HITACHI MAGNETIC STARTERS AND CONTACTORS

TECHNICAL NOTE

Hitachi Industrial Equipment Systems Co., Ltd.

CONTENTS

1. OUTLINE

1-1 TYPES OF STARTER, CONTACTOR AND THERMAL OVERLOAD RELAY

The types of starter, contactor and thermal overload relay are listed below.

Table 1. Applications and types

	Starter	Contactor	Contactor relay	Thermal overload relay
Application	Start, stop and control of motor. Protection of motor from burning due to overload and restriction.	Start, stop and control of motor. Used as starter in combination with thermal overload relay.	Used in operating circuits of starter, contactor , electromagnet and solenoid valve, and sequential control of automatic operation, etc.	Protection of motor from overload, restriction and single phase failure.
Types	・ With enclosure { Non-reversible type / Reversible type } ・ Without enclosure { Non-reversible type / Reversible type } ・ With push-button (with enclosure) ・ With saturation reactor ・ With mechanical interlock ・ DC operated type { Direct input coil type / Double-coil type } ・ With latch	・ Standard type ・ With twin contact ・ With latch ・ DC operated type	・ 2-phase type (1E thermal overload relay) ・ 3-phase type (1E thermal over-1oad relay) ・ For protection of overload and single phase failure (2E thermal overload relay) ・ With saturation reactor ・ Quick response type ・ Quick response type 2E	

1-2 STANDARDS FOR STARTER, CONTACTOR AND THERMAL OVERLOAD RELAY

The main standards for starter, contactor and thermal overload relay are as follows:

(1) General standards

Table 2. General standards

Name of country	Name of standard		Necessity of approval
International	IEC 60947-4-1	Low-voltage switchgear and control gear - Part 4 : Contactors and motor-starters, Section 1-Electromechanical contactors and motor-starters	None
Japan	JIS C8201-4-1	Low-voltage switchgear and control gear - Part 4 : Contactors and motor-starters, Section 1-Electromechanical contactors and motor-starters	None

Japan	JEM 1038 JIS C8201-5-1 JEM 1356 Electrical Appli-ance and Material Safety Law ＜PSE＞	AC Electromagnetic Contactors Low-voltage switchgear and control gear - Part 5-1 : Control circuit devices and switching elements - Electromechanical control circuit devices Protective Relays of Thermal type and Electromagnetic type for Induction Motors AC Electromagnetic Switches	None None None Necessary
U.S.A.	NEMA ICS UL 508	Industrial Controls and Systems Industrial Control Equipment	None Necessary
Canada	CSA C22.2 No. 14	Industrial Control Equipment for Use in Ordinary (Non-hazardous) Locations	Necessary
China	CCC GB14048.4	China Compulsory Certification	Necessary

(2) Standard for vessel

Table 3. Standards for vessel

Name of country	Name of standard		Necessity of approval
Japan	NK	Regulations for Steel Ships, Nippon Kaiji Kyokai	Necessary
U.K.	LR	Lloyd's Register of Shipping	Necessary
France	BV	Bureau Veritas	Necessary

1-3 SERVICE ENVIRONMENT

The performance of starter, contactor and thermal overload relay is guaranteed under the following normal service condition. Therefore, if they are compelled to be used under an adverse service environment different from the normal service condition, it is necessary to take into consideration the conditions given in paragraph (2).

(1) Normal service condition

(a) Ambient temperature: -5℃ to 40℃ (Usable up to 50℃ without enclosure)

(b) Relative humidity: 45% to 85%

(c) Altitude: 2,000m or lower

(d) Conditions free from abnormal vibration and shock

(e) Conditions free from risk of water or oil splash

(f) Atmosphere free of corrosive gas, combustible gas, dust, vapor, salt, etc.

(2) Adverse service environment

(a) High ambient temperature:

When the starter and contactor are used at an ambient temperature higher than the temperature of the normal service condition, it is necessary to take into consideration the reduction of load current lest the temperature (ambient temperature + temperature rise) of the molded part and terminal exceed the maximum allowable temperature and use of heat-resisting wire.

・ Maximum allowable temperature

Phenol-resin molded part : 115℃

Terminal: 105℃

(b) Low ambient temperature:

The tripping characteristic of the thermal overload relay cannot be guaranteed at a temperature lower than -5℃ and the performance of starter and contactor is effected by cold brittleness of metals and insulating materials at such a temperature. Therefore, it is necessary to take into consideration heating by providing the inside of the board with a space heater to ensure that the temperature there does not fall below -5℃.

However, when the starter and contactor are exposed temporarily to a low temperature during transportation to a cold area, even such low temperatures of -30℃ to -40℃ are no cause for concern. It is necessary, though, to take measures against deformation due to reverse bending of bimetals and brittleness of insulating materials, thus when placing an order, please inform us if transportation to a cold area is involved.

(c) High humidity:

In case of high humidity, there is the danger of lowering of insulation and decrease of the electrical endurance, etc. Accordingly, it is necessary to adopt an appropriate protective structure and perform sufficient maintenance and inspection.

