increase is larger than line current(detected current by TOR), it becomes 2/1.73=1.15 times and TOR doesn't operate depending on load state shown Fig53. But, we can't say this is directly connected to motor's burning. It is because current increase of motor's 1 phase is large, but other 2 phase is small and temperature increase of maximum current flowing phase by internal thermal equilibrium of motor. However, There is copper loss and iron loss's increase caused by the skin effect influenced by a backing magnet field, as a result, it is possibly a problem for temperature increase when phase disconnection of only bulk motor. The maximum temperature increasing ratio of driving with phase disconnection about motor of every capacity and 3 phase normal winding is as figure 3. Judging with this standard, Phase disconnection protecting type (MT line K type)TOR is recommended to use about motor which has more than 3.7kw.



T1 : Wire temperature rise when phase failure
T2 : Wire temperature rise when normal three phase

: A comparison between maximum value of wire temperature rise and normal three phase rated operation temperature rise in case that line current operate same with normal three phase rated when phase failure(T1/T3)

: A comparison between maximum value of wire temperature to normal three phase rated operation temperature rise on case that line current rise 10% than rated current when phase failure

Fig. 53. Motor winding temperature increasing ratio during driving phase disconnection (cited from JEM material 139)

■ Internal phase disconnection of delta connection motor

This accident happens when one line gets disconnected or when one contact of delta side contactor generates connection fault. The likelihood of this accident is very low, and a protection relay which has very small operating current of detecting phase disconnection can be protected, such as Electro Magnetic Protection Relay(see Note 1) detecting with line current, but there is a problem in TOR and it is difficult to protect because there is arare difference with general 3 element with insufficient phase disconnection detecting function due to every flowing current at 3 phase, when even using phase disconnection type TOR. However, it can be protected by 3 element or phase disconnection type TOR with same condition as star connection's motor protection about direct phase disconnection, if thermal relay can be put into phase of motor winding. Note 1) LSIS sells product series that magnetic electric motor protection relay is expanded to 2 types, Meta-MEC EMPR and DIGITAL EMPR. Please contact nearby sales office or visit LSIS Home page(www.lsis.biz) for more details.

■ Primary phase disconnec-tion of power transformer

This accident sometimes happens by 1 phase fusing of primary power fuse as shown in fig 54. Motor protection has a problem with 2 element TOR in this case, but it is ok by using 3 element or phase disconnection protection type TOR. However, protecting type in a package system is sometimes realistic and economical by inserting phase disconnection relay in transformer about this accident.

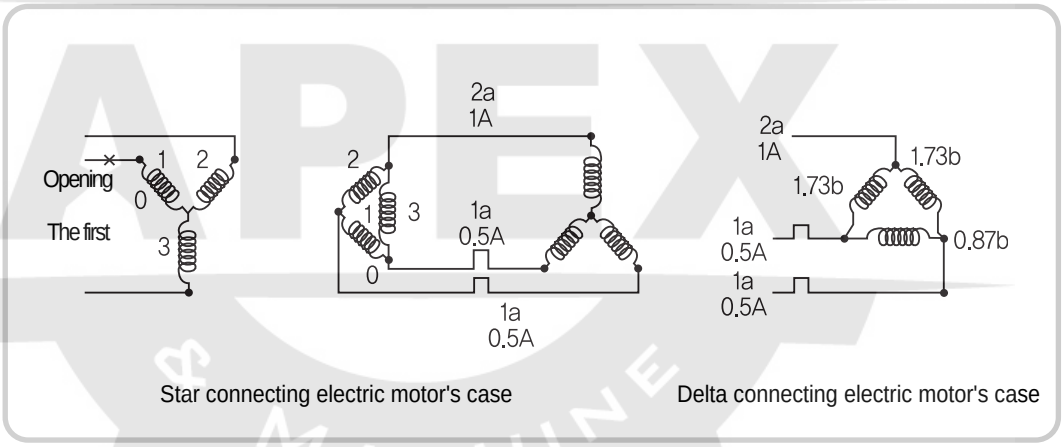


Fig. 54. Electric motor's current during transformer's primary phase disconnection

There is a similar unbalance voltage accident to phase disconnection, but it causes an increase of temperature, input and vibration due to an abnormal increase of unbalanced current by generating a big difference with normal impedance, phase reversal impedance, and simultaneously reducing output torque by generating phase torque and phase reversal torque when unbalanced voltage is applied to motor due to operational of V connection transformer or 3 phase unbalance load and large single phase load connection. The TOR should be used for preventing this accident.

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1. Motor Protection

1.5 Protection of Electric Motor with Long-term Starting Time

Starting is impossible because the motor operates at starting time in a normal TOR, when a long time is required for starting, such as with an electric motor driving inertia's large load, and it also cannot acquire a protection characteristic. Our company solves this problem by applying a lagged type TOR, lagged type only bimetal is being used with a standard TOR.

1. Protection of electric motor with long-term starting time Prevention of unwanted operation,but starting time is necessary to be shorter than allowable restraint time and it requires caution for applying it. Protection of electric motor with occasional driving sometimes large heater is selected even with taking shortage of overload.
2. Protection of electric motor with occasional driving sometimes even a large heater is selected for making up for a shortage of overload protection, when you want to take advantage of a motor's maximum short-term output power with occasional driving (including inching and anti-phase) for motor protection. Proper selection is possible for applying with rare loss of overload protection by using lagged type bimetal especially when occasional driving is periodic.
3. Large motor protection cooperation of starting current It is easy to take protection cooperation with fuse or distribution breaker when applying to large motor of starting current, and protection cooperation of motor and short circuit including circuit accident can be acquired. (refer to fig. 55)

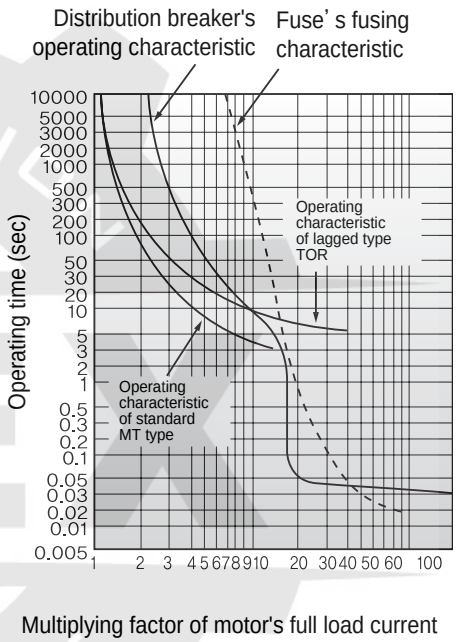


Fig. 55. MT and distribution breaker or protection cooperation of fuse

1.6 Protection of Motor with Occasional Driving

Enough preparation is required for using TOR for motor protection with occasional driving. It is difficult to expect optimized protection about motor with occasional driving by only TOR when there is big difference between thermal time constants of motor and TOR , it is necessary to find solution about each case and apply it. It is good to select control current based on motor's continuous rating when protection is prior with limiting somewhat motor's available performance, it is necessary to control large control current with taking a little loss of overload protection when you want to take advantage of maximum short-term output power. Time constant of standard TOR in this case, but it is not necessary to select large control current with using lagged type TOR. Selection of TOR's control current requires different preparation for showing motor's performance enough when intermittence is irregular, but proper selection is possible when it's periodic as following. As a reference, fig 55 shows heater temperature increase of TOR when accasional driving.

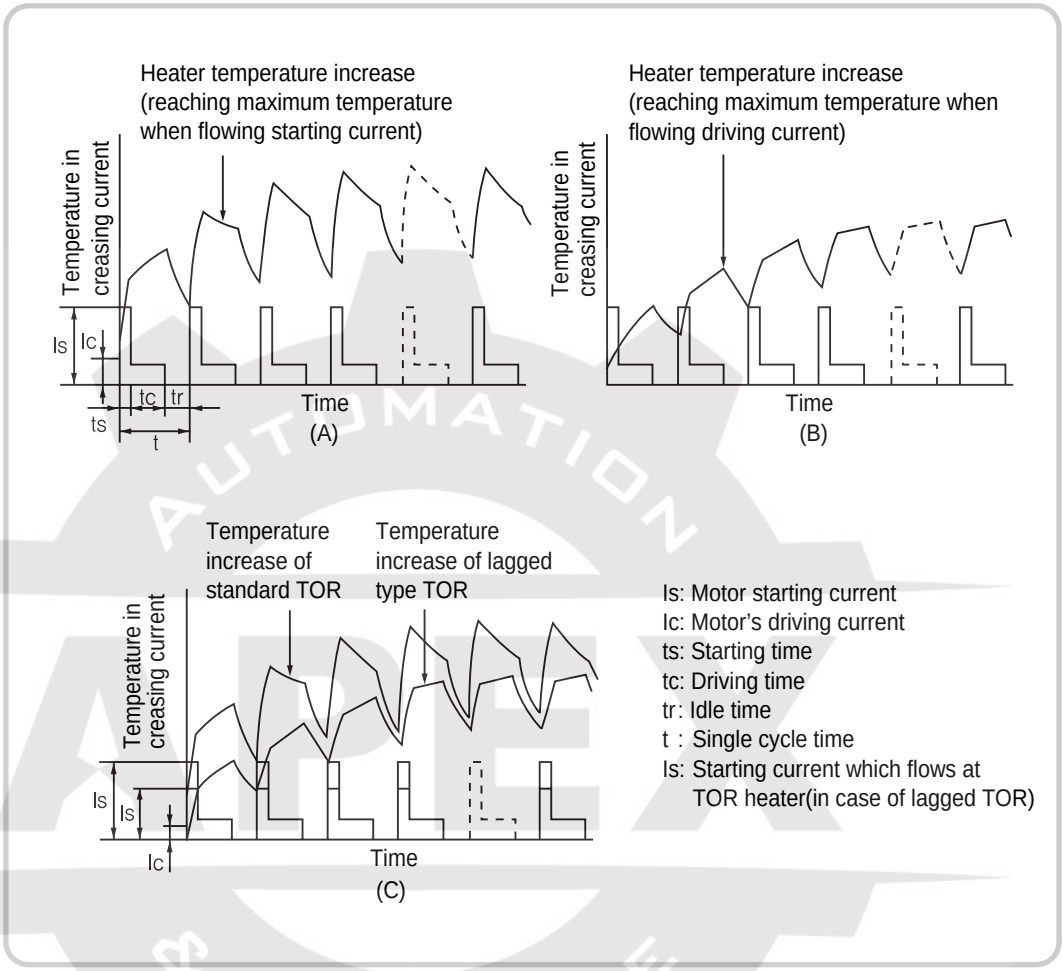


Fig. 56. Heater temperature increase of MT type TOR in the case of occasional load

(A) : Overload protection of motor is difficult because setting current is set to be large.

(B) : Setting current is possible for overload protection because it is selected by motor's continuous rating, but thermal time constant of TOR needs to be extremely large in this case.

(C) : It is possible to select relatively proper setting current when intermittent driving because flowing current at heater is controlled by bimetal from lagged type TOR and it is similar to state B.

1. Motor Protection

1.7 Electric Motor Protection

1. Contact unwanted-operation vibration

Check if contact is separated for more than 1ms with varying uniform frequency in 10~55Hz for cycle 1 minutes by maintaining vibration acceleration 19.6m/s2(2g) after setting current flowing temperature saturation to main circuit with setting value as minimum of control range. Direction of exciting vibration is 3-axis direction of top-bottom and left-right.

• Test result : All Metasol series product has no contact unwanted-operation.

2. Static vibration durability

Frequency 16.7Hz, double amplitude 4mm, direction of exciting vibration is 3 axis of top, bottom and left, right and exciting time is one hour each with each axis direction. Check characteristic variation, damage, looseness of screw bolt after exciting vibration.

• Test result: within variation ratio ±5% of 200% current operating time (within range of repetition error) no damage of parts, looseness of screw bolt (tightened with 80% of standard torque)

3. Contact unwanted-operating shock

Check contact separation more than 1ms with applying shock of acceleration 49.0m/s2(5g) by shock wave of schematic diagram 7 after setting current flowing temperature saturation to main circuit with setting value as minimum of control range. Direction of exciting shock is 6-axis direction of top-bottom, left-right and back-forth, and number of it is 3 times about each direction.

• Test result : Every Metasol series product has no contact point' s faulty operation.

4. Durability shock

Check characteristic variation, damage before and after applying shock of acceleration 490m/s2(50g) by shock wave in Fig. 57.

• Test result : within variation ratio ± 5% of 200% current operating time (within range of repetition error) no damage of parts

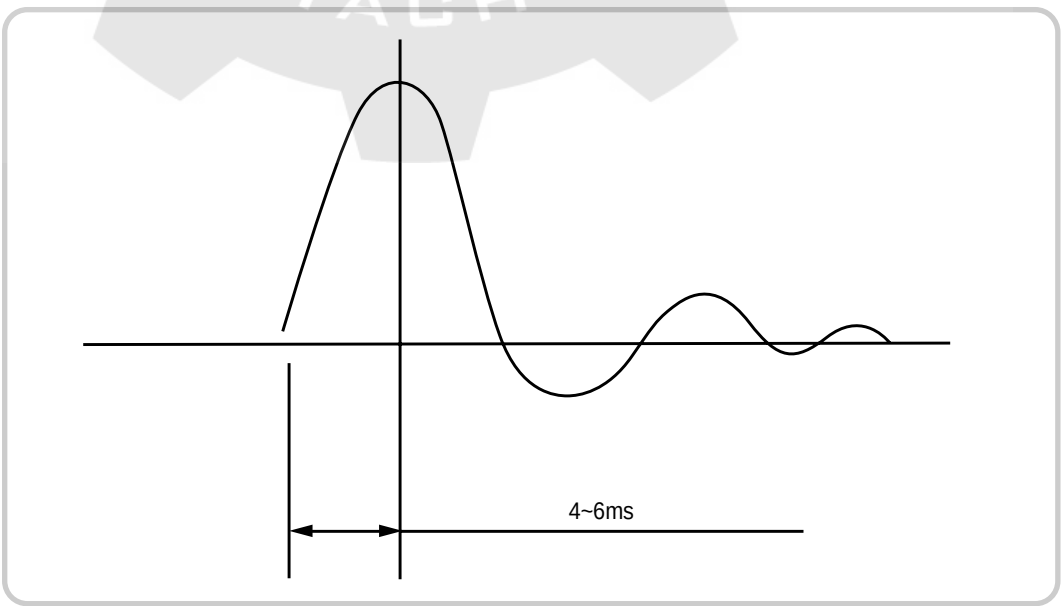


Fig. 57. Shock wave

2. Selection of Thermal Overload Relay

2.1 General of Thermal Overload Relay

Electric motor is the most common power user in almost every type of industrial facility, and they are becoming miniature, light-weight, and higher performance. Moreover, their operation al purposes now include clockwise and counter-clockwise driving, and intermittent driving. This variety of driving types contributes to higher performance, and better automation of facility or machines, meanwhile causes of faults are becoming more varied not only from existing overloads and restraints, but also due to phase disconnection and phase reversal. This has also caused an increase in fault frequency. Faults of electric motors don't just include stopping, but can also involve dangerous results spreading down an entire power supplying system. Therefore, proper types of protection suitable for application conditions must be selected after checking the thermal characteristic of the motor, and verifying sufficient driving type motor protection.

■ Type of TOR (Thermal Overload Relay)

Type of TOR can be categorized by general(standard)type, phase disconnection protection type, lagged type according to using purpose per load, they are a little different depending on manufacturer.

1. General(standard) type overload relay

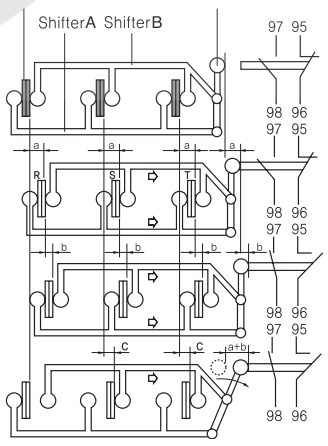
General(standard) type is most widely used in domestic market, it is classified with "2 element" product and "3 element product" according to number of heater detecting over-current element at each phase of internal Bi-metal. In domestic market, mainly "2 element " products are used,"3 element" product should be used for more precise load protection, because "2 element"products have no over-current detecting element structure at "S phase".

2.Overload relay of phase disconnection type

Phase disconnection protection type is a product which has "phase disconnection detecting function" is added to "general(standard) type", it is used to prevent accident by "phase disconnection", one of the biggest causes for motor's burning. "phase disconnection" means power is supplied with disconnected 1 phase among 3 phase power supplying line, internal winding of motor's deterioration (it causes motor's burning by 6~8 times of start electric current persistent flowing) happens by approximately 1.5 times of rated current flowing at other phases except for phase disconnected one, it spreads to very dangerous state with motor's burning depending on cases. Using "phase disconnection protection type" is the best which can detect other phase disconnection functions separately from general(standard) type products, because over-current increase happens rapidly during phase disconnection. Component of phase disconnection protection type product is shown in the figure on the right. Phase disconnection protection product with ADL(Amplified Differential Lever) bulges 3 bimetal by dimension and translates in parallel to the right by Shifter-A, Shifter-B, release lever by a, but contact is not released. In case of overload stat (phase disconnection of R phase), Bi-metal releases contact for short term than overload state through bulging by b than rated load driving state in case of overload state.

Bi-metal of R phase doesn't bulge and Bi-metal of S, T phase bulges, then release lever rotates to the right by Shifter-A with center of connected point with Shifter-B, by expanding translation degree to lever ratio. In other words, it is possible to protect motor with releasing faster than release time by bulging characteristic of Bi-metal.

It is the best way to select phase disconnection type among thermal overload relay used for protection of general electric motor.



During phase disconnection

Fig. 58. ADL mechanism

2. Selection of Thermal Overload Relay

2.2 TOR general

3. Lagged type overload relay

The lagged type is applied to products which have large inertia such as a fan, centrifugal separator or a blower with long operating time; their operating characteristics are different from general type products. Normal driving is possible by applying lagged type product because if a trip is generated during starting, then normal driving is impossible due to a long start time with large inertia load, when general type product is applied. The following graph shows operating characteristic of general type and lagged type product, tripping time is within approximately 10 seconds when 720% of rated current is applied in case of general type product, meanwhile, it is somewhat long with approximately 20 seconds. Trip class is regulated in standard KS C IEC 60947 as following table, general (standard) phase disconnection type product is class 10A and class 20 is a standard product in lagged type, among products of LSIS.