(d) Adverse atmosphere:

If the starter and contactor are used in an atmosphere containing much dust, corrosive gas, combustible gas, salt, etc., it is necessary to provide a protective structure which is dust-proof, corrosion-proof, explosion-proof, etc.

(e) Places where vibration and shock are great:

The starter and contactor should not be installed directly to a machine, equipment, etc. producing particularly great vibration and shock. If it is unavoidable to install in such a condition, a vibration isolating device should be provided.

2. CONTACTOR

2-1 STRUCTURE AND OPERATION

2-1-1 Standard Type Contactor

(1) Structure

The contactor is roughly composed of the following 3 parts.

(a) Part of contact: Part through which a current passes, and at which a circuit is opened and closed.

(b) Part of electromagnet: Part of power which moves the part of contact.

(c) Part of frame: An external frame housing the contact and the electromagnet to constitute a protective
(Case and cover) structure for improving the safety, such as insulation, etc.

Moreover, the structure consists of the horizontal plunger and the link structure types as shown in the following table.

Table 4. Horizontal plunger and link structure

Outline		Features	Frame used
Horizontal plunger	・ Working directions of the moving contact and moving core are horizontal.	・ Simple structure	8C ～ 250C
Link structure	・ Movement of the moving contact is horizontal. ・ Movement of the moving core is vertical.	・ Light shock to mounting board . ・ Compact and light weight.	300C ～ 600C

The exploded view of H35 as an example of the horizontal plunger type, and that of H300C as an example of the link structure are shown in Fig. 1 and Fig. 2, respectively.

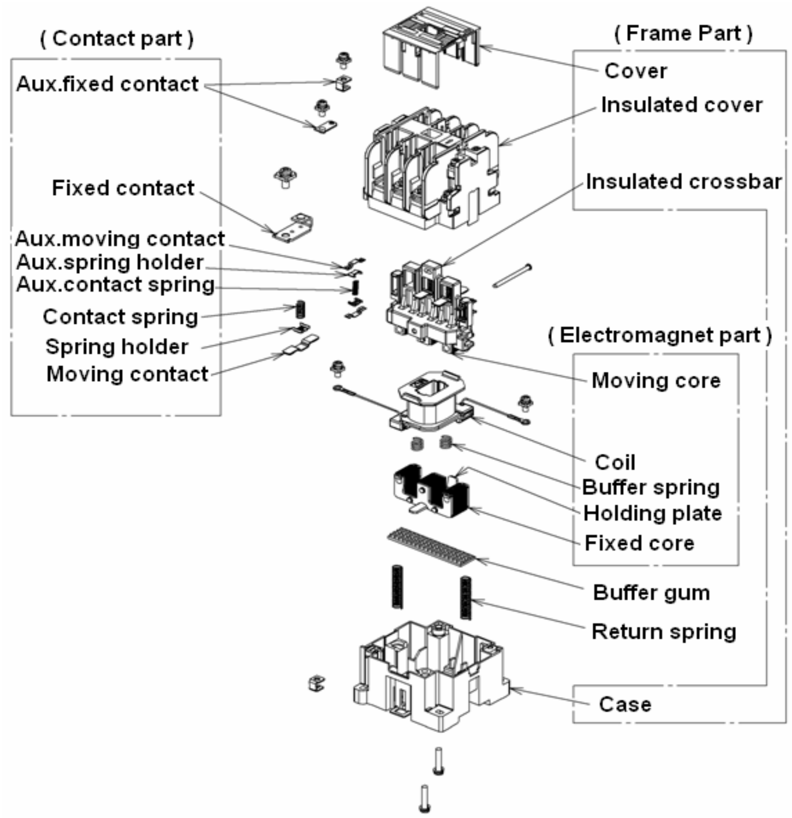


Fig 1. H35 (Horizontal Plunger type)