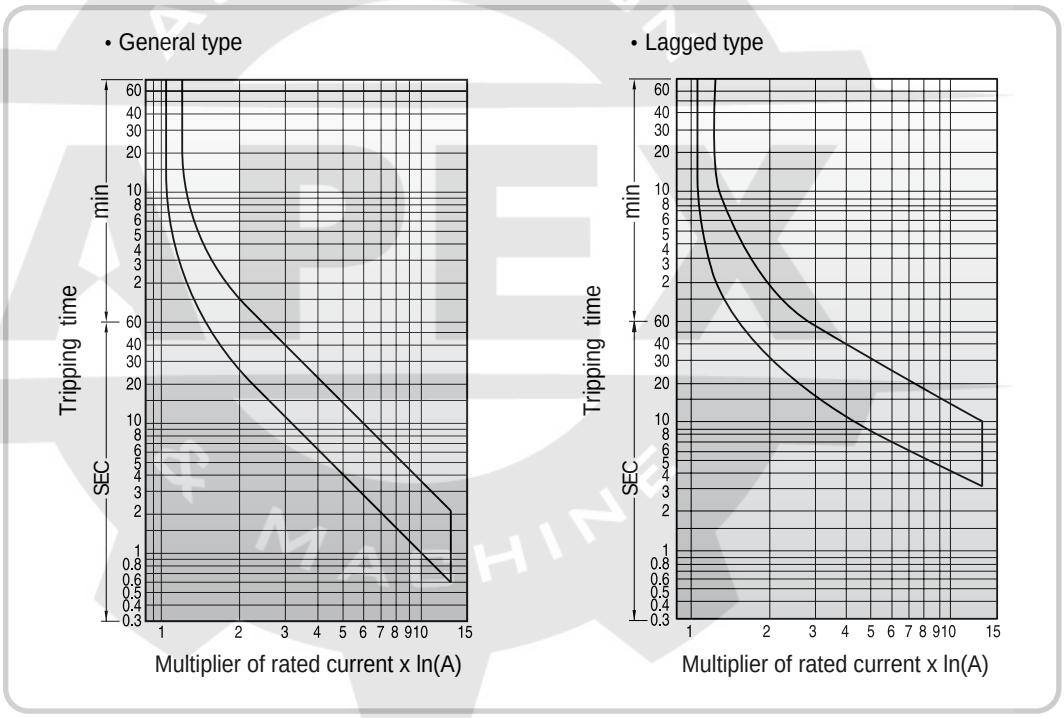
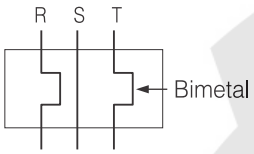
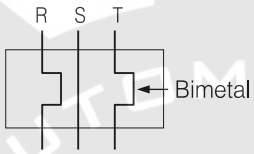
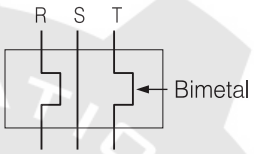
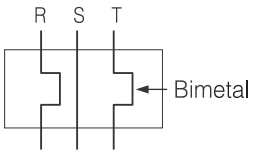
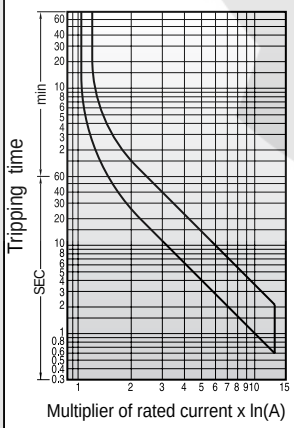
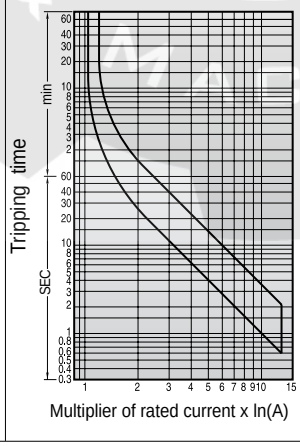
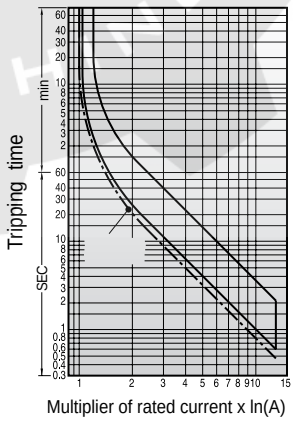
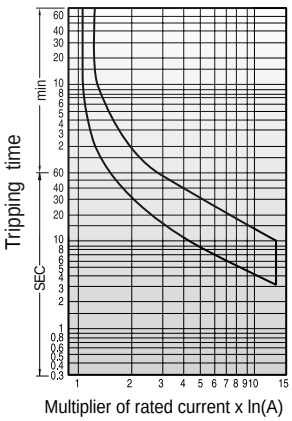


Fig. 59. Characteristic curve of general and lagged type

Table 1. Trip class standard

Trip Class	Range of trip time Tp
10A	$2 < Tp \leq 10$
10	$4 < Tp \leq 10$
20	$6 < Tp \leq 20$
30	$9 < Tp \leq 30$

Table 2. Types of thermal overload relay

Types	Thermal relay			
Exterior				
Diagram				
Name and Type	MT-□/2H 2 element type	MT-□/3H 3 element type	MT-□3K open phase protection type (3 element)	MT-□3D time lag type (3 element)
Schemez	Overload detecting bimetal is used only on R and T phase. It is an economical product which is widely used in Korea and Japan.	Overload detecting bimetal is used all for three phases and protecting range is wider than two elements type.	It is a product which "differential amplification mechanism" with 3 elements type is installed to machinery unit and rapid detecting function during open phase is added. It is widely used in Europe and America.	Open phase detecting mechanism is added separately to three poles and three elements type and it is suitable for the load which has long starting time.
Characteristic curves	Standard inverse time limit characteristic (Class 10A) 	Characteristic (Class 10A) 	Standard inverse time limit characteristic (Class 10A) 	Standard inverse time limit characteristic (Class 20) 
Features	Reset method : Basic reset type is manual.(user can change to automatic reset.) Auxiliary contact point : 1a1b Operation power : Not need Installation : It is possible to connect direct to magnetic contactor and be installed separately too.			

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2. Selection of Thermal Overload Relay

2.3 Understanding of Trip Characteristic Curves

■ Understanding of characteristic curves

The horizontal axis is a multiple of rated current and the vertical axis is the tripping time. If you look at tripping time on the graph when two times of setting current flows on the load, you can find out it is tripped at around 30 sec~1.5 min. The reason why there are two different characteristic curves is to show the error free range; the lower curve shows minimum value and the upper curve shows maximum value. So tripping time is between the minimum and the maximum value.

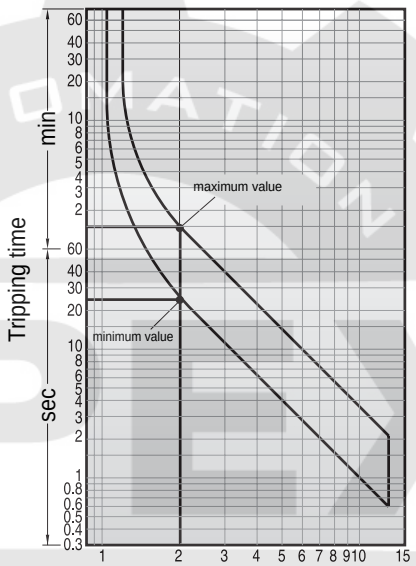


Fig. 60. Characteristic curve

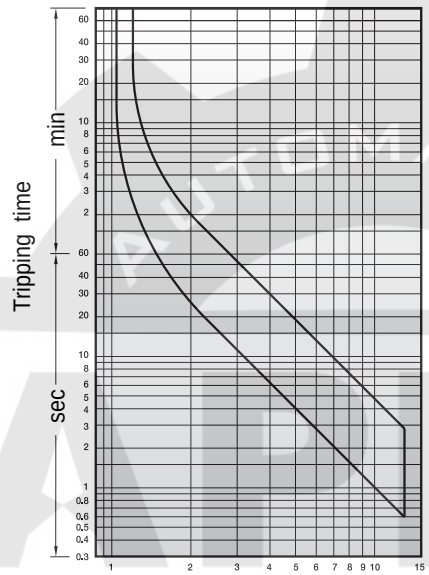
The tripping characteristic of a thermal overload relay basically has an inverse time characteristic. The characteristic curve is categorized by a cold start curve and hot start curve in figure 60, the electro-magnetic motor protection relay also has same characteristic considering starting current when starting. Operating characteristic should be selected without superposition with starting characteristic curve, because normally 6~8 times of rated current is generated when starting the motor. As mentioned above, a lagged type overload relay should be used in case of load over a long operating time (blower, fan and centrifugal separator etc). The tripping characteristic of the TOR after a certain number of hours driving changes into a hot characteristic curve. Therefore, trips such as electric motor's generated overload during driving uses hot characteristic curve as standard. As is sometimes happening in the field, even though there is no trip after the first startup, if you start up again right after turning off during motor operation, there are some cases of tripping at the contactor. In this case the TOR still has the hot characteristic. This phenomenon is solved by starting after approximately 20 minutes, because the Bi-metal inside the TOR will have had time to cool off, and return to a cold start characteristic.

2.4 Tripping Characteristic Curve (MT)

The thermal overload relay(MT) can be installed and used in series with a magnetic switch or individually. There are two elements type(2H) which have a heater only on R and T phase, three elements type(3H) which have heaters on R, S and T phases, open phase type(3K) which is operated by differential amplification machinery(ADL) at open phase moment, and automatic type(3D).

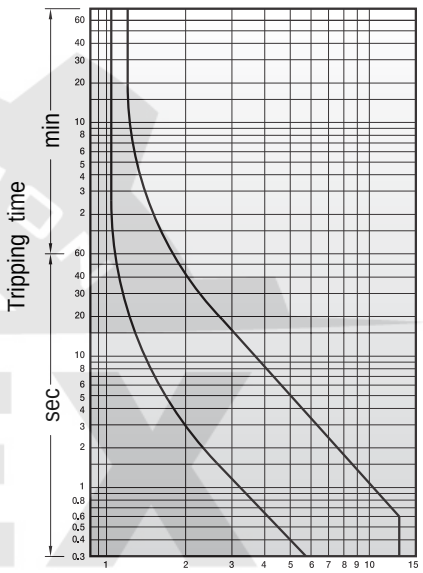
Class10A, 18AF

MT-12/2H
MT-12/3H
MT-12/3K



Multiplier of rated current x In(A)

Cold starting

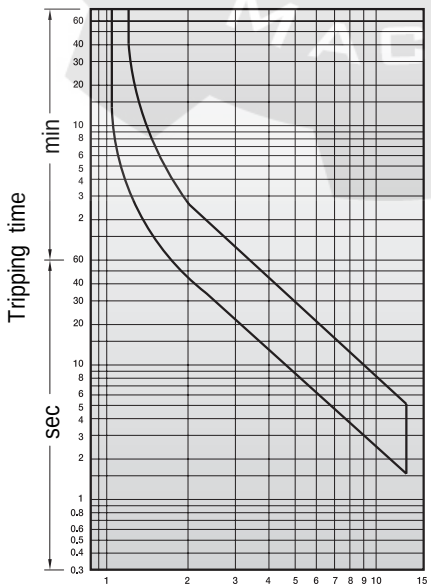


Multiplier of rated current x In(A)

Hot starting

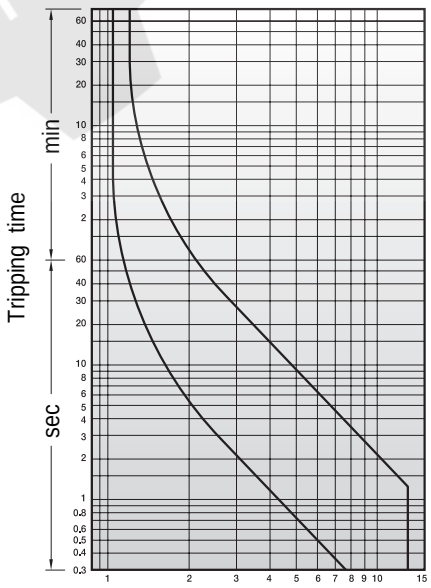
Class20, 18AF

MT-12/3D



Multiplier of rated current x In(A)

Cold starting



Multiplier of rated current x In(A)

Hot starting

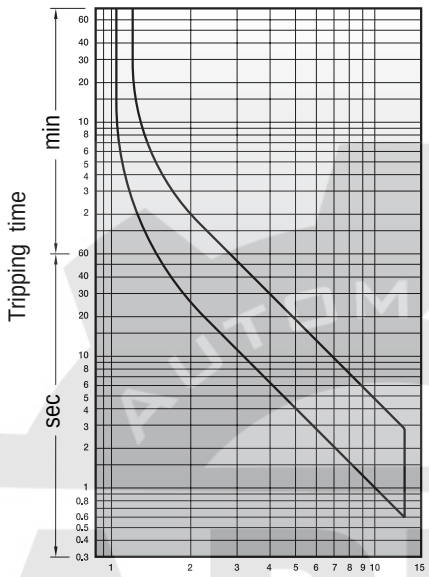
J

2. Selection of Thermal Overload Relay

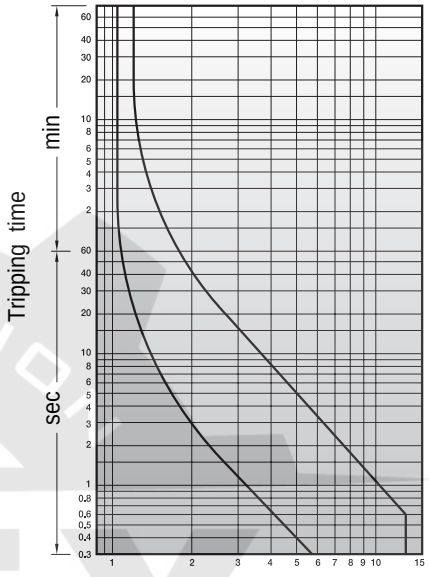
2.4 Tripping Characteristic Curve (MT)

Class10A, 40AF

MT-32/2H
MT-32/3H
MT-32/3K



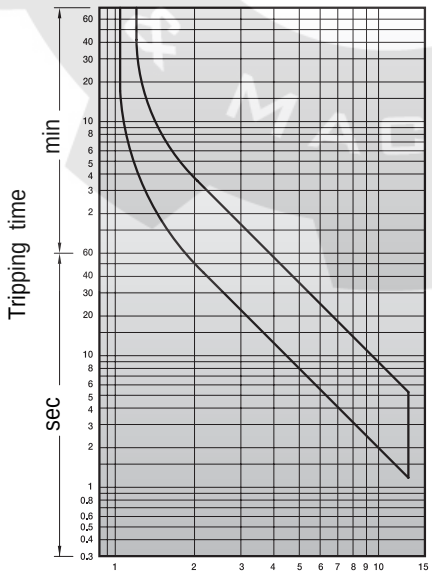
Multiplier of rated current x In(A)
Cold starting



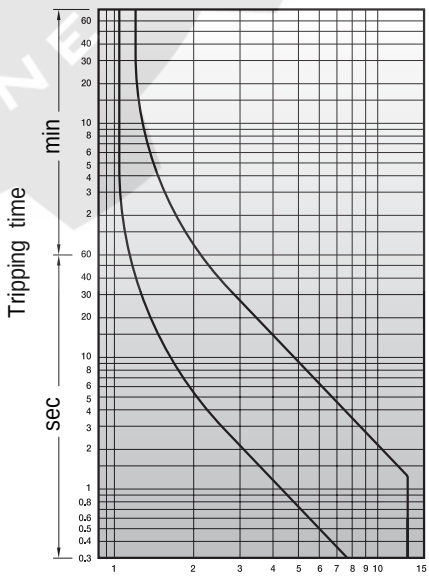
Multiplier of rated current x In(A)
Hot starting

Class20, 40AF

MT-32/3D



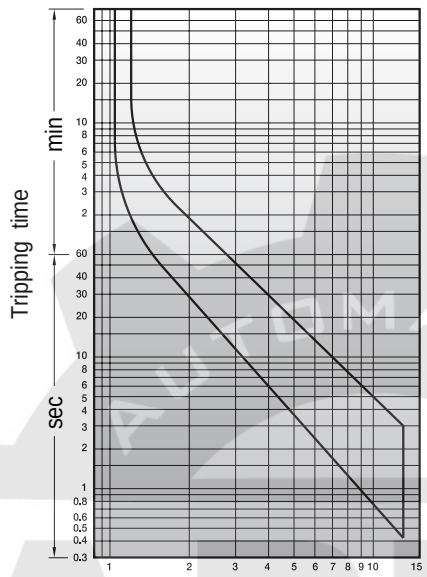
Multiplier of rated current x In(A)
Cold starting



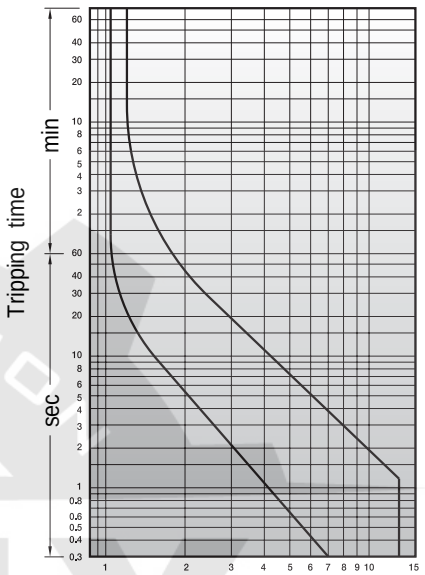
Multiplier of rated current x In(A)
Hot starting

Class10A, 65AF

MT-63/2H
MT-63/3H
MT-63/3K



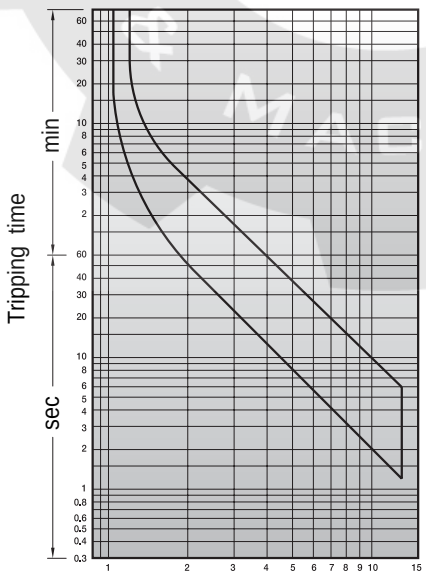
Multiplier of rated current x In(A)
Cold starting



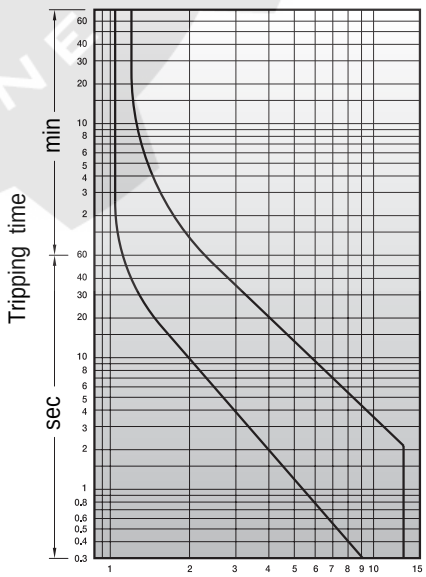
Multiplier of rated current x In(A)
Hot starting