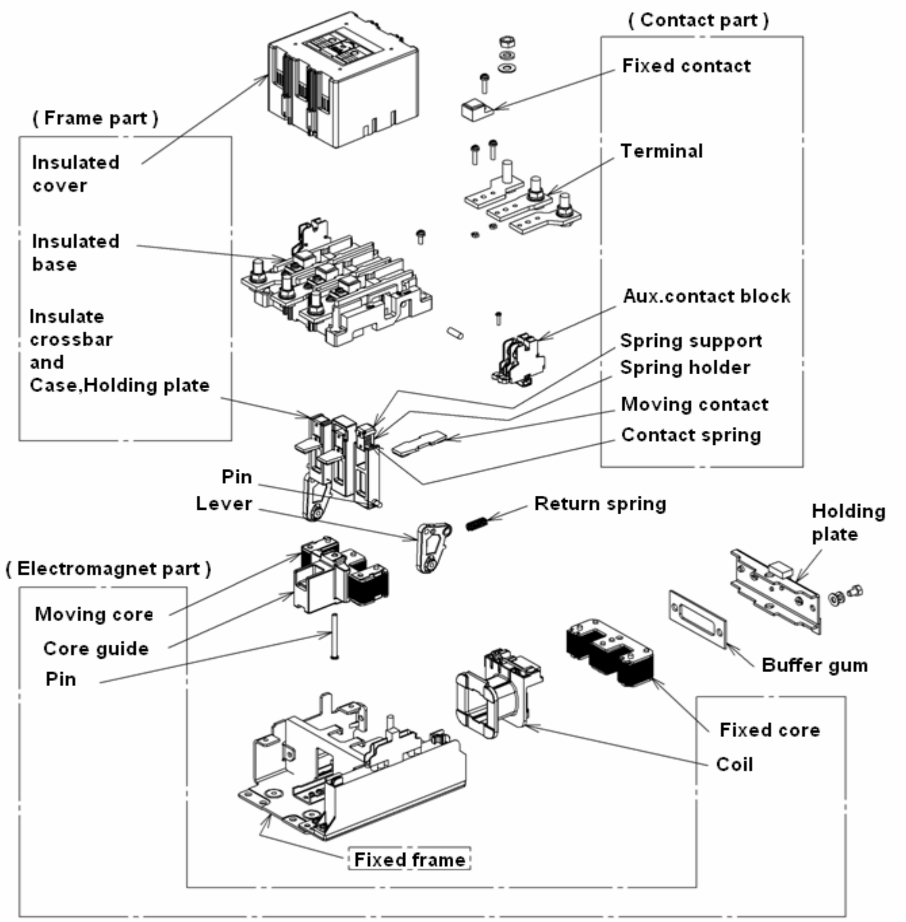


Fig 2. H300C (Link-structure)

(2) Operation

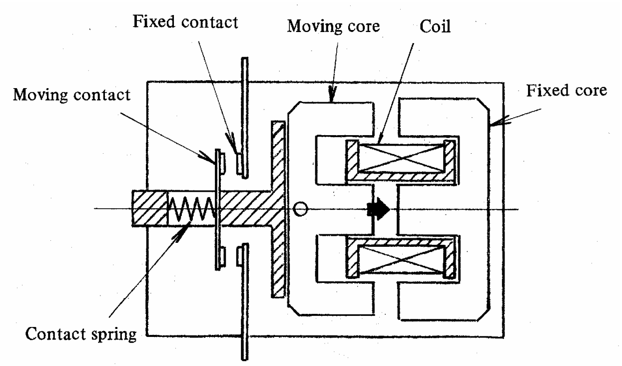


Fig. 3

When applying voltage to the coil, the electromagnet is excited and the moving core is attracted to the fixed core, then moves in the direction of the arrow. The moving contact linked to the moving core comes into contact with the fixed contact and closes the circuit. Then, contact pressure and contact over travel are applied to the contact by means of the contact spring.

When releasing the excitation of the coil, the moving core is separated from the fixed core, and the moving contact parts from the fixed contact, and opens the circuit.

The above movements are shown in Fig. 4: operation diagram.

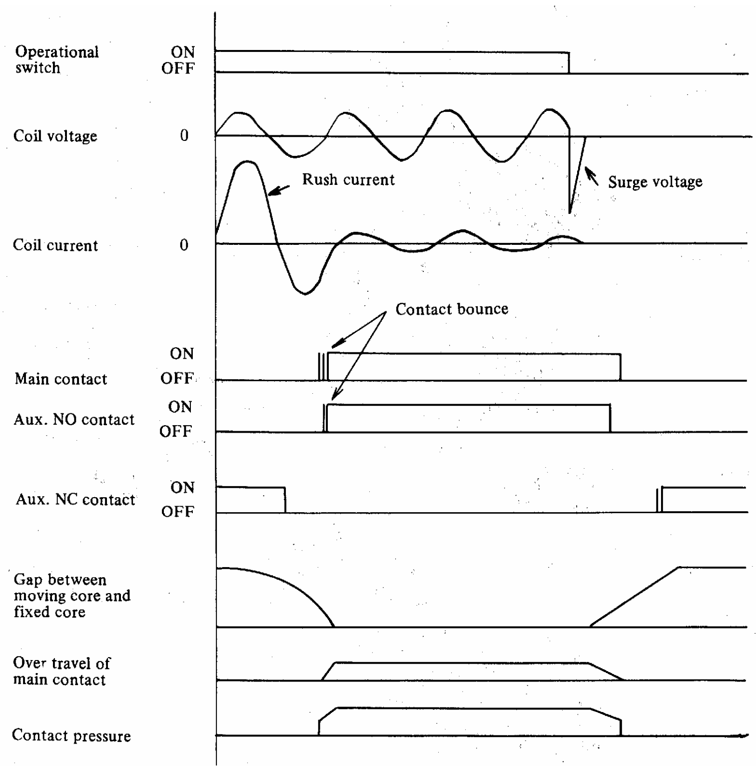


Fig. 4 Operation diagram

2-1-2 Features of Link Structure

When using the link structure for a large-capacity model,

- the shock to the mounting board given by the operation of the contactor becomes small;
- compactness and light weight can be realized;
- contact bounce produced when closing can be decreased.

(1) What is the link structure?

The link structure is shown in Fig. 5 , and is described below.

- A link connection is made so that the contact part is able to operate horizontally by keeping the working direction of electromagnet in parallel with the mounting board surface. (Thereby, reducing the shock to the mounting board).
- Compactness and reduction in weight is achieved by placing the electromagnet just under the contact.

As a result of adopting such a structure, contact bounce produced when closing is decreased, thus markedly improving the performance of large-capacity models.

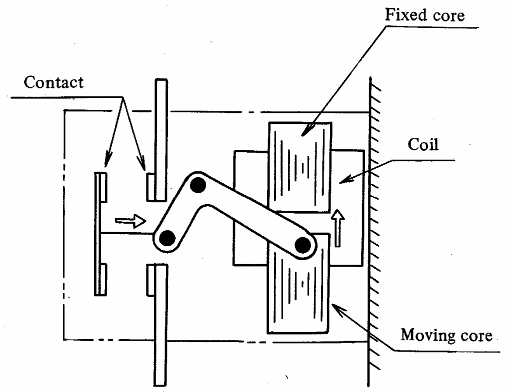


Fig. 5 Link structure

(2) Shock of link structure products to mounting board

Shocks in the case of horizontal plunger type (the contact and the moving core move horizontally in the same direction) of small- and medium-capacity models and in the case of link structure of large-capacity models are as shown in Fig. 7. It can be seen from the graph that the shock even in the case of large-capacity models is less than 6 times that of H20.

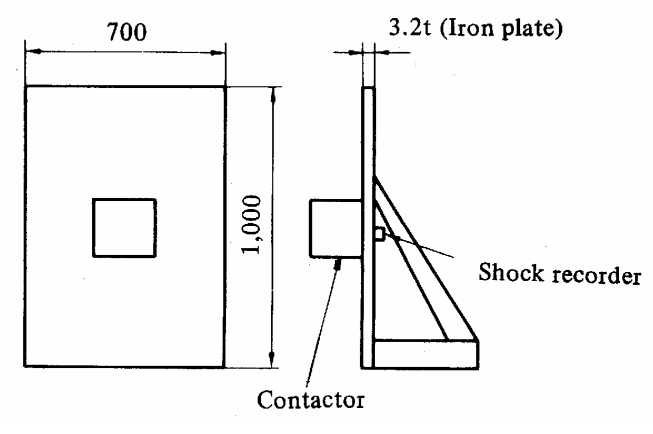


Fig. 6 Measurement of shock

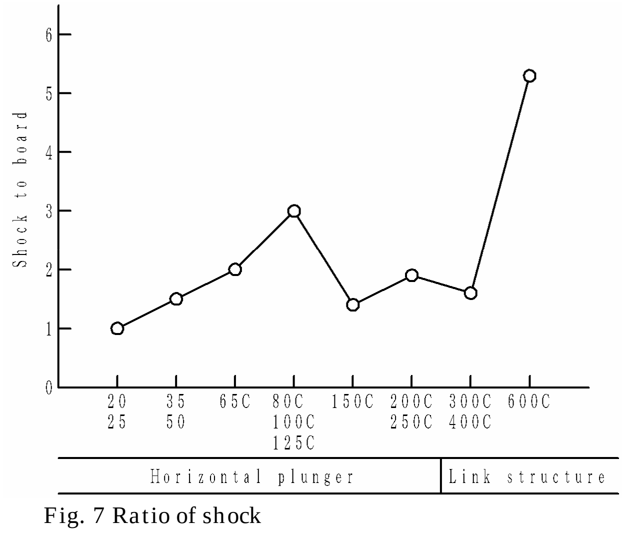


Fig. 7 Ratio of shock

(assuming that the shock of H20 is 1)