Class20, 65AF

MT-63/3D



Multiplier of rated current x In(A)
Cold starting



Multiplier of rated current x In(A)
Hot starting

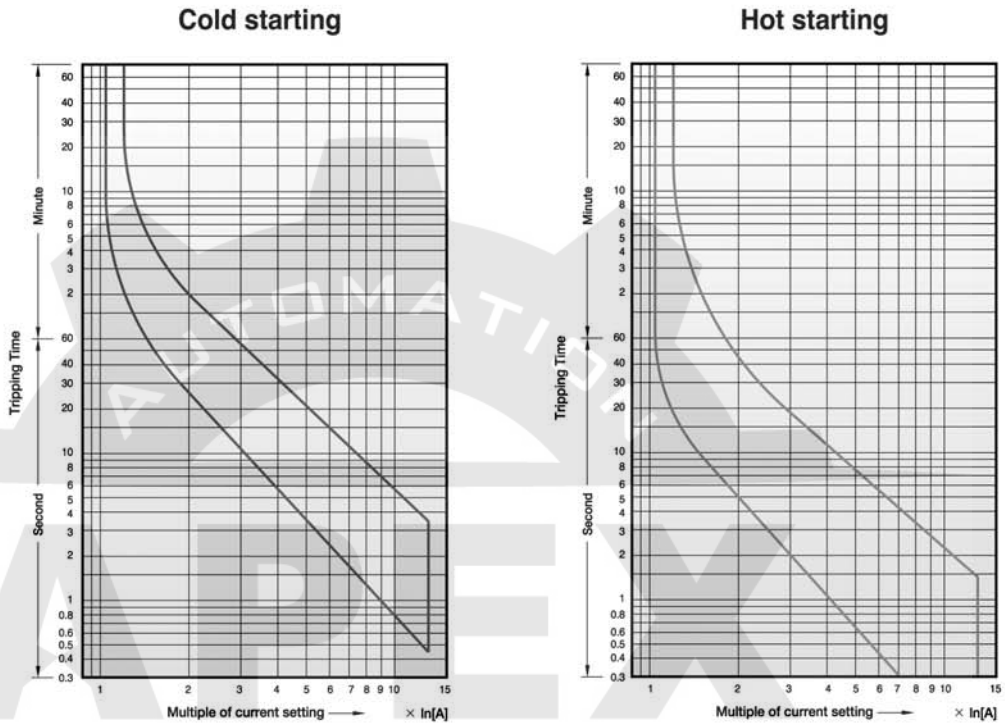
J

2. Selection of Thermal Overload Relay

2.4 Tripping Characteristic Curve (MT)

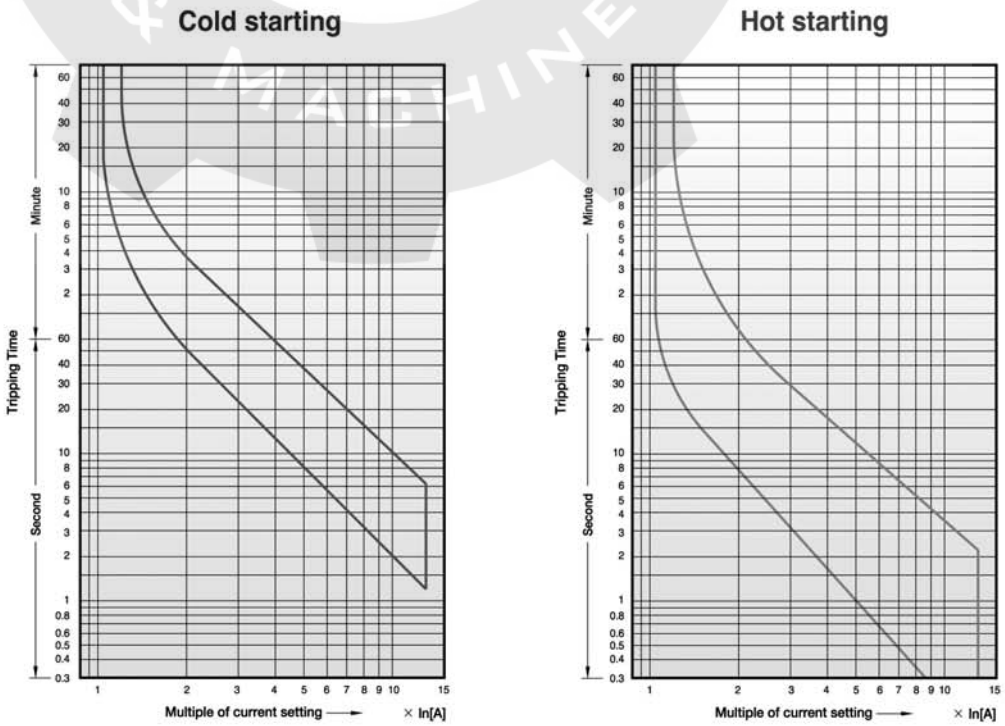
Class 10A, 100AF

MT-95/2H
MT-95/3H
MT-95/3K



Class 20, 100AF

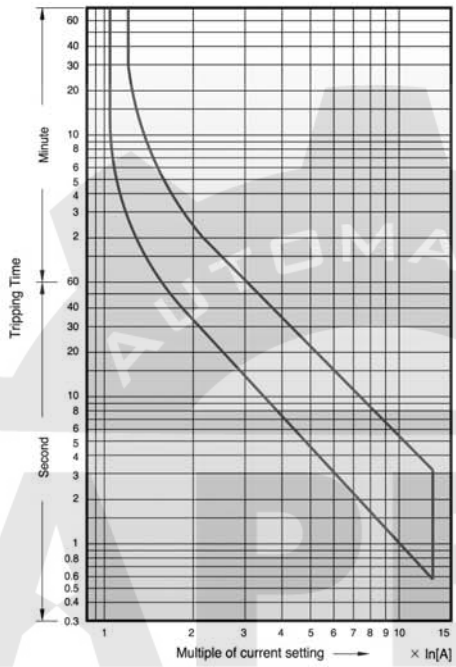
MT-95/3D



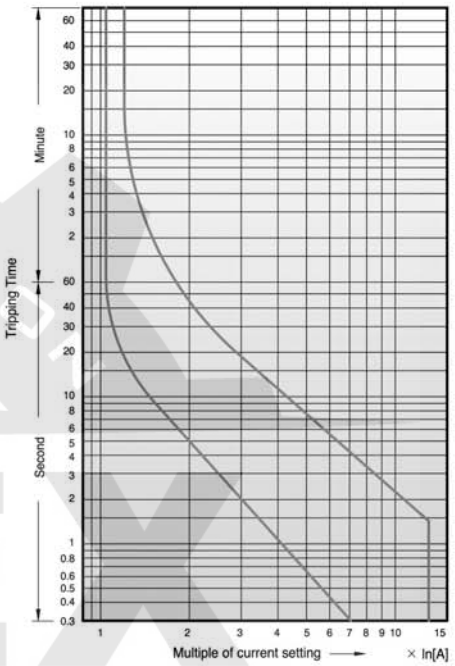
Class 10A, 150AF

MT-150/2H
MT-150/3H
MT-150/3K

Cold starting



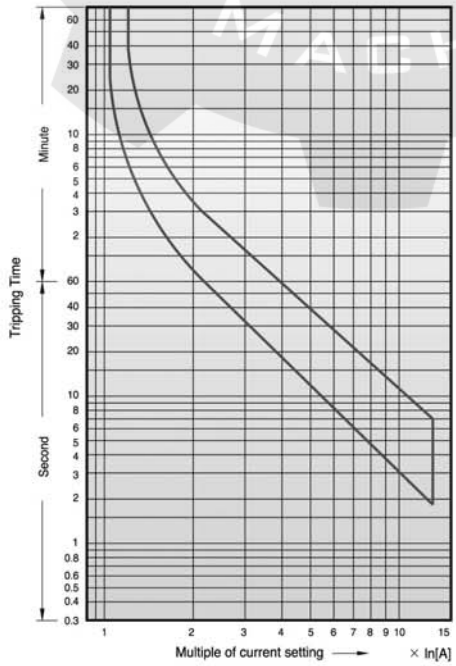
Hot starting



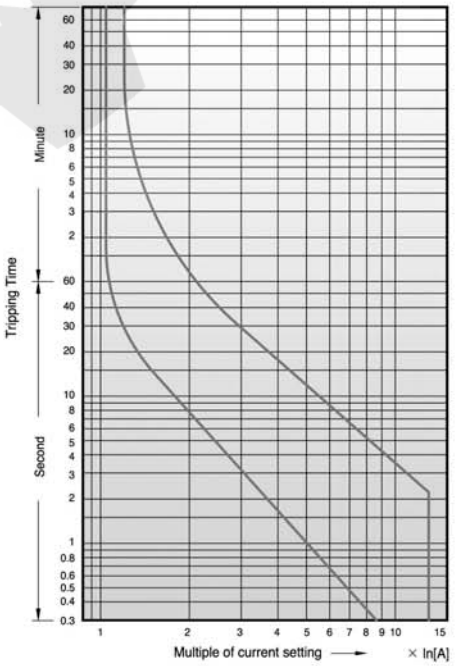
Class 20, 150AF

MT-150/3D

Cold starting



Hot starting



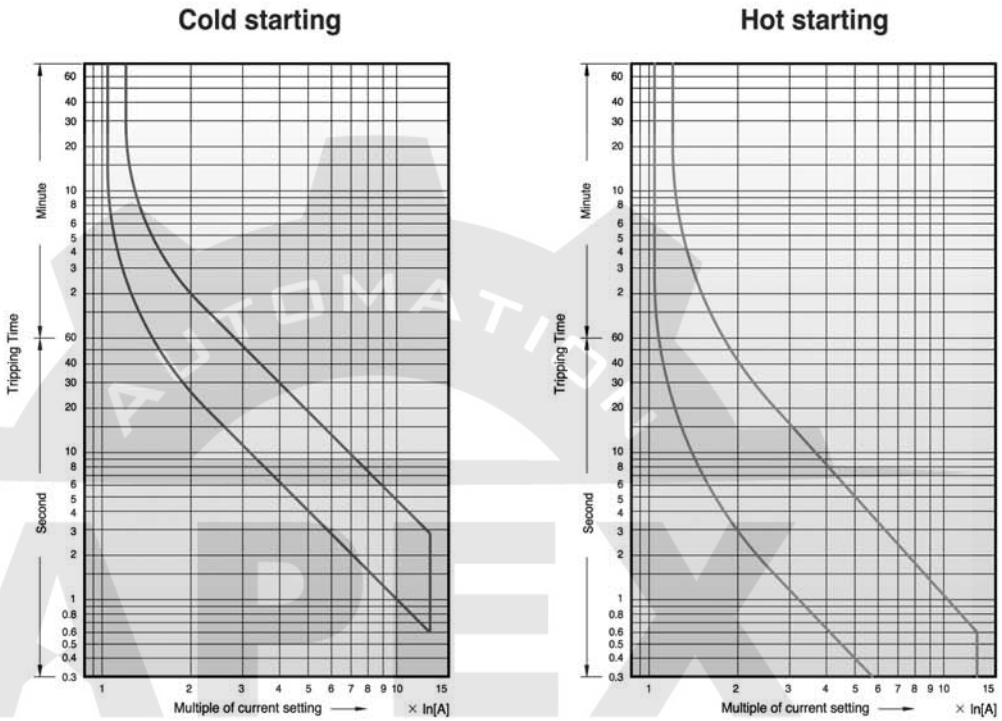
J

2. Selection of Thermal Overload Relay

2.4 Tripping Characteristic Curve (MT)

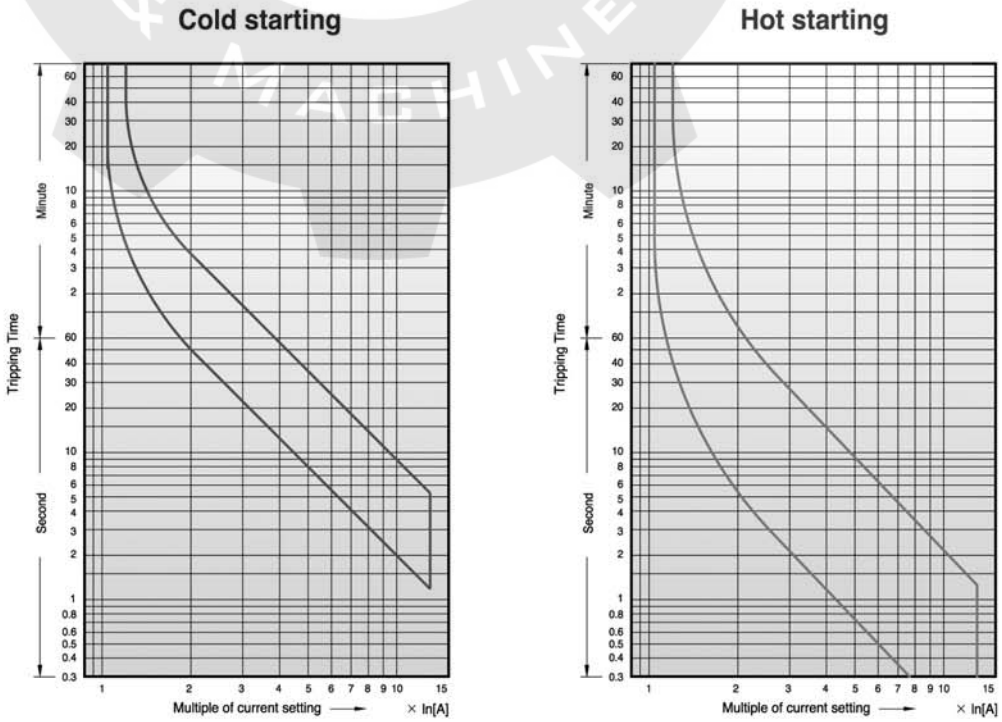
Class 10A, 225AF

MT-225/2H
MT-225/3H
MT-225/3K



Class 20, 225AF

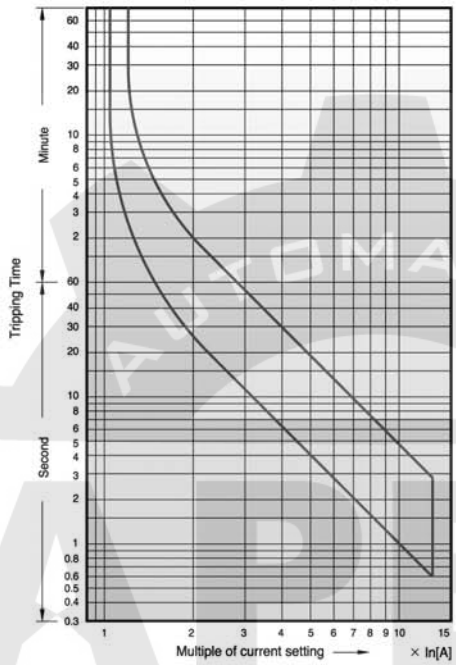
MT-225/3D



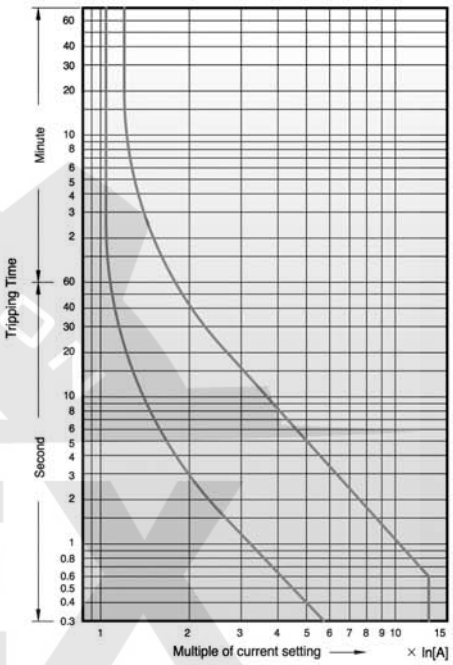
Class 10A, 400AF

MT-400/2H
MT-400/3H
MT-400/3K

Cold starting



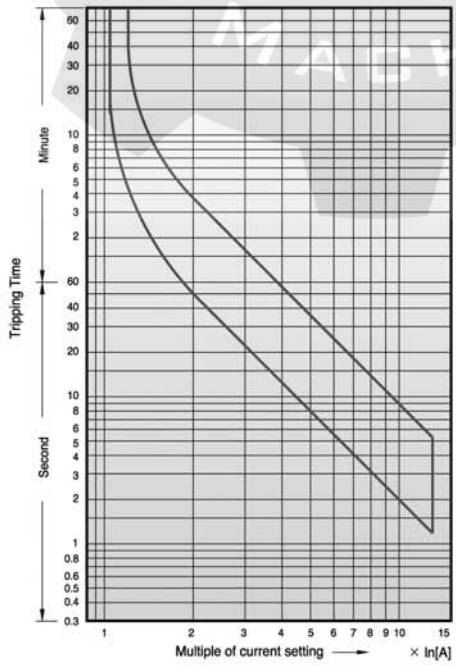
Hot starting



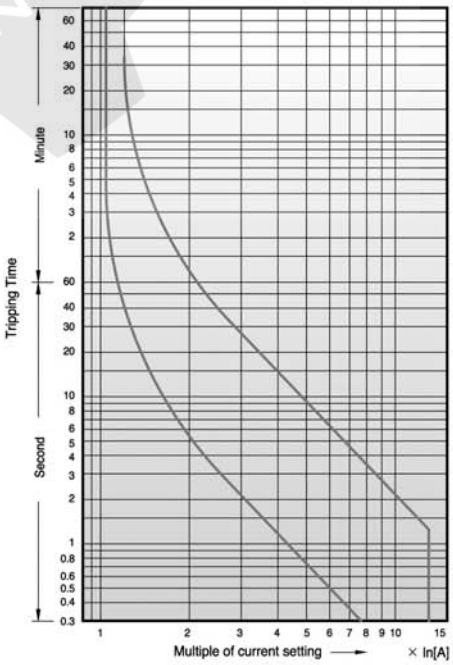
Class 20, 400AF

MT-400/3D

Cold starting



Hot starting



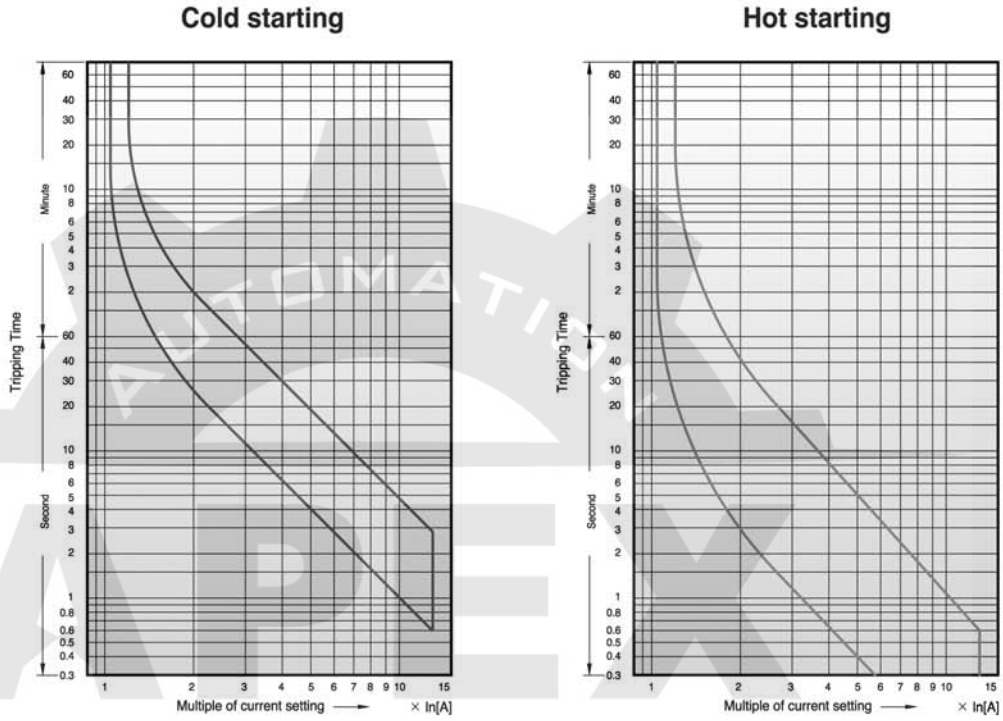
J

2. Selection of Thermal Overload Relay

2.4 Tripping Characteristic Curve (MT)

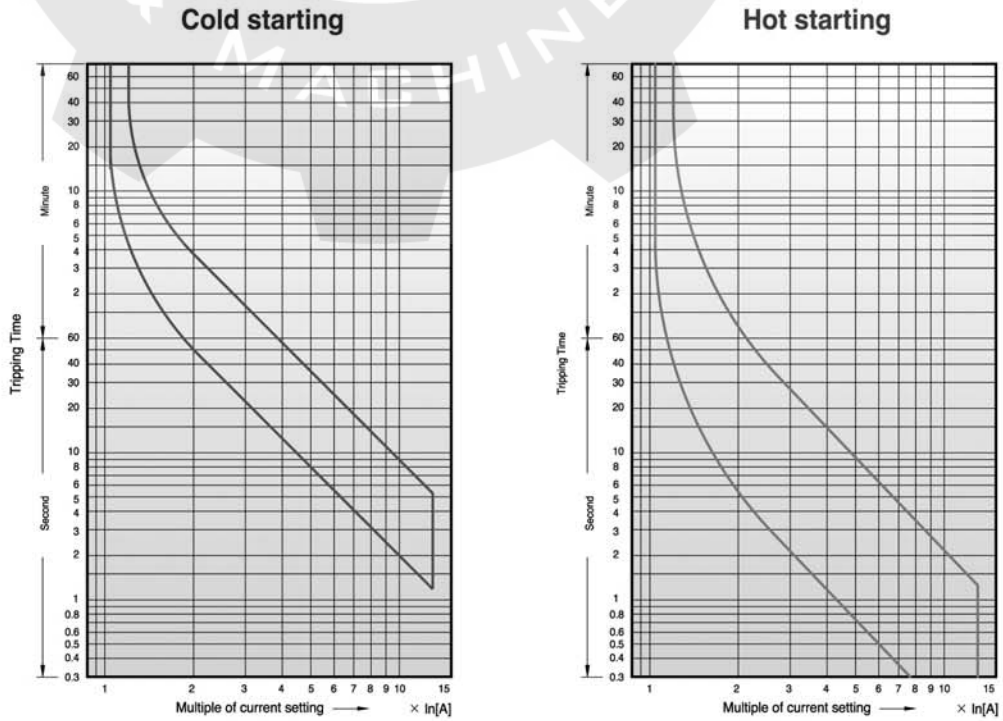
Class 10A, 800AF

MT-800/2H
MT-800/3H
MT-800/3K

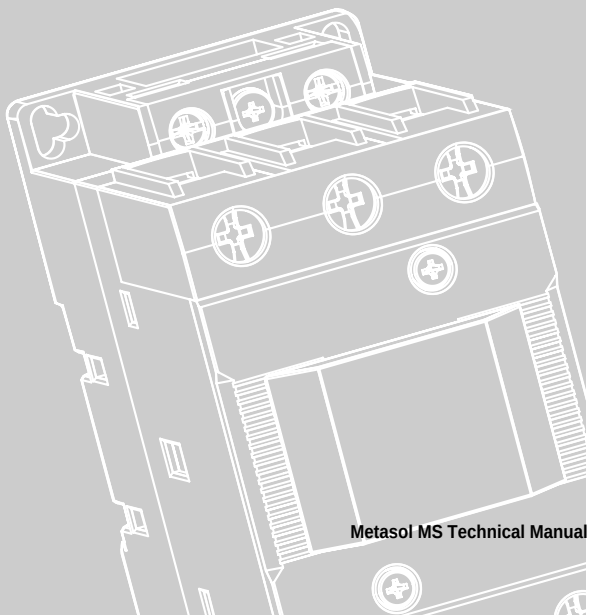


Class 20, 800AF

MT-800/3D



K. Coordination



1. Coordination

1.1 Protection Range of Magnetic Switch

Magnetic switch is mainly used for remote control of motor's starting, stopping, etc. and protecting from motor burnout by overload, binding, etc. Also its operational current range is relatively small so during short circuit, it is not capable of opening and closing large current. General magnetic switch on the market mostly has AC3 or AC4 level switching efficiency(8~10 times of rated operational current) which is designated by KSC IEC 60947-4-1 and even with extra about 10~15 times. If there is current over certain amount on TOR, except special case, there is a danger of heater fusion before it operates. To prevent heater fusion, KSC and IEC standards designate overload current flow test as resisting 13 times of current and electric installation technology and wiring regulations also test with 13 times of rated operational current. Our company's MT type satisfies above designated value(over 13 times) of the standards. So more than 13 times of rated operational current is out of magnetic switch's protection range and to protect from short circuit, you need to use short circuit protection breaker such as MCCB and ELCB, or short circuit protection fuse.

1.2 Protection Functions

1. Disconnection functions & short-circuit prot
- Breaking function Breaking motor's circuit before maintenance work
- Short circuit protection Wire and load devices protection from over current (I > 10In)

2. Control
- On and off operation Motor's starting and stopping

3. Heat and overload protection
- Overload protection Load devices protection from over current(I < 10In)
- Additional characteristic protection
  1. Restrictive protection of accident (during motor operating)
  2. Preventive protection of accident (motor insulation test during motor stopping)

4. Protection range
- Overload(I < 10In) Overload is occurred under following cases.
  1. Electric problem on main power(phase burnout, voltage difference between phases)
  2. Long start with excessive torque by system or motor damage (during bearing vibrating)
- Impedance short circuit(10 < I < 50In) Main reason of motor insulation burnout
- Short circuit (I > 50In)

The accident of this case barely occurs but the reason could be short circuit fault between phases during maintenance.

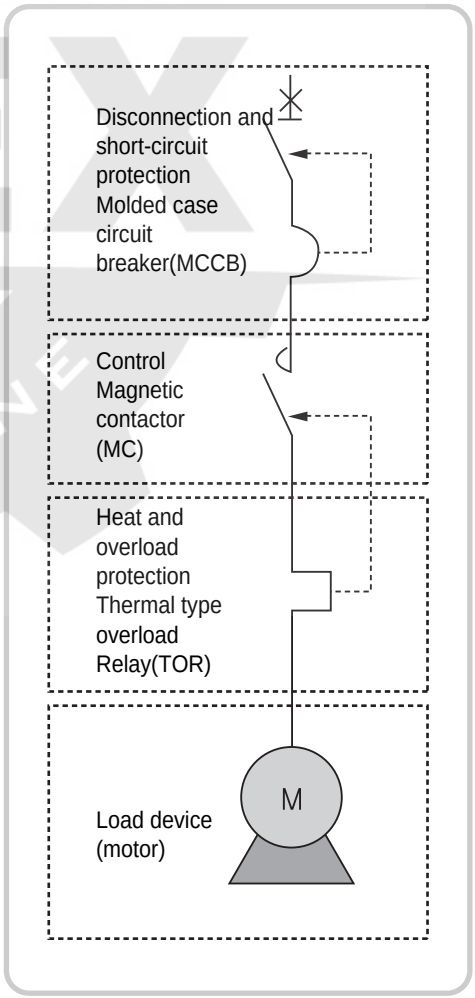


Fig. 61. Protection system

1.3 Application Standards

Motor circuit should be applied by designated general rules of KSC IEC 60947-4-1 and related contents with motor protection are as follow.

- Protection cooperation of motor circuit accessories, etc.
- Thermal type over current relay Trip Class
- Magnetic contactor application range
- Insulation cooperation

■ Different test currents

The standard for propriety of Type-2 coordination requires 3 different faulty current tests to check normal operation of magnetic switch and control devices under overload and short circuit condition.

1. "Ic" current (overload I < 10 In)

TOR provides protection against Ic value(Im or Isd function) indicated by manufacturer and this type of fault. And KSC 60947-4-1 designates two different tests which have to be operated to ensure protection cooperation between TOR and short circuit protection device.

- Apply to TOR in 0.75Ic.
- Apply to short circuit protection device in 1.25Ic.

TOR's tripping characteristic shouldn't be changed from 0.75 and 1.25Ic tests, and Type2 cooperation enhances service continuance. After getting rid of fault, magnetic contactor can be closed automatically.

2. "r" current(impedance short circuit 10 < I < 50 In)

The main cause of this type of fault is insulation destruction. KSC IEC 60947-4-1 describes instant short circuit current "r". This test current is used to check if the protection device provides protection against impedance short circuit. After this test, there shouldn't be any changes on basic characteristics of the magnetic contactor or TOR. The breaker should trip within 10ms against a faulty current of over 15In.

Table1. Estimated test current value by rated operating current

Motor operational current Ie(AC3) (A)	Estimated current "r"(kA)
Ie ≤ 16	1
16 < Ie ≤ 63	3
63 < Ie ≤ 125	5
125 < Ie ≤ 315	10
315 < Ie ≤ 630	18

1. Coordination

1.3 Application Standards

■ **Different test currents**

3. "Iq" current(short circuit I > 50In)

This type of fault is relatively rare. The possible cause of this could be connection fault during maintenance. Short circuit protection is provided by rapid breaking device. KSC IEC 60947-4-1 states "Iq" current as usually over 50kA. "Iq" current is used to check protection cooperation of magnetic switch and control device which is installed to motor supply circuit. After this test under extreme conditions, all assembled magnetic switch and control device should be operated continuously.

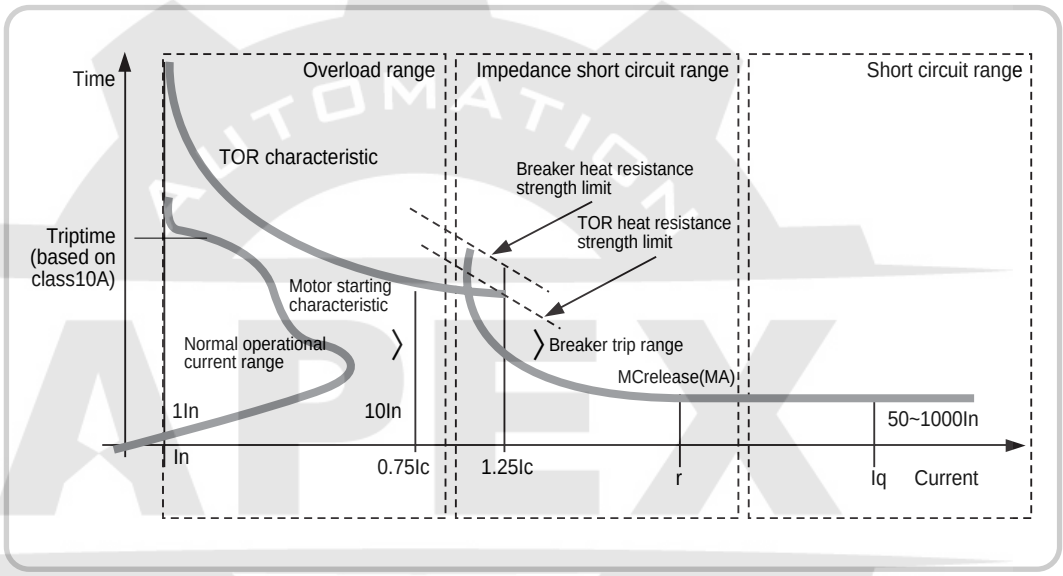


Fig. 62. Time-current characteristic curve

■ **TOR Trip Class**

Four trip classes of TOR are 10A, 10, 20 and 30(max. tripping time in 7.2Ir). Generally class 10 and 10A are used the most. Class 20 and 30 are needed for motors with long starting time. You can use fig 62 and table 2 to select right TOR for motor starting time.

Table 2. Operating range by trip class

Class	1.05 Ir	1.2 Ir	1.5 Ir	7.2 Ir
10A	t > 2h	t < 2h	t < 2 min.	2 ≤ t ≤ 10s
10	t > 2h	t < 2h	t < 4 min.	4 ≤ t ≤ 10s
20	t > 2h	t < 2h	t < 8 min.	6 ≤ t ≤ 20s
30	t > 2h	t < 2h	t < 12 min.	9 ≤ t ≤ 30s