applied to board by operation of contactor

2-1-3 Latched Contactor

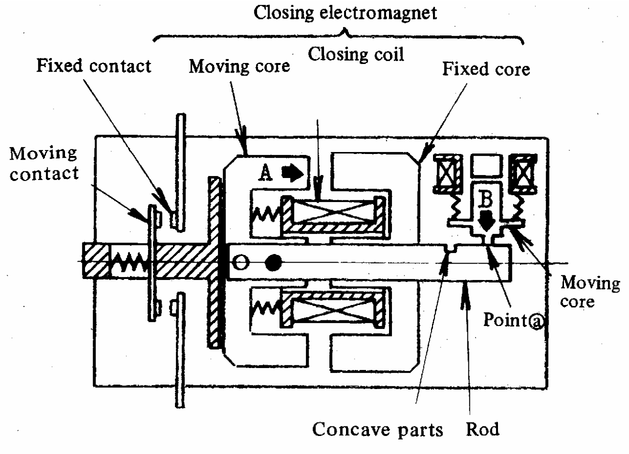


Fig. 8 Open condition

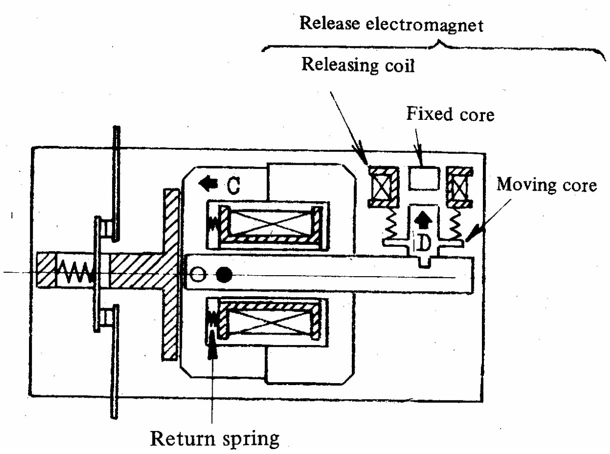


Fig. 9 Closed condition

Latched contactor has two coils, one is for closing and the other is for releasing. The structure of the latched contactor is shown in Fig. 8 and Fig. 9. When the closing coil is excited, the moving core is attracted to the fixed core so that it moves in the arrow A direction, and the moving contact linked to the moving core comes into contact with the fixed contact, then closes the circuit. At the same time, the rod linked to the moving core moves in the same direction as the moving core and the concave of the rod moves to point (a), then the moving core of the release electromagnet moves in the arrow B direction so as to engage with the concave part. In this state, the moving core of the closing electromagnet is mechanically held so that even when resetting the excitation of the closing coil, the contactor is still in closed condition.

When the releasing coil is excited, the moving core of release electromagnet is attracted to the fixed core so that it moves in the direction of the arrow D shown in Fig. 9, and the moving core disengages from the concave of the rod. Then, the moving core of closing electromagnet moves in the direction of the arrow C by the force of the return spring, and the moving contact linked to the moving core separates from the fixed contact, and simultaneously the circuit opens. The operating circuit is shown in Fig. 10.

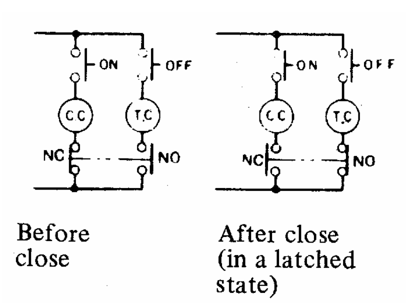


Fig. 10 Operating circuit

(Explanation)

ON: Closing by means of excitation of CC, which can be held mechanically. After closing, contact NO is in "ON" state, and contact NC is in "OFF" state.

OFF: Releasing by means of excitation of TC. After release, contact NO returns to "OFF" and contact NC, to "ON". Contacts NO and NC are built in. The explanatory figure shows a case where the power sources of ON and OFF are the same. However, even if they are different, the same ON/OFF operation is possible.

(Note) ON and OFF contacts should be interlocked.

Remarks: CC: Closing coil

TC: Releasing coil (Tripping coil)

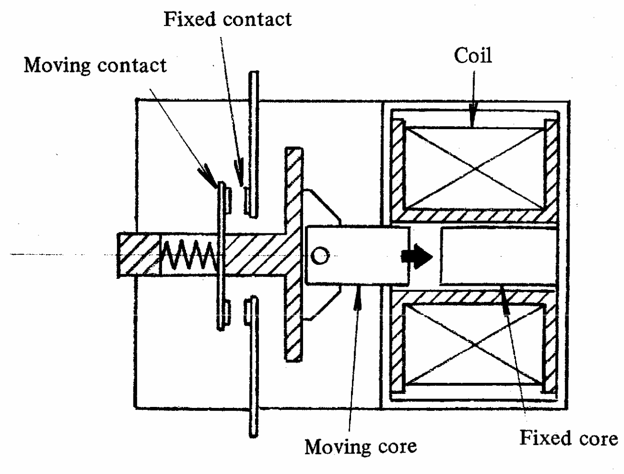


Fig. 11 Direct input coil type

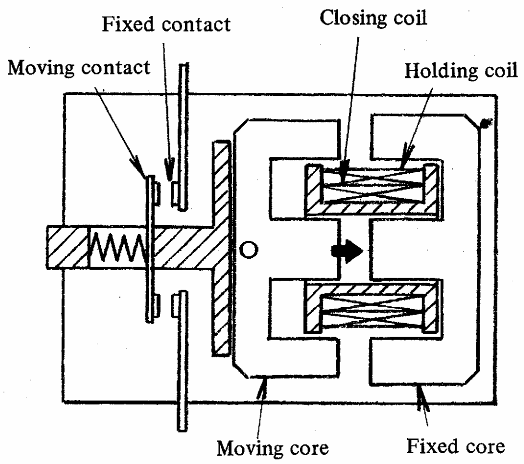


Fig. 12 Double coil type

(1) Direct input coil type

Because of the temperature rise of the coil, DC electromagnet is larger than AC one, thus DC operated contactor is higher than AC operated one.

(Operation)

When the coil is excited, the moving core is attracted to the fixed core, and the moving contact linked to the moving core comes into contact with the fixed contact, then closes the circuit. When the coil is released from excited condition, the moving core separates from the fixed core and the moving contact parts from the fixed contact, then opens the circuit.