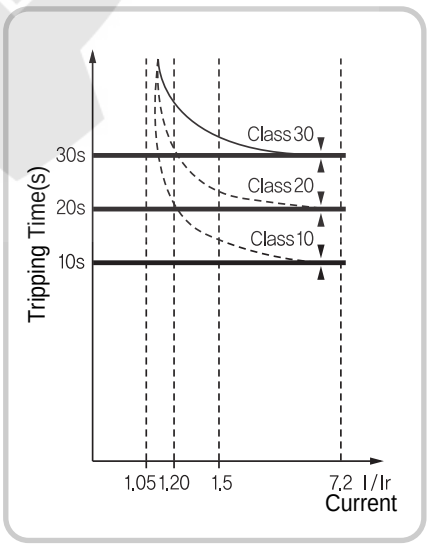


Fig. 63. Characteristic curve by trip class

1.4 General Consideration of Magnetic Switch and MCCB Coordination

■ Coordination conditions

When you determine protection cooperation for branch circuit with MCCB and magnetic switch which
have motor as load, the following details should be considered.

1. Magnetic switch should certainly be able to break the maximum current which could occur under motor's normal condition.
2. TOR should definitely have an operation characteristic to protect during motor's overload and binding.
3. MCCB should have the capacity to adequately break a short circuit current which could flow on each short circuit point.(including cascade breaking)
4. The thickness of the branch circuit wire should be the size which is not to be burnt out by 12t that passes through within MCCB breaking time, if there is a short circuit current.
5. Branch circuit wire should be protected from over current by TOR or MCCB.
6. MCCB should not operate faultily from motor's starting current or rush current.(Especially, be cautious of rush current of semi-cycle during closing.)
7. Operation characteristics of TOR and MCCB have an intersecting point and extended over the full current power, the protection operating characteristic should not have a gap. Also, for current power below the intersecting point, the TOR's characteristic should be on the lower side.
8. The intersecting point of the operation characteristic should be a current value which is less than the magnetic switch's breaking capacity.
9. If there is short circuit current on the magnetic switch, it should not be damaged until the MCCB breaks.

If the above conditions are satisfied, the protection cooperation of branch circuit is able to be completed but completing economic side and all conditions are not always the most advantageous plan. The protection cooperation degree of a branch circuit can be interpreted as the reliability of a branch circuit system but regarding reliability necessity and economical efficiency, several details need to be added. So from above details, 1~6 are required but depending on economic circumstances, 7~9 can be considered by their degrees of necessity.

■ The relation between MCCB and magnetic switch operation characteristics

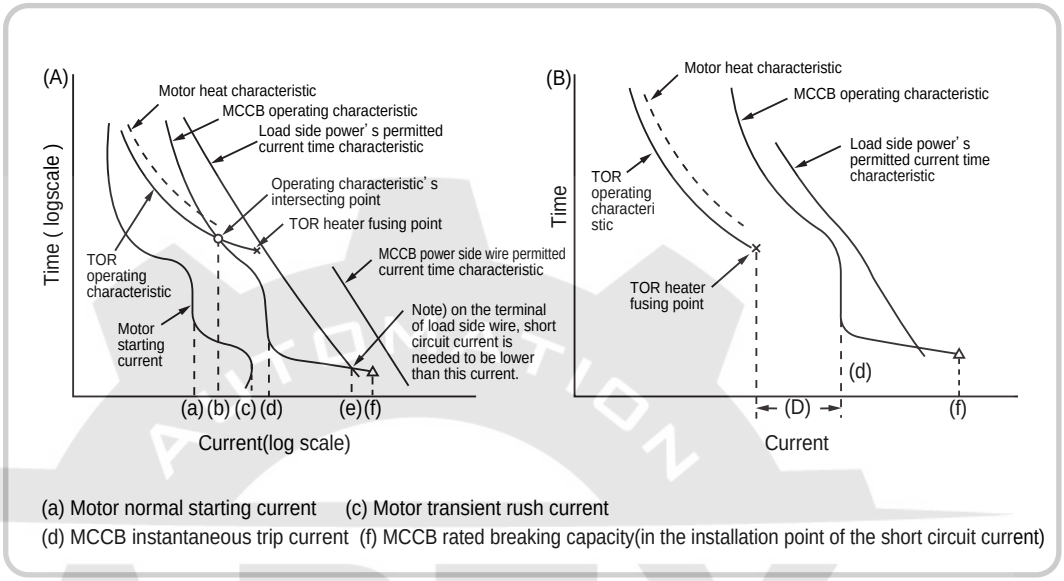
To protect the motor and to prevent faulty operation, a magnetic switch should be installed with an E type motor and it's TOR's operation characteristic should satisfy the following conditions.

1. Inactive operation with 105% of motor's rated current, operating with 120%.
2. Operating within 3~30sec with motor's starting(binding) current

Fig. 64 indicates the TOR's operation characteristic, the motor's heat characteristic and the motor's starting current but if each curve is same as fig. 64(A), the condition can be satisfied. This condition can be satisfied if in a modern (RC scale) TOR's selection the motor rated current is roughly the same as the heater set current.

1. Coordination

1.4 General Consideration of Magnetic Switch and MCCB Coordination



(a) Motor normal starting current (c) Motor transient rush current
(d) MCCB instantaneous trip current (f) MCCB rated breaking capacity(in the installation point of the short circuit current)

Fig. 64. Each characteristic's relation of protection cooperation

There is a possibility of faulty operation by rush current during motor's starting. For a squirrel-cage motor, approximately 5~7 times the normal starting current flows during starting but because direct current overlaps during early starting(especially very beginning of semi cycle), an even bigger transient rush current flows and the amplification changes by a power factor as in fig. 66. When motor's starting power factor is 0.4 delay, it becomes about 1.3 times of normal starting current. Moreover if there is instant restarting(after power is off, restarting before motor stops spinning), at worst it reaches two times, in other words, 2.6 times of normal starting current from effect of residual current of motor. Fig. 67 shows actual measurement results from a real motor. Instantaneous trip time of MCCB is operated around a semi cycle so it is necessary to be cautious not to be operated with selected rush current. To prevent faulty operation from this rush current, check actual measurement result and set breaker's instantaneous trip current as 14 times of rated current. After deciding operation characteristic of magnetic switch and MCCB like this, it is a problem to make each characteristic's intersecting point. Fig. 64(A) indicates when the 7th item (p231) of protection cooperation condition is satisfied and fig. 64(B) indicates when it's not satisfied. In the case of fig. 64(B), because there is gap of protection cooperation, if the current of this range flows, the TOR's heater will be fused. TOR operating characteristic MCCBoperating characteristic MCCB faulty opperation

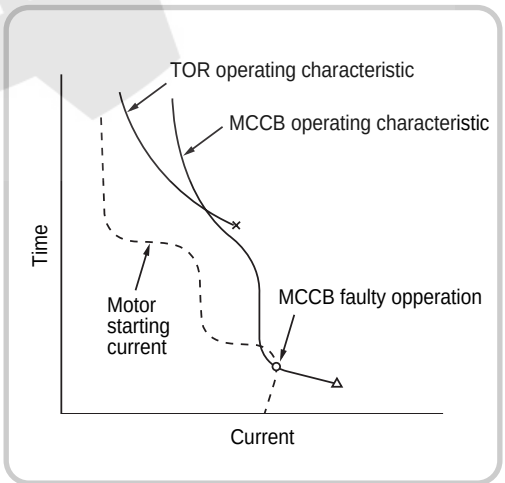


Fig. 65. Example of faulty operation by motor rush current of MCCB

Also on fig64(A), when the intersecting point of the operation characteristic exceeds the magnetic switch's breaking capacity, even if TOR is operated, the magnetic switch becomes incapable of breaking and is damaged. So in the case of having an intersecting point of operation characteristic for protection cooperation, the 8th item(p231) of protection cooperation condition needs to be satisfied. It is desirable to satisfy the condition stated in this paragraph for protection cooperation but because this kind of current range is relatively narrow and the possibility of flowing is also very rare(the current of this range is mostly from motor winding ground and layer.), it can be neglected.

■ Magnetic switch when short circuit current flows

If current flows on a magnetic switch, an electron repulsive power occurs between contact points. By this electron repulsive power, the magnetic switch will have contact points' loosening(separation) from 20~40 times current of usual rated operational current. So if more than that amount of short circuit current flows, an arc can occur by contact points' loosening, and there are possibilities of contact points' melting and short circuit between poles. If there is short circuit fault, it can be broken by MCCB but maximum value of the current and I2t which flows at that point are a function of agreed short circuit current and it tends to increase together with short circuit current increase. So if over certain limit of short circuit current flows, preventing damage of magnetic switch by MCCB prevents to have arc between these contact points(do not let them rise up.) and it is difficult if it's not suppressed with extremely small amount. But when short circuit current is small with short circuit point being load side's front and end, it is possible to avoid magnetic switch's damage as stated on short circuit fault consideration (p237).