(2) Double coil type

The dimension of double coil type DC operated contactor is the same as that of AC operated one. The double coil is a coil which has 2 coils, closing coil and holding coil wound on the coil bobbin.

(Operation)

When a voltage is applied to the coil, a current flows only to the closing coil, the moving core is attracted to the fixed core, and the moving contact linked to the moving core comes into contact with the fixed contact, then closes the circuit. A current flows to both the closing coil and the holding coil just before the moving core comes into contact with the fixed core; the current is reduced by a large resistance of the holding coil, and as a result, the temperature rise of the coil is controlled. The operating circuit is as shown in Fig. 13.

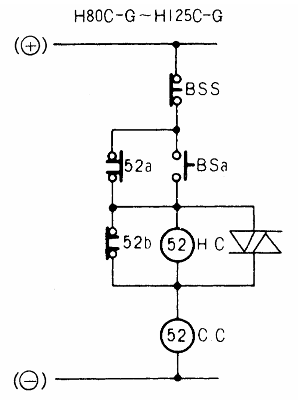


Fig. 13 Operating circuit

(Explanation)

(1) When BSa is closed, current flows as (+) → BSS → BSa → 52b → (CC) → (−) and is excited only at (CC) coil and picked up.

(2) When picked up, the changeover 52b contact opens, current flows as (+)→ BSS → 52a → (HC) → (CC) → (−) and is excited at both coils HC and CC. After pick-up, the internal resistance of (HC) is large in comparison to that of (CC) so current decreases and heat loss of the coil is reduced.

Remarks : CC : Closing coil
HC : Holding coil

2-2 PERFORMANCE

The performance of the contactor is guaranteed by carrying out a test under the testing conditions set forth according to the standard and satisfying the value specified therein. The testing conditions vary with the types of loads, which are classified into categories from AC1 to AC4 as given in Table 5.

Table 5. Utilization categories (IEC 60947-4-1)

Category	Typical applications
AC1	Non-inductive or slightly inductive loads, resistance furnaces.
AC2	Slip-ring motors: Starting, plugging [1].
AC3	Squirrel-cage motors: Starting, switching off motors during running.
AC4	Squirrel-cage motors: Starting, plugging [1], inching [2].
1) By plugging, is understood stopping or reversing the motor rapidly by reversing motor primary connections while the motor is running. 2) By inching (jogging), is understood energizing a motor once or repeatedly for short periods to obtain small movements of the driven mechanism.	

The major test items to determine the performance of the contactor are as follows.

- Temperature rise test
- Making and breaking capacities test
- Mechanical endurance test
- Electrical endurance test

(1) Temperature rise test

When the temperature rise becomes constant after the rated operational current or rated thermal current has flowed to the main circuit and auxiliary circuit, the temperature rise of each section should be measured. The temperature rise mentioned above must not exceed the specified limits given in Table 6 and Table 7.

Table 6. Temperature-rise limits for insulated coils in air (IEC 60947-4-1)

Class of insulating material	Temperature-rise limit (measured by resistance variation)
A	85 K
E	100 K
B	110 K
F	135 K
H	160 K

Table 7. Temperature-rise limits for the various materials and parts (IEC 60947-4-1)

Type of material Description of part	Temperature-rise limit (measured by thermocouple)
Contact parts in air (main, control and auxiliary contacts):	
- copper { uninterrupted duty	45 K
eight-hour, intermittent , or temporary duty	65 K
- silver or silver-faced	1)
Bare conductors including non-insulated coils	1)
Metallic parts acting as springs .	2)
Metallic parts in contact with insulating materials	3)
Terminals for external insulated connections	70 K

1) Limited solely by the necessity of not causing any damage to adjacent parts.
2) The resulting temperature shall not reach a value such that the elasticity of the material is impaired. For pure copper, this implies a total temperature not exceeding +75℃.
3) Limited solely by the necessity of not causing any damage to insulating materials.

When no current is passed to the main and auxiliary circuits and opening and closing operations in Table 8 corresponding to the intermittent duty class are performed, the temperature rise of the coil shall not exceed the limits as given in Table 6.

Table 8. Operating condition (IEC 60947-4-1)

Intermittent duty class of the contactor	One close-open operating cycle every	Interval of time during which the supply of the control coil is maintained
0.1	300 s	180 s
0.3	120 s	72 s
1	30 s	18 s
3	12 s	4.8 s
10	3s	1.2 s

The class of insulating material of coils is A or E and contactors satisfy the requirement of Class 10 of Table 8.

(2) Making and breaking capacities

The contactor is defined by its making and breaking capacities in accordance with utilization categories specified in Table 5.

The tests concerning the verification of the making and breaking capacities of the contactor are intended to verify that the contactor is capable of making and breaking the currents stated in Table 9, and not to verify the contact wear over long periods of operation.

The verifications of making capacity and breaking capacity are made as separate tests.

1 . Making capacity

The number is 100:50 operations of which are made at 85% and 50 operations at 110% of the rated coil voltage.

2. Breaking capacity

The total number of opening operations to be made is 25.

During tests within the limits of specified making and breaking capacities and with the specified number of operations, there shall be no permanent arcing, no flashover between poles, no blowing of the fuse in the earth circuit and no welding of the contacts.

Table 9. Conditions for making and breaking corresponding to the several utilization categories (IEC 60947-4-1)

Category	Value of the rated operational current	Make			Break		
		I/Ie	U/Ue	cos ϕ (1)	Ic/Ie	Ur/Ue	cos ϕ (1)
AC-1	(All values)	1.5	1.1	0.95	1.5	1.1	0.95
AC-2	(All values)	4	1.1	0.65	4	1.1	0.65
AC-3	Ie ≦ 17A	10	1.1	0.65	8	1.1	0.65
	17 A < Ie ≦ 100 A	10	1.1	0.35	8	1.1	0.35
	Ie > 100 A	8 (2)	1.1	0.35	6 (3)	1.1	0.35
AC-4	Ie≦17A	12	1.1	0.65	10	1.1	0.65
	17 A < Ie ≦ 100 A	12	1.1	0.35	10	1.1	0.35
	Ie > 100 A	10 (4)	1.1	0.35	8 (2)	1.1	0.35

Ie; Rated operational current U; Voltage before make

Ue; Rated operational voltage Ur; Recovery voltage

I; Current made Ic; Current broken.

1) Tolerance for cos ϕ: ± 0.05

2) With a minimum of 1000 A for I or Ic.

3) With a minimum of 800 A for Ic.

4) With a minimum of 1200 A for I.

(3) Mechanical endurance

With respect to its resistance to mechanical wear, the contactor is characterized by the number of no-load operating cycles (i.e., without current on the main contacts) which can be made before it becomes necessary to service of replace any mechanical parts.

The contactor shall be installed as for normal service; in particular, the conductors shall be connected in the same manner as for normal use.

The coils of the control electro-magnets shall be supplied at their rated voltage and, if applicable, at their rated frequency.

The tests are carried out at the frequency of operations corresponding to the class of intermittent duty.

Following the tests of mechanical endurance, the contactor shall still be capable of complying with the operating conditions. There shall be no loosening of the parts used for connecting the conductors.

(4) Electrical endurance

With respect to its resistance to electrical wear, the contactor is characterized by the number of on-load operating cycles, corresponding to the service conditions given in Table 10 which can be made without repair or replacement.

Table 10. Conditions for making and breaking corresponding to several utilization categories (IEC 60947-4-1)

Category	Value of the rated operational current	Make			Break		
		I/Ie	U/Ue	cos ϕ (1)	Ic/Ie	Ur/Ue	cos ϕ (1)
AC-1	(All values)	1	1	0.95	1	1	0.95
AC-2	(All values)	2.5	1	0.65	2.5	1	0.65
AC-3	Ie ≦ 17A	6	1	0.65	1	0.17	0.65
	Ie > 17A	6	1	0.35	1	0.17	0.35
AC-4	Ie ≦ 17A	6	1	0.65	6	1	0.65
	Ie > 17A	6	1	0.35	6	1	0.35

Ie ; Rated operational current U ; Voltage before make

Ue ; Rated operational voltage Ur ; Recovery voltage

I ; Current made Ic ; Current broken

1) Tolerance for cos ϕ: ±0.05

After the test, the contactor shall fulfill the operating conditions and withstand the dielectric test voltages.

2-3 CHARACTERISTICS

2-3-1 Voltage Allowable Range of Coil

When the power-source voltage of the operating circuit temporarily varies within a range of -15% to +10% of the rated voltage of coil, the contactor operates without any trouble. However, when the voltage constantly becomes higher or lower than the rated voltage, the following failures may occur, so be sure to use the contactor at the rated voltage .

(1) Where the power source voltage is higher than the rated voltage

(a) As the coil becomes overheated, its life may be shortened and it may be burnt. The electrical loss of the operating coil increases in proportion to approximately the square of the applied voltage, while the temperature rise of the coil is approximately in proportion to the electrical loss. Accordingly, if the power source voltage is 110% of the rated voltage of coil, the temperature of coil rises approximately 20%. As a result, there is a possibility that the life of the coil may be shortened and the coil may be burnt.

(b) The shock on closing becomes great and the mechanical endurance is shortened, or the contact jumps; as a result, there is a possibility of increased contact wear and occurrence of welding. The higher the voltage applied to coil, the greater the attraction. When the voltage increases by 10%, the attraction increases by about 20%. Because of this excessively strong attraction,

(i) the iron core of the electromagnet is damaged by a strong shock, and the fatigue of molded parts and pressed parts becomes greater, with the result that the mechanical endurance of the contactor is shortened by approximately 50%.

(ii) the contact increasingly jumps due to the strong shock and there is a possibility of abnormal wear and contact welding due to making and breaking of starting current of the motor.