■ Protection cooperation degree

Now MCCB which satisfies various function and characteristics are being manufactured and also for protection cooperation, small changes can be added to magnetic switch. About the details which are considered with relation between MCCB and magnetic switch operation characteristic(p233) and magnetic switch with short circuit current flowing (p231), each step can become feasible by protection cooperation degree. Certain requirements on top of this protection cooperation degree can be decided by its necessity and economical point of view which was mentioned before. In relation to this fact, KSC and IEC standard [electric machine type contactor and motor starter] indicates following coordination types by the level of magnetic switch's damage during short circuit. Type "1" is that contactor or starter should not be the main cause of harming human or facilities under short circuit condition and it doesn't have to be suitable to use continuously without repairing or exchanging accessories. Type "2" is that contactor or starter should not be the main cause of harming human or facilities under short circuit condition and it should be used continuously. When manufacturer is instructing steps to take for device repair, it is okay for contact point to be melted and fused. And as stated example of handling method with other various standards, UL standard (American Safety Standard) No. 508 and CSA standard(Canadian Safety Standard) C22-2 No. 14 designate that when 5000A short circuit current which is combined by 3~4 times of rated operational current's rated fuse or breaker, flows on magnetic switch,
magnetic switch would not have any abnormality(just, contact point's melting and fusion permitted).

1. Coordination

1.4 General Consideration of Magnetic Switch and MCCB Coordination

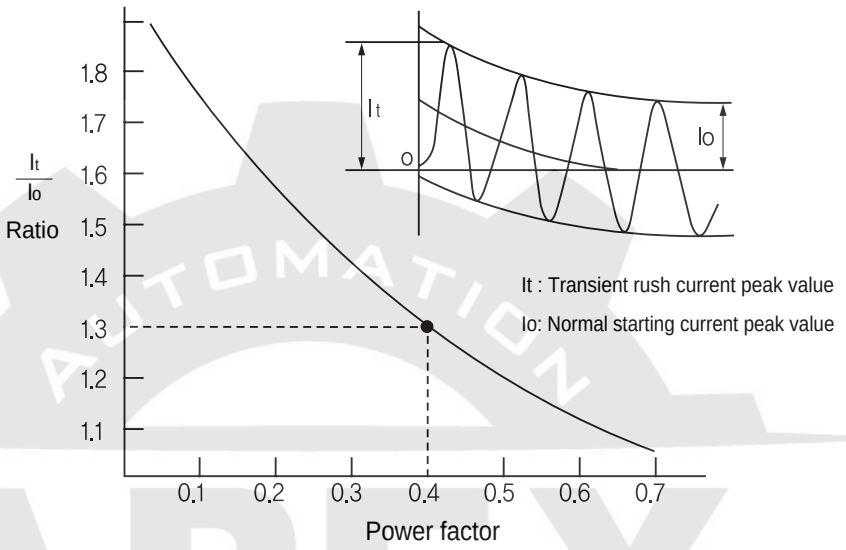
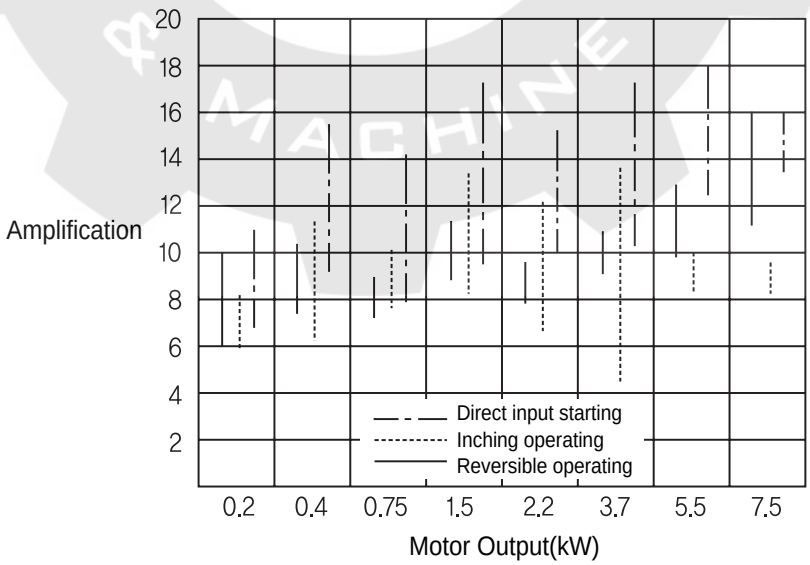


Fig. 66. Inrush current during motor's starting



Note) amplification = $\frac{\text{transient inrush current peak value}}{\text{rated current (effective value)}}$

Fig. 67. Amplification of motor's rated current and transient inrush current

1.5 Coordination of Metasol Series Magnetic Switch and Metasol MCCB

■ Breaking capacity of Metasol series magnetic contactor

The intersecting point of the MCCB and the TOR's operation characteristics are not just on the breaker's inverse limit time characteristic range shown as fig. 64(A) but also on instantaneous trip range shown as fig. 68. In this case, if the magnetic contactor does not have any extra breaking capacity, it's possible for the intersecting point to exceed the magnetic contactor's breaking capacity. With consideration of this point, the Metasol series magnetic contactor has been made to have enough extra breaking capacity, and as shown on table 3, it is over 13 times of rated operational current below 440V. So even when operation characteristic's intersecting point is the same as fig. 68, maximum rated capacity can be selected for the motor so in the case of selecting protection cooperation, it is economically advantageous.

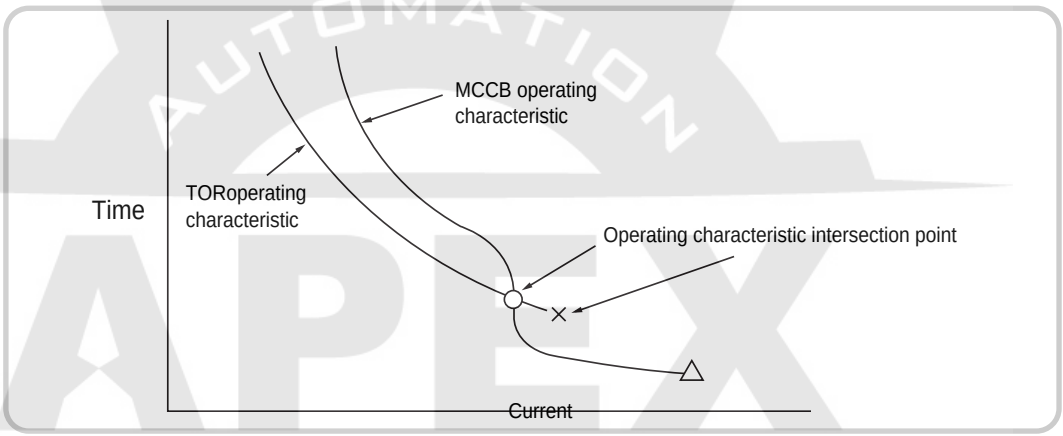


Fig. 68. Intersecting point of breaker and thermal relay

Table 3. Breaking limit of Metasol series magnetic switch

Type		Type Rated operational current(A) AC-3 level440V	Breaking possible current(kA) 440V
18AF	MS-6a	6	100
	MS-9a	9	100
	MS-12a	12	150
	MS-18a	18	200
22AF	MS-9b	9	100
	MS-12b	12	150
	MS-18b	18	200
	MS-22b	22	208
40AF	MS-32a	32	500
	MS-40a	40	600
65AF	MS-50a	50	700
	MS-65a	65	950
100AF	MS-75a	75	950
	MS-85a	85	1200
	MS-100a	95	1200
150AF	130a	110	1800
	150a	150	2300
225AF	185a	185	2700
	225a	225	3600
400AF	265a	265	4200
	330a	330	5200
	400a	400	7200
800AF	500a	500	6400
	630a	600	6400
	800a	800	8200

1. Coordination

1.5 Coordination of Metasol Series Magnetic Switch and Metasol MCCB

■ MT type TOR over current resistance quantity

The MT type TOR used in the Metasol series magnetic switch is designed either to have a slightly longer operating time to possibly bring the operation characteristic's intersecting point from breaker's inverse limit time characteristic range or to have a large heater over current resistant quantity, etc. with operation characteristic cooperation with MCCB. Particularly, the fusing point at which the heater melts before TOR operates is shown on fig. 69 but because it becomes 13 times the maximum heater current, it is considered to have a certain cooperation with the MCCB. Also, the TOR heater fusing during a short circuit fault is decided by the value of passing I^2t but heater fusing I^2t value of MT type is relatively big so it is easy to get good protection cooperation. Approximate value of MT type TOR's permitted fusing I^2t and heater fusing I^2t are stated on table 4.

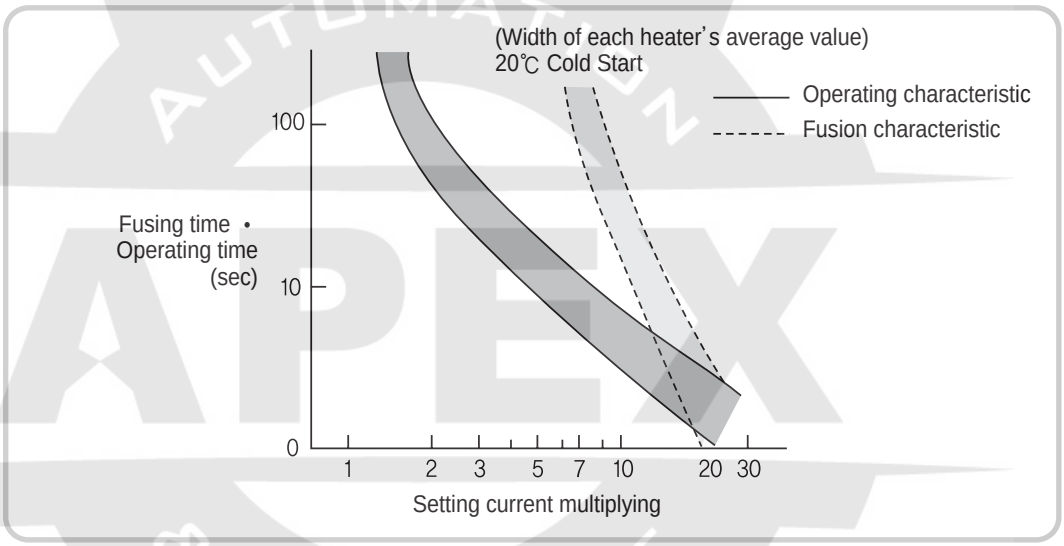


Fig. 69. Example of MT type TOR's heater fusion characteristic

Table 4. MT type TOR's permitted 12t when short circuit current passes

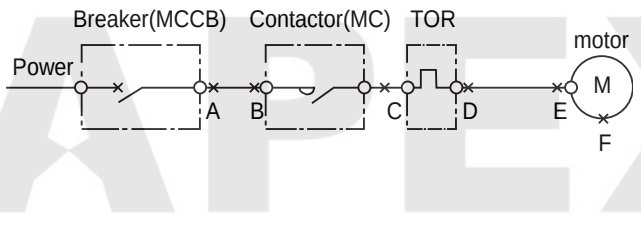
Type	Reusable permission I2t (A2s)	Heater fusion I2t (A2s)
MT-32	150 ~ 500 I^2	250 ~ 1000 I^2
MT-63	250 ~ 600 I^2	400 ~ 1000 I^2
MT-95	3000 ~ 700 I^2	500 ~ 1000 I^2

■ Operation character-istic's coordination

To prevent faulty operation, the instantaneous trip current of MCCB is set with a slightly higher value. So the rated current of a Metasol series MCCB which is to be selected for proper protection cooperation with Metasol series magnetic switch is better to be relatively small and it is almost 1.5 times of TOR heater set current. A combination example of a Metasol series MCCB and magnetic switch which are selected in regards to operation characteristic cooperation is stated on machinery selection for Type 2 protection cooperation(p239~242). The one problem regarding operation characteristic cooperation is related with short circuit capacity when it is necessary to select a breaker with a bigger frame compared to an MT type TOR's heater size. In this case, the breaker's lowest value of rated current is limited so protection cooperation can be difficult. The solution to this is applying an automatic type TOR.

■ Short circuit fault investigation

In an MCCB which has a motor with a load and branch circuit with a magnetic switch, short circuit points related with this breaker are the six spots A through F in fig. 70 and since all other points have almost no possibility of a short circuit fault, they are not considered. Therefore short circuit faults on each point are investigated as below. At first, KSC and IEC standards' protection cooperation type as protection cooperation degree (p233) was introduced but if there is short circuit fault on C or D point of fig. 70, the short circuit current is big and permitted over current of Metasol series magnetic contactor is as shown on table 5. So generally protection cooperation type will be Type"1" and it is difficult to set it as Type"2". But when the short circuit point is on E or F of fig. 70, current decrease by wiring's impedance is quite big and the calculated result (higher impedance from D point is 0.) for wire length, 50m and 100m between D and E of fig. 70 is value shown on table 6. In fact, higher impedance is also added from D point so if there is short circuit to E point, the current which flows to magnetic switch gets smaller than the value on table 5. In this case, there is big possibility of having Type "2" as the cooperation type. If there is fault on F point, current gets smaller so the condition is better than E point.



A: MCCB terminal unit
B: MC power side terminal unit
C: MC load side terminal unit
(TOR power side terminal unit)
D: TOR load side terminal unit
E: Motor terminal unit
F: Motor winding unit M
F: Power

Fig. 70. Branchcircuit's short circuit points

Table 5. Metasol series Magnetic switch permitted overcurrent

Type	Current flow 10ms permitted overcurrent(A)	Wire length that short circuit current is less than permitted overcurrent fromleft column(m)			
		Wire size (mm^2)	Circuit voltage		
			220V	440V	550V
MS-6a, 9a, 9b, 12a, 12b	800	2	50	100	125
MS-18a, 18b, 22b	1000	3.5	16	33	41
MS-32a, 40a	1600	8	35	69	87
MS-50a, 65a	2200	14	45	86	111
MS-75a, 85a	3000	22	53	106	133
MS-100a	3000	30	69	137	172
MS-130a, 150a	3600	38	72	144	179
MS-185a, 225a	6500	60	62	124	155
MS-265a, 330a, 400a	10000	200	95	190	238
MS-500a, 630a, 800a	15000	325	114	228	285

1. Coordination

1.5 Coordination of Metasol Series Magnetic Switch and Metasol MCCB

■ Short circuit fault investigation

Based on Metasol series magnetic contactor's permitted over current(the value in the case of no current limit of short circuit current with MCCB breaking time as 10ms), the calculated result of wire length which is needed to make protection cooperation Type"2" possible, is stated on table 5. This value is also calculated with higher impedance from D point as 0, so actual wire length will become a little shorter than this. Even when the length of wire is short, it is relatively easy to make possible up to certain length by methods as (1) enlarge magnetic contactor's size, (2) use MCCB with current limit effect, etc. over current resistant quantity is stated on table 4 but except small quantity rated heater, generally coordination Type"2" is relatively easily satisfied. In the case of a short circuit fault on A or B point of fig. 70, if the MCCB's breaking capacity is sufficient, there is no problem.

Table 6. Conventional short circuit current in the case of short circuit at end of wiring (symmetrical value)

Wire thickness mm²	Short circuit current(A)			
	When wire length is 50m		When wire length is 100m	
	220V	440V	220V	440V
Ø1.6	300	600	150	300
Ø2	460	920	230	460
5.5 mm²	800	1600	400	800
8 mm²	1100	2200	550	1100
14 mm²	2300	4600	1150	2300
22 mm²	3100	6200	1550	3100
30 mm²	4100	8200	2050	4100
38 mm²	5200	10400	2600	5200
50 mm²	6700	13400	3350	6700
60 mm²	8000	16000	4000	8000
80 mm²	10500	21000	5200	10500
100 mm²	13000	26000	6500	13000
125 mm²	15000	30000	7500	15000
150 mm²	17000	34000	8500	17000
200 mm²	19000	38000	9500	19000

■ Coordination of Metasol series MCCB and Metasol series magnetic switch

As investigated above, if each selection is correct, coordination of Metasol series MCCB and magnetic switch is relatively easily satisfies 1~8 details of coordination conditions (p195). But during the event of a disconnection fault, it becomes about type"2" of KSC and IEC standards coordination for short circuit on E or F point of Fig. 70 or type "1" for short circuit on C or D point. Depending on short circuit protection device, it is possible to have type "2" of coordination type even with short circuit fault of point C or D. But point C or D's short circuit occurs in magnetic contactor or TOR's terminal unit so it is impossible to avoid insulation deterioration between terminals and terminal's burnout. Eventually a magnetic switch needs to be exchanged so even with type "2" of coordination type, it should be regarded as having fewer advantages. So for coordination coordination type during short circuit, type"2" is proper in the case of short circuit on E or F point and type"1" for short circuit on C or D point. If you interpret that 9th detail of coordination conditions(p195) is applied to the short circuit case on E or F point, as stated above, it can be said that combination of Metasol series MCCB and Metasol magnetic switch can be satisfied at certain level.

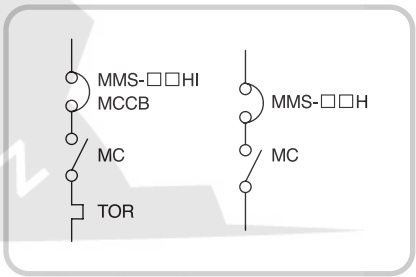
2 . Machinery Selection Table for Type II Coordination

2.1 Relation of Breaking Coordination between Contactor(Switch) and Breaker(MCCB for Protecting Motor)

When a breaker and a switch or an MMS and a switch are combined and used, the breaker breaks to protect line if there is any fault but part of short circuit current will be transmitted to lower contactor and overload relay too. So lower contactor and overload relay should be structured to resist certain amount of short circuit current.
KSC and IEC standards are regulating about this with Type II coordination item and overseas advanced companies have this type of test as a basic item, then list test contents in catalogue and technical data. According to this, LS Industrial Systems also completed the test as KSC and IEC standards at electric power test center (PT&T) and provided selecting table.

■ Coordination of motor circuit

Machinery selection table for Type2 coordination
MCCB+MC, MMS+MC(220/240Vstandard)



MCCB	N	H	L
TD100	85kA	100kA	200kA

MMS	S	HI, H
MMS-32	50kA	100kA

Motor rated power				MCCB, MMS		Con tactor	Thermal Overload Relay		Short circuit breaking capacity	
kW	Rated current (A)			Type	Rating (A)	Type	Type	Setting current (A)	Ir (kA)	Iq (kA)
	380V	400V	415V							
0.06	0.21	0.20	0.19	MMS-32HI	0.25	MC-6a	MT-12	0.16~0.25	1	50
0.09	0.32	0.30	0.29	MMS-32HI	0.4	MC-6a	MT-12	0.25~0.4	1	50
0.12	0.46	0.44	0.42	MMS-32HI	0.63	MC-6a	MT-12	0.4~0.63	1	50
0.18	0.63	0.60	0.58	MMS-32HI	0.63	MC-6a	MT-12	0.4~0.63	1	50
0.25	0.89	0.85	0.82	MMS-32HI	1	MC-6a	MT-12	0.63~1	1	50
0.37	1.16	1.10	1.06	MMS-32HI	1.6	MC-12a,12b	MT-12	1~1.6	1	50
0.55	1.6	1.5	1.4	MMS-32HI	1.6	MC-12a,12b	MT-12	1~1.6	1	50
0.75	2.0	1.9	1.8	MMS-32HI	2.5	MC-12a,12b	MT-12	1.6~2.5	1	50
1.1	2.8	2.7	2.6	MMS-32HI	4	MC-22b	MT-32	2.5~4	1	50
1.5	3.8	3.6	3.5	MMS-32HI	4	MC-22b	MT-32	2.5~4	1	50
2.2	5.2	4.9	4.7	MMS-32HI	6	MC-22b	MT-32	4~6	1	50
3.0	6.8	6.5	6.3	MMS-32HI	8	MC-40a	MT-32	5~8	1	50
4.0	8.9	8.5	8.2	MMS-32HI	10	MC-40a	MT-32	6~9	1	50
5.5	12.1	11.5	11.1	MMS-32HI	13	MC-40a	MT-32	9~13	3	50
7.5	16.3	15.5	14.9	MMS-32HI	17	MC-40a	MT-32	12~18	3	50
11.0	23.2	22.0	21.2	TD100	25	MC-50a	MT-63	18~25	3	70
15.0	31	29	28	TD100	32	MC-50a	MT-63	24~36	3	70
18.5	37	35	34	TD100	40	MC-50a	MT-63	28~40	3	70
22	43	41	40	TD100	50	MC-50a	MT-63	34~50	3	70
30	58	55	53	TD100	63	MC-65a	MT-63	45~65	3	70
37	69	66	64	TD100	80	MC-75a	MT-95	54~75	5	70
45	84	80	77	TD100	100	MC-85a	MT-95	63~85	5	70
55	-	-	93	TD100	100	MC-100a	MT-95	70~95	5	70

2 . Machinery Selection Table for Type II Coordination

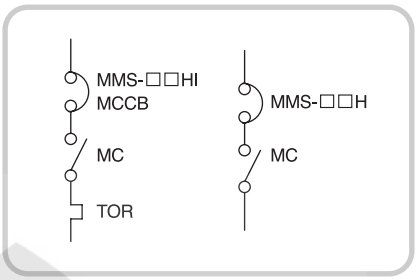
2.1 Relation of Breaking Coordination between Contactor(Switch) and Breaker(MCCB for Protecting Motor)

■ **Motor circuit's coordination**

Machinery selection table for Type 2 coordination
MCCB+MC, MMS+MC(380/415Vstandard)

MCCB	N	H	L
TD100	50kA	85kA	150kA

MMS	S	HI, H
MMS-32	50kA	50kA



Motor rated power				MCCB, MMS		Con tactor	Thermal Overload Relay		Short circuit breaking capacity	
kW	Rated current (A)			Type(1)	Rating (A)	Type	Type(1)	Setting current (A)		
	380V	400V	415V						Ir (kA)	Iq (kA)
0.06	0.21	0.20	0.19	MMS-32HI	0.25	MC-9a(b)	MT-12	0.16~0.25	1	30
0.09	0.32	0.30	0.29	MMS-32HI	0.4	MC-9a(b)	MT-12	0.25~0.4	1	30
0.12	0.46	0.44	0.42	MMS-32HI	0.63	MC-9a(b)	MT-12	0.4~0.63	1	30
0.18	0.63	0.60	0.58	MMS-32HI	0.63	MC-9a(b)	MT-12	0.4~0.63	1	30
0.37	1.16	1.10	1.06	MMS-32HI	1.6	MC-9a(b)	MT-12	1~1.6	1	30
0.55	1.6	1.5	1.4	MMS-32HI	1.6	MC-9a(b)	MT-12	1~1.6	1	30
0.75	2.0	1.9	1.8	MMS-32HI	2.5	MC-9a(b)	MT-12	1.6~2.5	1	30
1.1	2.8	2.7	2.6	MMS-32HI	4	MC-18a(b)	MT-12	2.5~4	1	30
1.5	3.8	3.6	3.5	MMS-32HI	4	MC-18a(b)	MT-12	2.5~4	1	30
2.2	5.2	4.9	4.7	MMS-32HI	6	MC-18a(b)	MT-12	4~6	1	30
3.0	6.8	6.5	6.3	MMS-32HI	8	MC-32a	MT-32	5~8	1	50
4.0	8.9	8.5	8.2	MMS-32HI	10	MC-32a	MT-32	6~9	1	50
5.5	12.1	11.5	11.1	MMS-32HI	13	MC-32a	MT-32	9~13	3	50
7.5	16.3	15.5	14.9	MMS-32HI	17	MC-32a	MT-32	12~18	3	50
11.0	23.2	22.0	21.2	MMS-32HI	25	MC-40a	MT-32	18~25	3	50
15.0	31	29	28	MMS-32HI	32	MC-40a	MT-32	24~36	3	50
18.5	37	35	34	MMS-32HI	40	MC-40a	MT-32	28~40	3	50
22	43	41	40	TD100	50	MC-50a	MT-63	34~50	3	70
30	58	55	53	TD100	63	MC-65a	MT-63	45~65	3	70
37	69	66	64	TD100	80	MC-75a	MT-95	54~75	5	70
45	84	80	77	TD100	100	MC-85a	MT-95	63~85	5	70
55	-	-	93	TD100	100	MC-95a	MT-95	70~95	5	70

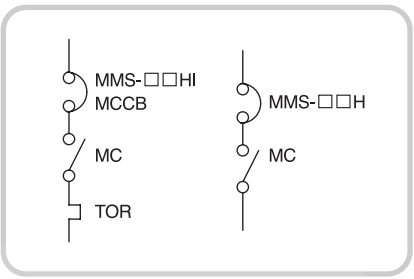
(1) If "H" model is used instead of "HI" model for MMS, use without thermal relay.

■ Motor circuit's coordination

Machinery selection table for Type 2 coordination
MCCB+MC, MMS+MC(440Vstandard)

MCCB	N	H	L
TD100	42kA	72kA	130kA

MMS	S	HI, H
MMS-32	38kA	50kA



Motor rated power		MCCB, MMS		Con tactor	Thermal Overload Relay		Short circuit breaking capacity	
kW	Rated current(A) 440V	Type(1)	Rating (A)	Type	Type(1)	Setting current (A)	Ir(kA)	Iq(kA)
0.06	0.18	MMS-32HI	0.25	MC-9a(b)	MT-12	0.16~0.25	1	30
0.09	0.27	MMS-32HI	0.4	MC-9a	MT-12	0.25~0.4	1	30
0.12	0.40	MMS-32HI	0.63	MC-9a(b)	MT-12	0.4~0.63	1	30
0.18	0.55	MMS-32HI	0.63	MC-9a(b)	MT-12	0.4~0.63	1	30
0.37	1.00	MMS-32HI	1.6	MC-9a(b)	MT-12	1~1.6	1	30
0.55	1.4	MMS-32HI	1.6	MC-9a(b)	MT-12	1~1.6	1	30
0.75	1.7	MMS-32HI	2.5	MC-9a(b)	MT-12	1.6~2.5	1	30
1.1	2.5	MMS-32HI	4	MC-9a(b)	MT-12	2.5~4	1	30
1.5	3.3	MMS-32HI	4	MC-18a(b)	MT-12	2.5~4	1	30
2.2	4.5	MMS-32HI	6	MC-18a(b)	MT-12	4~6	1	30
3.0	5.9	MMS-32HI	8	MC-18a(b)	MT-12	5~8	1	30
4.0	7.7	MMS-32HI	10	MC-32a	MT-32	6~9	1	50
5.5	10.5	MMS-32HI	13	MC-32a	MT-32	9~13	1	50
7.5	14.1	MMS-32HI	17	MC-32a	MT-32	12~18	3	20
11.0	20.0	MMS-32HI	20	MC-40a	MT-32	18~25	3	20
15.0	26	MMS-32HI	32	MC-40a	MT-32	24~36	3	20
18.5	32	TD100	32	MC-50a	MT-63	24~36	3	50
22	37	TD100	40	MC-50a	MT-63	28~40	3	50
30	50	TD100	50	MC-65a	MT-63	45~65	3	50
37	60	TD100	63	MC-65a	MT-63	45~65	3	50
45	73	TD100	80	MC-85a	MT-95	54~75	5	50
55	88	TD100	100	MC-95a	MT-95	70~95	5	50

(1) If "H" model is used instead of "HI" model for MMS, use without thermal relay.

K

2 . Machinery Selection Table for Type II Coordination

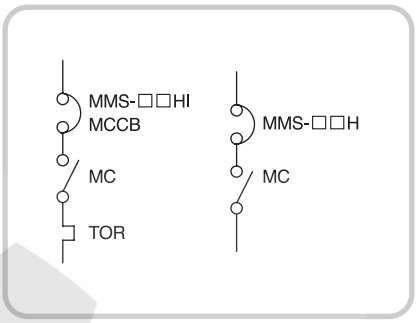
2.1 Relation of Breaking Coordination between Contactor(Switch) and Breaker(MCCB for Protecting Motor)

■ **Motor circuit's coordination**

Type2 coordination machinery selection table
MCCB+MC, MMS+MC(480/500Vstandard)

MCCB	N	H	L
TD100	30kA	50kA	65kA

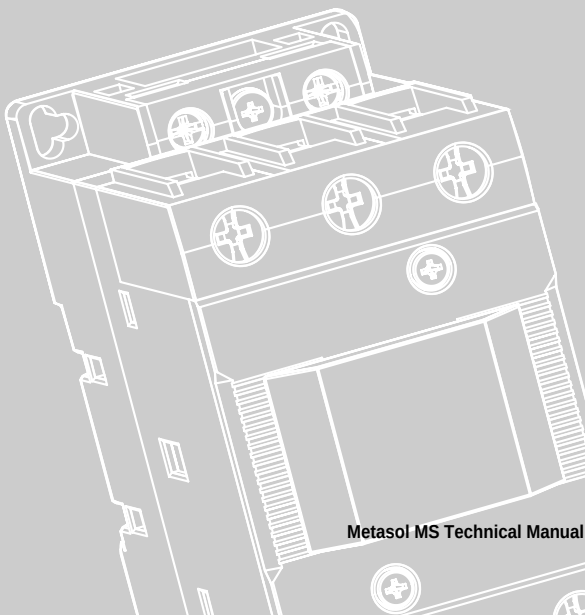
MMS	S	HI, H
MMS-32	38kA	50kA
MMS-63	10kA	35kA



Motor rated power		MCCB, MMS		Con tactor	Thermal Overload Relay		Short circuit breaking capacity	
kW	Rated current(A) 500V	Type (1)	Rating (A)	Type	Type (1)	Setting current (A)	Ir(kA)	Iq(kA)
0.06	0.16	MMS-32HI	0.25	MC-9a(b)	MT-12	0.16~0.25	1	30
0.09	0.24	MMS-32HI	0.25	MC-9a(b)	MT-12	0.16~0.25	1	30
0.12	0.32	MMS-32HI	0.4	MC-9a(b)	MT-12	0.25~0.4	1	30
0.18	0.48	MMS-32HI	0.63	MC-9a(b)	MT-12	0.4~0.63	1	30
0.37	0.88	MMS-32HI	1	MC-9a(b)	MT-12	0.63~1	1	30
0.55	1.2	MMS-32HI	1.6	MC-9a(b)	MT-12	1~1.6	1	30
0.75	1.5	MMS-32HI	1.6	MC-9a(b)	MT-12	1~1.6	1	30
1.1	2.2	MMS-32HI	2.5	MC-9a(b)	MT-12	1.6~2.5	1	30
1.5	2.9	MMS-32HI	4	MC-18a(b)	MT-12	2.5~4	1	30
2.2	3.9	MMS-32HI	4	MC-18a(b)	MT-12	2.5~4	1	30
3.0	5.2	MMS-32HI	6	MC-18a(b)	MT-12	4~6	1	30
4.0	6.8	MMS-32HI	8	MC-32a	MT-32	5~8	1	30
5.5	9.2	MMS-32HI	10	MC-32a	MT-32	7~10	1	30
7.5	12.4	MMS-32HI	13	MC-32a	MT-32	9~13	3	30
11.0	17.6	MMS-32HI	22	MC-40a	MT-32	12~18	3	20
15.0	23	MMS-32HI	26	MC-40a	MT-32	18~25	3	20
18.5	28	MMS-32HI	32	MC-40a	MT-32	24~36	3	20
22	33	MMS-63HI	40	MC-50a	MT-63	24~36	3	10
30	44	MMS-63HI	50	MC-50a	MT-63	34~50	3	10
37	53	TD100	63	MC-65a	MT-63	45~65	3	10
45	64	TD100	80	MC-65a	MT-63	45~65	5	10
55	78	TD100	100	MC-85a	MT-95	63~85	5	30

(1) If "H" model is used instead of "HI" model for MMS, use without thermal relay.

L. Standards



1. Verification Organizations and Standards

1.1 Power Testing & Technology Institute (PT&T)

PT & T was established by LSIS, a Korean heavy electric machinery manufacturer. We have built the first short circuit test facility, high voltage test facility, reliability facility and revision/correction facility of 1600MVA capacity. We have a target of technology development for product performance and reliability improvement, technical specialties in tests and evaluation tasks and fair management. These goals are especially important as an international public test organization and correction organization recognized by KOLAS, we contribute to technological development in the heavy electric machine industry and strive for competitiveness improvement through evaluation of international levels and correction service.

■ Standard certification

KS Korea (Industry) Standard
IEC International Electrotechnical Commission
ES, PS Korea Electric Power Corporation Standards
KEMC Korea Electrical Manufactures's Cooperative Standards
ANSI American National Standards Institute
Etc.

■ Test organization certification

The Power Testing & Technology Institute is recognized as test organization according to the 23rd National standard fundametal law same law enforcement directive and international standard. We are officially recognized national test center which shares test results with other organizations such as UL(American Safety Standards) and CE(Eurpean Community Assurance Mark) standard test and also cooperating with overseas test organization such as KEMA of Netherlands , CESI of Italy.
Test cooperative organization : KEMA(Netherlands), CESI(Italy), UL(America) etc

1.2 Standards

■ International standards

IEC 60947-1	**low voltage switch gear and control gear** • Part1 : general regulations (NFC63-001)
IEC 60947-4-1	**low voltage switch gear and control gear** • Part4 : contactor and motor starter • Section1 : electric machinery contactor and motor starter (NFC63-001)
IEC 60947-5-1	**low voltage switch gear and control gear** • Part5 : control circuit device and switching element • Section1 : electric machinery control circuit device (NFC63-146)
IEC 60947-6-1	**low voltage switch gear and control gear** • Part6 : multi-function device • Section1 : Automatic transfer switching device (NFC63-160)
IEC 60204-1	**Electrical devices of industrial equipment** • Part1 : general requirements (NFC79-130)
IEC 60204-2	**Electrical devices of industrial equipment** • Part2: Item design, drawing, diagram, table and operating example (Publication 204-1' Appendices Dand E)

■ European standards

EN 50 001	**industrial low voltage switch gear and control gear** • range : General Requirements (NFC63-090)
EN 50 002	**industrial low voltage switch gear and control gear** • range : Dimensions and Installation of contactor relay Hole (NFC63-091)
EN 50 003	**industrial low voltage switch gear and control gear** • range : Dimensions and installation of motor contactor Hole (NFC63-092)
EN 50 005	**industrial low voltage switch gear and control gear** • distinguishing number with element mark: general regulations (NFC63-030)
EN 50 011	**industrial low voltage switch gear and control gear** • element mark for specified contactor relay, distinguising number, distinguishing character (NFC 63-031)
EN 50 012	**industrial low voltage switch gear and control gear** • element mark and distinguishing number for specified contactor's sub contact point (NFC 63-032)
EN 50 022	**industrial low voltage switch gear and control gear** • installation rail • 35mm width top hat rail of snap-on installation equipment (NFC63-015)
EN 50 023	**industrial low voltage switch gear and control gear** • 75mm width top hat rail of snap-on installation equipment (NFC63-016)
EN 60 947-1	**industrial low voltage switch gear and control gear** • Part1 : general regulations (NFC63-001) + revisionA11
EN 60947-4-1	**industrial low voltage switch gear and control gear** • Part4 : contactor and motor starter • Section1 : electric machinery contactor and motor starter (NFC63-110)
EN 60947-5-1	**low voltage switch gear and control gear** • Part5 : control circuit device and switching element • Section1 : electric machinery control circuit device (NFC63-146)

1. Verification Organizations and Standards

1.2 Standards

■ **National standards**

1. Germany : DIN VDE 0660

Part 100	**Industrial low-voltage switch gear and control gear** • general regulations (EN60 947-1) • Part100/A11. revisionA11
Part 102	Electric machinery contactor and motor starter (EN60 947-4-1)
Part 200	Control circuit device and switching element; electric machinery control circuit device (EN60 947-5-1)

2. France

UTE NFC 63-001	**Voltage switch gear and control gear** • : general regulations+ revisionA11 (EN60 947-1 + A11)
UTE NFC 63-110	**Voltage switch gear and control gear** • Part4 : contactor and motor starter • Section1 : electric machines contactor and motor starter (EN60 947-4-1)
UTE NFC 63-140	**For control/sub circuit including control switch contactor relays low voltage switching device** • Part1 - Section1 : general requirements
UTE NFC 63-146	**Low voltage switch gear and control gear** • Part5 : control circuit device and switching element • Section1 : electric machinery control circuit device (EN60 947-5-1)

3. Switzerland: SEV Version

N° 1025	Safety and regulations for contactors
TP 17 B/2A-d	Motor protection and overload protection switch test's requirements and conditions
TP 17 B/4A-d	Requirements and conditions of motor protection and overload protection switch test's

4. England

BS 5424 (Part 1)	1000V a.c. and up to 1200V d.c.'s voltage control gear specifications
BS 4794	Including contactor about control circuit 1000V a.c. and up to 1200V d.c switching device (Similar to IEC 337 Publication)
BS 4941	Motor starter about voltage of 1000V a.c. and up to 1200V d.c (Similar to IEC 292 Publication)

5. Sweden

SS 428 0600	**Switching device for maximum 1kV, standards investigation** • International Standards • Switzerland Standards' s effectiveness SS428 0600

2. Product Standards and Approvals

2.1 Product Standards

■ **Standards' suitability**

The majority of products of LSIS adhere to international standards (Englands' BS, France's NF, Germany's DIN) and European standards(CENELEC) or, International Standards(IEC). Product performance designed by this standard is defined in detail(KSC IEC 60947 about low voltage device). Assembling facility, machinery system or installation adhere to product standard is possible, when it is used according to technology rules or regulation with manufacturer's intentions. (for example : IEC 204 related with electric devices which are used in industrial equipment). LSIS can prove the suitability of manufacture to selected standards by quality assurance system, and provide the following depending on requirements.

- Suitability declaration
- Suitability verification(KEMA, DEMCO, TÜV)
- Approval verification and agreement with particular specifications and process

Standard	Standard Name		Country
	Full name	Abbreviation	
ANSI	American National Standards Institute	ANSI	USA
BS	British Standards Institution	BSI	Great Britain
CEI	Comitato Electtrotechnico Italiano	CEI	Italy
DIN/VDE	Verband Deutscher Electrotechniker	VDE	Germany
EN	Comite Europeen de Normalisation Electrottechnique	CENELEC	Europe
GOST	Gosudarstyenne komitet Standartov	GOST	Russia
IEC	International Electrotechnical Commission	IEC JISC	Worldwide
JIS	Japanese Industrial Standard	IBN	Japan
NBN	Institut Belgge de Normalisation	NNI	Belgium
NEN	Nederlands Normalisatie Instittut	JISC	Netherlands
NFC	Union Technique de l' Electricite	UTE	France
SAA	Standards Association of Australia	SAA	Australia
UNE	Instituto Nacional de Racionalizacion y Normalizacion	IRANOR	Spain

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2. Product Standards and Approvals

2.1 Product Standards

■ European EN standards

This is the certification of a related committee inside CENELEC membership countries (EEC and EFTA), the techinical specification group is decided there and commonly agreed European standards are established by majority vote. When they conflict with national standards the chosen standards are abolished but otherwise they are combined with national standards. European standards are currently combined with French standards and they have initials such as NF, EN. According to the "Technical Union of Electricity" he French version of European standards which adhere to (UTE) have two marks such as the following. European reference (NF EN ...)and classification (C ...). They can also conform effectively to the French version of standards NF EN 60947-4-1 and European standard EN60947-4-1 related with electric motor and magnetic contactor, magnetic switch and, it takes UTE classification C 63-110. These standards are the same as BS(British Standards) EN 60947-4-1, or German standards DIN VDE 0660 Teil 102. In a rational case, European standards reflect International standards(IEC) all the time. LSIS fulfils the requirements of the French NF standard for essential aspects as well as other industrial countries requirements of automatic system products and line installation devices.

2.2 Regulations

■ European directives

The product introduction into the European market means complying with regulations in each membership country of the European Community. The purpose of European Directives are removing obstacles which disturb the free circulation of products in the European Community, membership countries should enact each directive with their national regulations and abolish violating regulations at the same time. Here the directives related to specified techincal contents are decided with the only purpose, they are called "essential requirements". Manufacturers have the responsibility to guarantee that every method which can be applied to specified directive regulation has been applied to the product. The manufacturer verifies with general regulation the suitability about the directive's essential requirements of the product by attaching the CE Mark. LSIS will keep attaching CE Mark continuously throughout the transition period as indicated in French and Europian regulations.

■ The importance of the CE Mark

The magnetic switch is suitable for export to Europe which is governed according to IEC standards and is suitable for the Low Voltage Directive. The Low Voltage Directive which is one of the European directives became compulsory in January 1997. The CE Mark is attached to products to prove they adhere to European directives for the manufacturer, this is ensures the product follows several European directives before it is circulated freely in the European community.

- Low Voltage Directive
  - 73/23/EEC(original text)
  - 93/68/EEC(revised text)

- Type of products to which it can be applied

  Opperating products with 50~1000VAC/75~1500VDC, CE marking is necessary because it is the target of the low-voltage directive when it is individually exported to Europe.

1. Low voltage directive countermeasure

1) CE Mark is necessary for circulation in EU regions with magnetic switch when it is countermeasured to EC directive, in case of magnetic switch is used as a component, but the magnetic switch as a part of an assembled product doesn't require the mark when the CE Mark is marked to machine tool, control device. operational of the third-party recognized product (recognized by KEMA) is recommended in 2), when CEmark is affixed to a control device.

2) Magnetic switch's countermeasure as an individual export
Magnetic switch becomes the subject of the low voltage directive in case of individual export inside of EU regions, the low-voltage directive is implimented with module A and suitability certification is basically done by self-declaration.

Applicable product standards are as follows:

EN60947-1	Control device general standards
EN60947-4-1	Magnetic switch standards
EN60947-5-1	Sub-relay standards

The magnetic switch's basic type is a standard, it is suitable for low-voltage directive.

3) Third-party recognition (KEMA recognition) aquisition type
When CEmarking to machine tools, control device, operational of magnetic switch of third-party recognized product(KEMA recognition) is recommended as a component for assembly. Magnetic switch aquires KEMA recognition.

2. Other

Machine directives' countermeasure of magnetic switch

Magnetic switch is a part used with machine tools, control devices, it is an exeception for machine directives. operational of magnetic switch of the third-party (KEMA recognition) is recommended in case of affixing the CEmark to machine tools control device. Magnetic switch has aquired KEMA recognition.

2. Product Standards and Approvals

2.2 Regulations

■ KEMA certification

The domestic committee, Netherlands Electrotechinical Committee (NEC) of IEC and CENELEC in The Netherlands is working in the electronic technical field in cooperation with Netherlands Normalisatie Instituut (NNI) through KEMA(KEURING VAN ELECTROTECHNISCHE MATERIALEN : Netherlands electricity test center) in the Netherlands. KEMA is a private corporation which was established to take responsibility for power supply in 1927, for the purpose of investigation of power supply, and testing and checking of electric products in the center of the supply community. KMA currently has two R&D centers, is investigating/pursuing R&D of testing for electric power devices, safety testing of electric heaters, close examination chemical service of electrical standards and all other electricity related fields.

2.3 Approvals

Some countries demand approval of specified electric devices by law, a certificate of approval is issued by a public test organization in this case. Each product should have a related quality label as required.

Standard	Full Name	Country
ASE	Association Suisse des Electriciens	Switzerland
CSA	Canadian Standards Association	Canada
DEMKO	Danmaarks Elektriske Materielkontrol	Denmark
FI	Sankotarkastuskeskus Elinspektions Centralen(SETI)	Finland
Underwriters	Norges Elektriske Materiellkontroll	Norway
UL	Underwriters Laboratories	USA

UL

The magnetic switch is well suited for export to North America because it has aquired certification from American UL Standard(UL508). We need to be careful with the issued approval from UL(Underwriters Laboratories), because there are two levels of approval. UL is an American organization enacting UL safety standards, testing for safety recognition according to the standard, and issuing certificates and approving labels to the qualifying products. The UL recognized label is applied nationwide in America, UL recognition is required in some major cities, so UL approval is necessary when exporting machinery, control units, and other equipment to America. The magnetic switch has aquired UL part recognition or UL product listing corresponding to control unit UL standard(UL508), so it can be used in control unit equipment exported to America. About UL : UL is a non-profit committee established by the American Insurance Company in 1894. Currently, it' s purpose is for protection of property and human life from accidents such as fire, robbery, eletrocution, etc. They do this through:

1. Enactment of standards for safety.
2. Individual product tests based on standards.
3. As it is the oldest, largest authority for safety testing in the world it handles the publishing of test results for insurance dealers, government agencies, related communities and general consumers etc. It publishes devices, products, and materials which have UL approval in an annually issued Product Directory, and permits applying the approval mark to approved products of manufacturers.

■ UL approval mark

UL approval types	Publication method		Scheme
	Product mark	Publication by UL	
Listing	Listed Mark  LISTED	Electrical Construction Materials (electric construction common name : UL Green Book)	• It is called recognition, given to product as grouped product which is available to sell to user and use. • white card is issued to manufacturer.
Recognition	Recognition Mark 	Recognized Component (recognized product common name : UL Yellow Book)	• It is called condition recognition, can be given to combined and assembled product with other devices. • yellow card is issued to manufacturer.

■ UL /CUL approval mark

UL/CUL approval type	Product mark	Scheme
Listing	Listed Mark  LISTED	• Listing for both America, Canada • UL standard recognition by test organization UL
Recognition	Recognition Mark 	• Recognition for both America and Canada • UL, CUL standard recognition by test organization UL • CUL standard product recognition

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2. Product Standards and Approvals

2.3 Approvals

■ **Marine classification authorities**

In case of operational in electric devices intended for a marine environment, pre-approval is generally required from specified marine classification authorites:

Standard abbreviation Mark	Standard name	Scheme
LR	Lloyds register of shipping (english Lloyds Marine classification Association)	• It is a standard of Lloyds Marine Classification Association with headquarters in London, it has a tradition as classification for marine. • Regarding automatic devices used for UMS(Unmanned ship), it has recognition system in the center of environmental test, recognized product is added in the annual recognized list from Lloyds Association.
BV	Bureau verilas (french bureau verilas marine classification association)	• French marine standard control devices need to be BV recognition acquired products used by AUT with taking approval system for control devices added to the recognition system of circuit breakers like LR standard.
GL	Germanischer lloyed (german lloyd marine classification association)	• It is a standard of marine classification association with headquarters in Hamburg Germany, it has nothing to do with English Lloyd's. There are two methods of recognition, the mark below the left hand side in case of unconditional passing, mark is recognized above the left hand side in the case of conditional passing.
NKK	Japanese marine classification association	• It is stipulated to recognize by a type test about fuse, breaker, explosion-proof machine, magnetic contactor and cables under 600V. • It takes recognition test when it is admitted to be suitable by investigating real conditions of entire process's quality management including material, manufacturing method, and investigation standards of company. We can mark the recognized number with the same kinds and shape of product as a recognized product, if it passed the test. Expiration period is four years, recognition system in the center of the environmental test about control devices used for automation of engine room is taken in the near future.

Standard	Full name	Country
BV	Bureau Veritas	France
DNV	Det Norske Veritas	Norway
GL	Gemanischer Lloyd	Germany
LR	Lloyd's Register of Shipping	Great britain
NKK	Nippon Kaiji Kyokai	Japan
RINA	Registro Italiano navale	Italy
RRS	Register of Shipping	Russia

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3. KSC IEC60947-4-1 Standard Description

Item	Standard description contents
Application range	Device with main contact of which rated voltage doesn't exceed AC1000V, DC 1500V.

Unbroken distance

Minimum unbroken distance interval

Rated insulated voltage of equipment or operational voltage AC RMS value or DC (V) Note4	Unbroken distance interval of equipment depends on long-term stress													
	Degree of contamination			Degree of contamination				Degree of contamination				Degree of contamination			
	1	2	1	2				3				4			
	Material Class			Material Class				Material Class				Material Class			
	Note2	Note3	Note2	Note1	II	IIIa	IIIb	I	II	IIIa	IIIb	I	II	IIIa	IIIb
10	0.025	0.04	0.08	0.4	0.4	0.4		1	1	1		1.6	1.6	1.6	Note4
12.5	0.025	0.04	0.09	0.42	0.42	0.42		1.05	1.05	1.05		1.6	1.6	1.6	
16	0.025	0.04	0.1	0.45	0.45	0.45		1.1	1.1	1.1		1.63	1.6	1.6	
20	0.025	0.04	0.11	0.48	0.48	0.48		0.2	1.2	1.2		1.6	1.6	1.6	
25	0.025	0.04	0.125	0.5	0.5	0.5		0.25	1.25	1.25		1.4	1.7	1.7	
32	0.025	0.04	0.14	0.53	0.53	0.53		0.3	1.3	1.3		1.8	1.8	1.8	
40	0.025	0.04	0.16	0.56	0.8	1.1		0.4	1.6	1.8		1.9	2.4	3	
50	0.025	0.04	0.18	0.6	0.85	1.2		0.5	1.7	1.9		2	2.5	3.2	
63	0.04	0.063	0.2	0.63	0.9	1.25		0.6	1.8	2		2.1	2.6	3.4	
80	0.063	0.01	0.22	0.67	0.95	1.3		0.7	1.9	2.1		2.2	2.8	3.6	
100	0.1	0.16	0.25	0.71	1	1.4		0.8	2	2.2		2.4	3.0	3.8	
125	0.16	0.25	0.28	0.75	1.05	1.5		0.9	2.1	2.4		2.5	3.25	4	
160	0.25	0.4	0.32	0.8	1.1	1.6		2	2.2	2.5		3.2	4	5	
200	0.4	0.63	0.42	1	1.4	2		2.5	2.8	3.2		4	5	6.3	
250	0.56	1	0.56	1.25	1.8	2.5		3.2	3.6	4		5	6.3	8	
320	0.75	1.6	0.75	1.6	2.2	3.2		4	4.5	5		6.3	8	10	
400	1	2	1	2	2.8	4		5	5.6	6.3		8	10	12.5	
500	0.3	2.5	1.3	2.5	3.6	5		6.3	7.1	8.0		10	12.5	16	
630	0.8	3.2	1.8	3.2	4.5	6.3		8	9	10		12.5	16	20	
800	2.4	4	2.4	4	5.6	8		10	11	12.5	Note4	16	20	25	
1000	3.2	5	3.2	5	7.1	10		12.5	14	16		20	25	32	
1250			4.2	6.3	9	12.5		16	18	20		25	32	40	
1600			5.6	8	11	16		20	22	25		32	40	50	
2000			7.5	10	14	20		25	28	32		40	50	63	
2500			10	12.5	18	25		32	36	40		50	63	80	
3200			12.5	16	22	32		40	45	50		63	80	100	
4000			16	20	28	40		50	56	63		80	100	125	
5000			20	25	36	50		63	71	80		100	125	160	
6300			25	32	45	63		80	90	100		125	160	200	
8000			32	40	56	80		100	110	125		160	200	250	
10000			40	50	71	100		125	140	160		200	250	320	

(Note 1) Class 1, 2, 3a, 3b which are likely to pursuit are reduced by the condition of 10.8 of IEC 60664A.

(Note 2) Material class I, II, IIIa, IIIb

(Note 3) Material class I, II, IIIa

(Note 4) Unbroken distance is not set up in this region. Material class 3b is not generally recommended to apply to degree of contamination 3 and 4 under 630V.

(Note 5) Exceptionally, the unbroken distance compatible to the lower value, 125, 400, 630, 800Vcan be used in case of rated insulation voltage 127, 208, 415, 440, 660/190 and 630V.

(Note 6) This given value is applied to the unbroken distance of printed wiring materials from these two columns.

Reference1) Tracking or Decay are not expected to occur in the insulation belonging to the working voltage under 32V. But electrolytic decay possibility should be considered, so the minimum unbroken distance is stated for this reason.

Reference2) The voltage value is selected with the serial R10

3. KSC IEC 60947-4-1 Standard Description

<table>
<tr><th>Item</th><th>Standard description contents</th></tr>
<tr><td>Separation distances</td><td>
Minimum separation distance in the air
<table>
<tr><th rowspan="3">Rated impulse withstanding voltage uimp(kV)</th><th colspan="8">Minimum separation distance (mm)</th></tr>
<tr><th colspan="4">A type nonhomogeneous electrical field conditions</th><th colspan="4">B type homogeneous electrical field conditions</th></tr>
<tr><th colspan="4">Degree of contamination</th><th colspan="4">Degree of contamination</th></tr>
<tr><th></th><th>1</th><th>2</th><th>3</th><th>4</th><th>1</th><th>2</th><th>3</th><th>4</th></tr>
<tr><td>0.33
0.5
0.8
1.5
2.5
4
6
8
12</td><td>0.01
0.04
0.1
0.5
1.5
3
3.5
8
14</td><td>0.2
0.5
1.5
3
5.5
8
14</td><td>0.8
1.5
3
3.5
8
14</td><td>1.6
3
5.5
8
14</td><td>0.01
0.04
0.1
0.3
0.6
1.2
2
3
4.5</td><td>0.2
0.3
0.6
1.2
2
3
4.5</td><td>0.8
1.2
2
3
4.5</td><td>1.6
2
3
4.5</td></tr>
</table>
Reference) The minimum separation distance in the air is based on impulse voltage, 1.2/50ms barometric pressure of 80kpa such as normal air pressure at 2000m above sea level.
</td></tr>
<tr><td>Rated impulse withstanding voltage and switching overload voltage</td><td>Manufacturer can declare rated impulse withstanding voltage (Uimp).
Recommended value (kV) : 0.33, 0.5, 0.8, 1.5, 2.5, 4, 6, 8, 12
Insulation distance is the first attached tag 13, 15 incase of declaration, and the device shouldn't generate switching overload voltage higher than rated impulse withstanding voltage. Or impulse withstanding voltage test of transfer test implies the duty.</td></tr>
<tr><td>Rated operational current or rated operational power</td><td>Rated operational current is indicated including protection type by rated operational voltage, open current, closed thermal current, rated current of overload relay, rated frequency, rated duty, rated load type and enclosure. The manufacturer should necessarily prepare the relation indication of current and power in case of switching of each electrical motor.</td></tr>
<tr><td>Open thermal current</td><td>The open thermal current in an eight hour duty should be at least the same as the maximum value of the rated operational current of the open-type device.</td></tr>
<tr><td>Closed thermal current and insulation distance</td><td>A closed-type thermal current in an eight hour duty shouldn't be less than the maximum value of the rated operational current of closed-type equipment.</td></tr>
</table>

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<table>
<tr><th>Item</th><th>Standard description contents</th></tr>
<tr><td>Rated continuous current</td><td>Current flow for more than eight hours without breaking, and under the condition without current flow</td></tr>
<tr><td>Operational load type</td><td>AC-1 Non-inductive or low conductive load resistance furnace.
AC-2 Wound rotor type motor: start, stop
AC-3 Squirrel-cage motor: during starting, driving
AC-4 Squirrel-cage motor:driving, plugging,inching
AC-5b Incandescent lamp switching
AC-6a Transformer switching
AC-6b Condenser bank switching
AC-7a Low-inductive load in home appliances or other similar cases
AC-7b Electrical motor load for home appliances
AC-8a Hand-reset type overload sealed type Freezing compressor motor control
AC-8b Automatic reset type overload sealed type Freezing compressor motor control
DC-1 Non-conductive or low-resistance furnace. conductive load resistance furnace
DC-3 Shunt motor: start, plugging, inching, stop, dynamic suspension
DC-5 Series motor: start, plugging, driving inching, dynamic suspension
DC-6 Incandescent lamp switching</td></tr>
<tr><td>Switching frequency (intermittant duty)</td><td>Driver: 1, 3, 6, 12, 30, 120, 300, 1200(times / hour)
Contactor: 1, 3, 12, 30(times / hour)</td></tr>
<tr><td>Sub circuit</td><td>The characteristic of the sub-contact or sub-switch follows the requirements IEC60947- 5 (please refer to part 1).</td></tr>
<tr><td>Thermal overload relay</td><td><table><tr><th>Trip Class</th><th>Driving time at 720% current of set current Tp(s)</th></tr><tr><td>10A</td><td>2<Tp≦10</td></tr><tr><td>10</td><td>4<Tp≦10</td></tr><tr><td>20</td><td>6<Tp≦20</td></tr><tr><td>30</td><td>9<Tp≦30</td></tr></table></td></tr>
<tr><td>Cooperation with short circuit protection device (SCPD)</td><td>Confirmation of protection cooperation is required depending on short-circuit test at the part indicated type, rating, characteristic of SCPD</td></tr>
</table>

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3. KSC IEC 60947-4-1 Standard Description

<table>
<tr><th>Item</th><th>Standard description contents</th></tr>
<tr><td>Temperature Increase</td><td>
Main circuit of contactor or starter at ON position are implemented with combination overcurrent trip device. Every sub-circuit flowing common current, load at maximum rated operational current, applied control circuit are excited to rated voltage. It should not be over temperature increase as in the following table, should flow the following current. In case of continuous duty : open thermal current or closed current In case of continuous duty intermittent temporary duty : related rated operational current
<table>
<tr><th colspan="3" rowspan="2">Types</th><th colspan="2">Temperature increase (K)</th></tr>
<tr><th>Thermometer method</th><th>Resistance method</th></tr>
<tr><td rowspan="5">Terminal</td><td colspan="2">copper</td><td>60</td><td>-</td></tr>
<tr><td colspan="2">copper alloy</td><td>65</td><td>-</td></tr>
<tr><td colspan="2">tinning copper, copper alloy</td><td>65</td><td>-</td></tr>
<tr><td colspan="2">silver plating, nickel plating copper, or copper alloy</td><td>70</td><td>-</td></tr>
<tr><td colspan="2">other</td><td>(65)</td><td>70</td></tr>
<tr><td rowspan="6">Coil</td><td rowspan="4">aerial</td><td>A</td><td>-</td><td>85</td></tr>
<tr><td>E</td><td>-</td><td>100</td></tr>
<tr><td>B</td><td>-</td><td>110</td></tr>
<tr><td>F</td><td>-</td><td>135</td></tr>
<tr><td>hydraulic</td><td>H</td><td>-</td><td>160</td></tr>
<tr><td>A E B</td><td>-</td><td>60</td></tr>
<tr><td rowspan="6">Possible part for connection</td><td rowspan="2">manual control part (holding part)</td><td>Metal</td><td>15</td><td>-</td></tr>
<tr><td>Non-metal</td><td>25</td><td>-</td></tr>
<tr><td rowspan="2">contact but no hold</td><td>Metal</td><td>30</td><td>-</td></tr>
<tr><td>Non-metal</td><td>40</td><td>-</td></tr>
<tr><td rowspan="2">commonly used in location without human contact</td><td>Metal</td><td>40</td><td>-</td></tr>
<tr><td>Non-metal</td><td>50</td><td>-</td></tr>
<tr><td>Other</td><td colspan="2">insulation material</td><td colspan="2">Insulation temperature rating follows the reference IEC 6008</td></tr>
</table>
</td></tr>
<tr><td>Operation</td><td>Starter shouldn't be tripped by the shock during rapid three-time operation from normal switching order, after starter using the contactor reaches thermal equilibrium by flowing rated entire load current about maximum and minimum, both directions of thermal relay when it can be controlled about standard surrounding temperature +20℃. The contactor should be opened by tripping device operation as the closed circuit of contactor in case of thermal overload relay equipped with stop and trip device.</td></tr>
<tr><td>Operation Limit of Contactor</td><td>1. Closed Circuit
After temperature saturation with continuous application of 100% Us to coil at surrounding temperature 40℃, precisely possible for closed circuit at 86%~100% of Us(rated control power voltage).
2. Open Circuit
It is opened entirely at 75~20% of Us in AC, 75~10% in DC at the surrounding temperature of -5℃(normally it can be verified by calculation based on the value from surrounding temperature) and opened entirely.</td></tr>
</table>

Item	Standard Description Contents

Overload thermal relay operating limit

1. The range of current flow to every pole

Condition		Surrounding temperature compensation		Evaluation	
		none	exists	Trip class	Operation time
multiple of setting current	A. Cold start	1.0	1.05		no operation for 2 hrs
	B. Continuousfrom A	1.2	1.2		operation within 2 hrs
	C. Hot Start	1.5	1.5	10A 10 20 30	operation less than 2 min operation less than 4 min operation less than 8 min operation less than 12 min
	D. Cold Start	7.2	7.2	5 10A 10 20 30	Tp≦5s 2≦Tp≦10s 4≦Tp≦10s 6≦Tp≦20s 9≦Tp≦30s
standard surrounding temperature		+40℃	+20℃		

2. 2 Three-pole TOR operation characteristic range with two-pole current flow

	condition				Evaluation	
	Surrounding temperature compensation	attch.	none	attch.	Trip class	Operation time class
	Open phase detection	none	none	attch.		
Multiple of setting current	A. Cold Start	3 pole 1.0	3 pole 1.0	2 pole 1.0 1 pole 0.9	all	no operation for 2 hours
	B. A continuous	2 pole 1.32 1 pole 0	2 pole 1.25 1 pole 0	2 pole 1.15 1 pole 0	all	operation within 2 hours
Standard surrounding temperature		+20℃	+40℃	+20℃		

Note) Connected wire size is chosen from the following test current
trip class 10A: 100% of setting current
trip class 10,20,30 : 125% of setting current

Withstanding voltage

Test voltage is sine wave 45~65Hz, apply the following value in the table for one minute.

Rated insulation voltageUi(V)	Withstanding voltage test voltage(rmsV)
Ui ≦ 60	1000
60 < Ui ≦ 300	2000
300 < Ui ≦ 690	2500
690 < Ui ≦ 800	3000
800 < Ui ≦ 1000	3500
1000 < Ui ≦ 1500 (DConly)	3500

Note) It is an exception when the manufacturer declares rated impulse with standard voltage value.

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3. KSC IEC 60947-4-1 Standard Description

<table>
<tr><th>Item</th><th>Standard description contents</th></tr>
<tr><td>Insulation resistance</td><td>No regulation</td></tr>
<tr><td>Rated closed circuit and breaking capacity</td><td>
Rated closed-circuit breaking capacity condition depends on operational load type.
<table>
<tr><th rowspan="2">Type of operational load</th><th colspan="6">Closed circuit and breaking condition</th></tr>
<tr><th>Ic/Ie</th><th>Ur/Ue</th><th>cos Ø or L/R</th><th>ON time(s)</th><th>OFF time(s)</th><th>Operating Cycle(times)</th></tr>
<tr><td>AC-1</td><td>1.5</td><td>1.05</td><td>0.8</td><td>0.05</td><td>(Note1)</td><td>50</td></tr>
<tr><td>AC-3</td><td>8</td><td>1.05</td><td>(Note2)</td><td>0.05</td><td>(Note1)</td><td>50</td></tr>
<tr><td>AC-4</td><td>10</td><td>1.05</td><td>(Note2)</td><td>0.05</td><td>(Note1)</td><td>50</td></tr>
<tr><td>DC-1</td><td>1.5</td><td>1.05</td><td>1.0ms</td><td>0.05</td><td>(Note1)</td><td>(Note3)</td></tr>
<tr><td>DC-5</td><td>4</td><td>1.05</td><td>15.0ms</td><td>0.05</td><td>(Note1)</td><td>(Note3)</td></tr>
</table>
<table>
<tr><th rowspan="2">Type of operational load</th><th colspan="6">Closed circuit condition</th></tr>
<tr><th>Ic/Ie</th><th>U/Ue</th><th>cos Ø</th><th>ON time(s)</th><th>OFF time(s)</th><th>Operating Cycle(times)</th></tr>
<tr><td>AC-3</td><td>10</td><td>1.05</td><td>(Note2)</td><td>0.05</td><td>10</td><td>50(Note4)</td></tr>
<tr><td>AC-4</td><td>12</td><td>1.05</td><td>(Note2)</td><td>0.05</td><td>10</td><td>50(Note4)</td></tr>
</table>
I : closed circuit, Ic :closed circuit breaking current, Ie :rated operational current, U:applied voltage,
Ur : Commercial frequency or DC reset voltage, Ue : Rated operational voltage
Note 1) Relation between breaking current and off time
<table>
<tr><th>Breaking current Ic (A)</th><th>OFF time (sec)</th></tr>
<tr><td>Ic ≦ 100</td><td>10</td></tr>
<tr><td>100 < Ic ≦ 200</td><td>20</td></tr>
<tr><td>200 < Ic ≦ 300</td><td>30</td></tr>
<tr><td>300 < Ic ≦ 400</td><td>40</td></tr>
<tr><td>400 < Ic ≦ 600</td><td>60</td></tr>
<tr><td>600 < Ic ≦ 800</td><td>80</td></tr>
<tr><td>800 < Ic ≦ 1000</td><td>100</td></tr>
<tr><td>1000 < Ic ≦ 1300</td><td>140</td></tr>
<tr><td>1300 < Ic ≦ 1600</td><td>180</td></tr>
<tr><td>1600 < Ic</td><td>240</td></tr>
</table>
Note 2) Ie≤100A:0.45 Ie>100A : 0.35
Note 3) One-sided polarity : 25 times, counter-polarity : 25 times
Note 4) 1.1Us:25 times, 0.85Us : 25 times
</td></tr>
<tr><td>Operation characteristics</td><td>
Regulated operation characteristic of closed circuit, breaking conditions about operational load type.
<table>
<tr><th rowspan="2">Operational load type</th><th colspan="6">Test condition of closed circuit and Breaking</th></tr>
<tr><th>Ic/Ie</th><th>Ur/Ue</th><th>cos Ø or L/R</th><th>ON time(s)</th><th>OFF time(s)</th><th>Operating cycle(times)</th></tr>
<tr><td>AC-1</td><td>1</td><td>1.05</td><td>0.8</td><td>0.05</td><td>(Note1)</td><td>6000</td></tr>
<tr><td>AC-3</td><td>2</td><td>1.05</td><td>(Note2)</td><td>0.05</td><td>(Note1)</td><td>6000</td></tr>
<tr><td>AC-4</td><td>6</td><td>1.05</td><td>(Note2)</td><td>0.05</td><td>(Note1)</td><td>6000</td></tr>
<tr><td>DC-1</td><td>1</td><td>1.05</td><td>1.0ms</td><td>0.05</td><td>(Note1)</td><td>50(Note3)</td></tr>
<tr><td>DC-5</td><td>2.5</td><td>1.05</td><td>7.5ms</td><td>0.05</td><td>(Note1)</td><td>50(Note3)</td></tr>
</table>
Note1) Note 2)Same as closed circuit, closed circuit capacity table
Note 3) One-sided polarity : 3000 times, Counter- polarity 3000 times
</td></tr>
</table>

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<table>
<tr><th>Item</th><th>Standard description contents</th></tr>
<tr><td>Durability</td><td>
1. Mechanical Durability
Verified with special test
Condition : 1) Unloaded switching
2) Applying rated voltage, frequency at control coil
3) Switching frequency is countermeasured type
4) No part replacement
Result : Contactor, thermal overload relay satisfies performance limit test.
at room temperature, no wire loosening. Statistically one out of the following
two tests is implemented
• Single 8 test : 8 product test,passing when there are less than two product failures
• Double 3 test : 3 product test, failure if there are more than two product failures
If additional 3 products are passed, in case of 1 failure, it passes
The recommended value of operation times(1,000,000 times)
• 0001, 0.003, 0.01, 0.03, 0.1, 0.3, 1, 3, 10
2. Electrical Durability
Verified with special test.
Attaching countermeasured condition depends on operational load type
mechanical durability condition is 2) 3) 4) except for operational load type test condition
are as follows
<table>
<tr><th rowspan="2">Operational load type</th><th rowspan="2">Rated Operational current</th><th colspan="3">Closed circuit</th><th colspan="3">Breaking</th></tr>
<tr><th>I/Ie</th><th>U/Ue</th><th>Power factor</th><th>Ic/Ie</th><th>Ur/Ue</th><th>Power factor</th></tr>
<tr><td>AC-1</td><td>Total</td><td>1</td><td>1</td><td>0.95</td><td>1</td><td>1</td><td>0.95</td></tr>
<tr><td rowspan="2">AC-3</td><td>Ie ≦ 17</td><td>6</td><td>1</td><td>0.65</td><td>1</td><td>0.17</td><td>0.65</td></tr>
<tr><td>17 < Ie</td><td>6</td><td>1</td><td>0.35</td><td>1</td><td>0.17</td><td>0.35</td></tr>
<tr><td rowspan="2">AC-4</td><td>Ie ≦ 17</td><td>6</td><td>1</td><td>0.65</td><td>6</td><td>1</td><td>0.65</td></tr>
<tr><td>17 < Ie</td><td>6</td><td>1</td><td>0.35</td><td>6</td><td>1</td><td>0.35</td></tr>
<tr><th rowspan="2">Operational load type</th><th rowspan="2">Rated Operational current</th><th colspan="3">Closed circuit</th><th colspan="3">Breaking</th></tr>
<tr><th>I/Ie</th><th>U/Ue</th><th>time constant</th><th>Ic/Ie</th><th>Ur/Ue</th><th>time constant</th></tr>
<tr><td>DC-1</td><td>entirely</td><td>1</td><td>1</td><td>1ms</td><td>1</td><td>1</td><td>1ms</td></tr>
<tr><td>DC-5</td><td>entirely</td><td>2.5</td><td>1</td><td>7.5ms</td><td>2.5</td><td>1</td><td>7.5ms</td></tr>
</table>
Result
Contactor or starter after test should endure within the voltage twice that of rated operational voltage Ue satisfying operation limit test (minimum 900V).
</td></tr>
<tr><td>Overload current limit quantity of contactor</td><td>
AC-3 or AC-4 contactors should endure the given overload current from the following.
Test implements with arbitrary voltage, contactor starts the test at room temperature. Verify that the contactor after test is in the same condition as before the test with a naked eye investigation.
<table>
<tr><th>Rated operational current</th><th>Test current “r”</th><th>Test time</th></tr>
<tr><td>Ie ≦ 630A</td><td>8 × Ie max / AC-3</td><td>10 s</td></tr>
<tr><td>630A < Ie</td><td>6 × Ie max / AC-3 *)</td><td>10 s</td></tr>
</table>
* Minimum value is 5040A
</td></tr>
</table>

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3. KSC IEC 60947-4-1 Standard Description

<table>
<tr><th>Item</th><th>Standard description contents</th></tr>
<tr><td></td><td>
A contactor with a backup to a short circuit protection device and short circuit current at the regular condition part of starter should be verified by short circuit test.

Estimated current "r" of rated operational current
<table>
<tr><th>C</th><th>Estimated current“r”kA</th><th>Estimated current“r”kA</th><th>Estimated current“r”kA</th></tr>
<tr><td>0＜Ie≦16</td><td>1</td><td>315＜Ie≦630</td><td>18</td></tr>
<tr><td>16＜Ie≦63</td><td>3</td><td>630＜Ie≦1000</td><td>30</td></tr>
<tr><td>63＜Ie≦125</td><td>5</td><td>1000＜Ie≦1600</td><td>42</td></tr>
<tr><td>125＜Ie≦315</td><td>10</td><td>1600＜Ie</td><td>＊＊</td></tr>
</table>
＊ If no AC-3 designation, rated operational current at maximum
＊＊ According to agreement between manufacturer and user.
Coordination is distinguished type 1 or type 2
short circuit test is implemented with estimated current "r" or short circuit current "iq" higher than "r" at rated condition part designated by manufacturer.
</td></tr>
<tr><td>Cooperation with short circuit protection device(SCPD)

1) Short circuit condition part</td><td>
<table>
<tr><th></th><th>Type 1</th><th>Type 2</th></tr>
<tr><td>Performance</td><td>• It isn't harmful to humans or the facility.
• Part replacement and repair is possible.</td><td>• It isn't harmful to humans or the facility.
• Continuous operational is possible (contact melting and fusion is allowed)</td></tr>
<tr><td>Test conditions</td><td>O Note1) CO Note2)</td><td>O-CO</td></tr>
<tr><td></td><td>test with each new product</td><td>test with one new product</td></tr>
<tr><td rowspan="5">Evaluation</td><td colspan="2">A. Arc detection fuse, no connection conductor heater fusing.</td></tr>
<tr><td colspan="2">C. No damage to conductor, terminal and conductor should not be excluded from the terminal.</td></tr>
<tr><td colspan="2">D. No crack at insulating stand</td></tr>
<tr><td>H. Damage of main body is possible carry-out of part is impossible</td><td>J. Main body damage is impossible Contact melting and fusion is possible</td></tr>
<tr><td rowspan="2">I. It satisfies withstanding voltage 2x Ue for one minute (min1000V)</td><td>K. TOR's characteristic satisfies characteristic curve</td></tr>
<tr><td>It satisfies withstanding voltage 2x Ue for one minute</td></tr>
</table>
Note 1) Breaking by flowing current with protection device after circuit closing the main body contact.
Note 2) Breaking by flowing current with protection device after circuit closing the short circuit current at main body contact.
</td></tr>
<tr><td>Degree of contamination</td><td>Contactor and starter are used under the environment of degree of contamination 3 without designation by manufacturer. But, other degrees of contamination may be applied depending on clean environmental conditions.
Contamination Level 3 : There is contamination with conductive characteristics. Or it becomes conductive because of circuit disconnection, but normally dry non-conductive contamination happens.</td></tr>
</table>

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<table>
<tr><th>Item</th><th>Standard description contents</th></tr>
<tr><td>Test sequence</td><td>Test SequenceI
(1) Temperature (2) Operation and operation limit
(3) Insulation characteristic (withstanding voltage)

Test Sequence II
(1) Cosed circuit (2)closed circuit and breaking
(3) Performance characteristic [(1) is omitted when AC-1]

Test Sequence III
(1) Short Circuit Test
Starter which doesn't appear overcurrent operation cooperation between starter and short-circuit protection device by type of SCPD, rating and characteristic can be replaced with overload limit quantity test.

Test Sequence IV
(1) Overload current limit quantity</td></tr>
<tr><td>Terminal structure</td><td>Mechanical terminal strength test, terminal curvature test, tensile test, ring shaped conductor insertion test are necessary.</td></tr>
<tr><td>Connection capacity</td><td>The manufacturer indicates that the maximum and minimum sectional area of conductive part which is supplied to type(hard solid or flexible) and the number of conductors which is possible to connect to the terminal at one time.
<table>
<tr><th colspan="3">< ISO/AWG ></th></tr>
<tr><th>Test current
A</th><th>ISO
mm²</th><th>AWG
MCM</th></tr>
<tr><td>0 < I ≦ 8</td><td>1.0</td><td>18</td></tr>
<tr><td>8 < I ≦ 12</td><td>1.5</td><td>16</td></tr>
<tr><td>12 < I ≦ 15</td><td>2.5</td><td>14</td></tr>
<tr><td>15 < I ≦ 20</td><td>2.5</td><td>12</td></tr>
<tr><td>20 < I ≦ 25</td><td>4.0</td><td>10</td></tr>
<tr><td>25 < I ≦ 32</td><td>6.0</td><td>10</td></tr>
<tr><td>32 < I ≦ 50</td><td>10</td><td>8</td></tr>
<tr><td>50 < I ≦ 65</td><td>16</td><td>6</td></tr>
<tr><td>65 < I ≦ 80</td><td>25</td><td>4</td></tr>
<tr><td>80 < I ≦ 100</td><td>35</td><td>3</td></tr>
<tr><td>100 < I ≦ 115</td><td>35</td><td>2</td></tr>
<tr><td>115 < I ≦ 130</td><td>50</td><td>1</td></tr>
<tr><td>130 < I ≦ 150</td><td>50</td><td>0</td></tr>
<tr><td>150 < I ≦ 175</td><td>70</td><td>00</td></tr>
<tr><td>175 < I ≦ 200</td><td>95</td><td>000</td></tr>
<tr><td>200 < I ≦ 225</td><td>95</td><td>0000</td></tr>
<tr><td>225 < I ≦ 250</td><td>120</td><td>250</td></tr>
<tr><td>250 < I ≦ 275</td><td>150</td><td>300</td></tr>
<tr><td>275 < I ≦ 300</td><td>185</td><td>350</td></tr>
<tr><td>300 < I ≦ 350</td><td>185</td><td>400</td></tr>
<tr><td>350 < I ≦ 400</td><td>240</td><td>500</td></tr>
</table></td></tr>
</table>

3. KSC IEC 60947-4-1 Standard Description

Item	Standard description contents
Connection capacity	Similar relation with ISO of conductor sectional area and ISO sectional area except for the size written above is applied on both tables refer to the following.

Standard sectional area of ring-shaped conductor

ISO Section (mm^2)	AWG / MCM	
	Size	Related section (mm^2)
0.2	24	0.205
-	22	0.324
0.5	20	0.519
0.75	18	0.82
1	-	-
1.5	16	1.3
2.5	14	2.1
4	12	3.3
6	10	5.3
10	8	8.4
16	6	13.3
25	4	21.2
35	2	33.6
50	0	53.5
70	00	67.4
95	000	85
-	0000	107.2
120	250 MCM	127
150	300 MCM	152
185	350 MCM	177
240	500 MCM	253
300	600 MCM	304

Reference) (-) from the table is calculated with the size considering connection capacity.

4. Acquisition Standard Table

January 2009 standard

Type	Device type	Approval					Verification	Certification of marine classification association					
	Abbrieviation	IEC	UL & CSA		Safety cert	GB	IEC	KR	LR	BV	NK	ABS	DNV
	Mark	CE	UL & CSA		-	Tilva	KEMA					ABS	DNV
	Region	Europe	America	Canada	Korea	China	Netherlds	Korea	England	France	Japan	America	Norwa
MC	MC-6a	●	●	●	●		●	○	○	○		○	○
	MC-9a	●	●	●	●		●	○	○	○		○	○
	MC-12a	●	●	●	●		●	○	○	○		○	○
	MC-18a	●	●	●	●		●	○	○	○		○	○
	MC-22b	●	●		○		●	○	○	○		○	○
	MC-32a	●	●	●	○		●	○	○	○		○	○
	MC-40a	●	●	●	●		●	○	○	○		○	○
	MC-50a	●	●	●	○		●	○	○	○		○	○
	MC-65a	●	●	●	●		●	○	○	○		○	○
	MC-75a	●	●	●	○		●	○	○	○		○	○
	MC-85a	●	●	●	○		●	○	○	○		○	○
	MC-100a	●	●	●	●		●	○	○	○		○	○
MT	MT-12	●	●	○	●		●	○	○	○		○	○
	MT-32	●	●	●	●	●	●	●	●	○		●	○
	MT-63	●	●	●	●	●	●	●	●	○		●	○
	MT-95	●	●	●	●	●	●	●	●	○		●	○

● Approved ○ Estimated Approva

Name of Document : Metasol Magnetic Switch
Technical Manual
(Installation and Handling)

Number of Document : Technology MS 695-009
Issued by : Technology Management Team
Production & Technology Group
LSIS Co., Ltd.
Total number of document printed : 200
Issued date : 2011. 06

Green Innovators of Innovation

Safety Instructions

- For your safety, please read user's manual thoroughly before operating.
- Contact the nearest authorized service facility for examination, repair, or adjustment.
- Please contact a qualified service technician when you need maintenance.
  Do not disassemble or repair by yourself!
- Any maintenance and inspection shall be performed by the personnel having expertise concerned.

LS IS Co., Ltd.

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2013. 05

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