(2) Where the power source voltage is lower than the rated voltage

When the power source voltage is low, it nears the closing voltage (lower than 85% of the rated voltage) of the contactor. As a result, a case occurs wherein the electromagnet is not attracted to the fullest extent because of variation of voltage, voltage drop due to rush current of coil, and the like, so that the contact flutters and troubles may be caused including abnormal contact wear and contact welding, or burning of coil (because the rush current of coil flows for a long time).

Moreover, the motor may incur failures such as burning caused by continuous flow of starting current.

The starting current of the motor causes voltage drop if the wire of the main circuit is long or fine, so the voltage of coil becomes lower than 85% of the rated voltage, and the same phenomenon as above may take place ; attention should be paid to this point. The causes of voltage drop of power source at closing are shown in Table 11 , so that they should be investigated and measures against them taken.

Table 11. Causes of voltage drop of coil power source

Class	Causes
Main circuit	· The wire of main circuit is fine, so the voltage is dropped by the starting current of the motor. · The wire of main circuit is long, so the voltage is dropped by the starting current of the motor.
Operating circuit	· The wire of operating circuit is fine, so the voltage is dropped by the rush current of the coil. · The wire of operating circuit is long, so the voltage is dropped by the rush current of the coil. · The capacity of power source transformer for operating circuit is short, so the voltage is dropped by the rush current of the coil.
Power source	· The voltage regulation of power source is large.

2-3-2 Operating Time

Cited below are the items to which attention should be paid when handling the closing and releasing times of the contactor.

(1) Closing and releasing time

The closing and releasing times of the contactor vary from 10 to 50 ms as shown in the catalog. This is due to the phase and value of voltage applied to the coil and the friction of the mechanical section. Examples of these variations are as shown in Fig. 14.

Where it is not desired that two electrical signals are sequentially lapped, the contactor is placed in the other circuit to create a time lag. However, this time lag is not a strict time difference, but one which is used as appropriate when an approximate time lag is wanted.

While, if this closing or releasing time is used in place of a timer to get the accurate time lag, no degree of accuracy can be expected because of the above-mentioned variation from 10 to 50 ms. Attention, therefore, should be paid to this point.

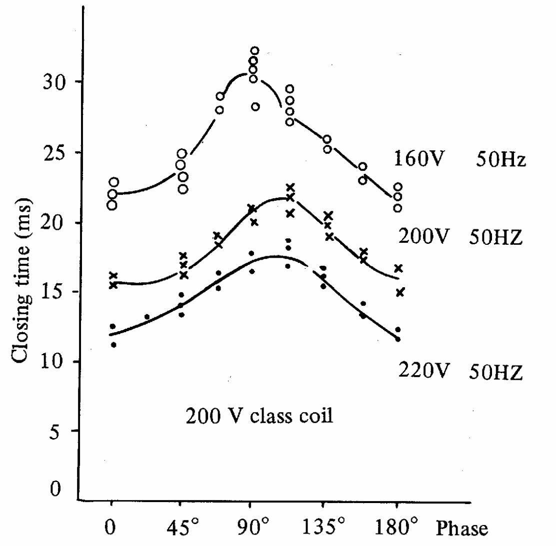


Fig. 14 Example of closing time

(2) Difference between AC and DC operations

The closing time of AC operated contactor and the double coil type DC operated one is short, and that of the direct input type DC operated one is long. This is because the former flow a large current at closing and perform attraction with a strong force, and after closing, the large current is changed to a small current. The releasing time of DC operated contactor is longer than that of AC operated one.

2-3-3 Suppression of Coil Surge Voltage

Generally, in the semi-conductor circuits, an external noise generated near them may cause an unexpected malfunction. When operating the contactor, especially when cutting off the exciting current of coil, the coil generates a sharp surge voltage with the result that the peak voltage may reach higher than 4kV and the frequency, higher than 5kHz. This is radiated as noise to the outside, and it is difficult to prevent such noise even if a protective element is placed in the semiconductor circuit. Therefore, it is necessary to take measures against occurrence of noise from the coil. Connect coil surge absorber including condenser and resistor in series to the coil of the contactor in parallel. Then, the noise generated from the coil when cutting off the exciting current can be reduced Coil surge absorber is shown on catalogue page 42 and 43.

2-3-4 Power Consumption

When calculating the in-board temperature rise of the control board, switchboard, etc., the power consumption of the equipments used must be considered. The power consumption of the starter and contactor is given in Table 12.

Table 12. Power consumption

Frame	Contact resistance (mΩ)	Power consumption (W)		Condition of current (Rated operational current)
		contactor	starter	
H8C～12 HS8,HS10	3.8 ～ 8.1	6	10	12
H20,HS20	3.6 ～ 5.2	10	14	20
H25,HS25	2.9 ～ 4.3	13	16	26
H35,HS35	1 .7 ～ 2.5	14	22	35
H50,HS50	1 .6 ～ 2.2	23	30	50
65C	0.6 ～ 1.2	22	37	65
80C	0.6 ～ 1.0	29	44	80
100C	0.6 ～ 1.0	40	55	100
125C	0.6 ～ 1.0	57	72	125
150C	0.3 ～ 0.6	48	63	150
200C	0.2 ～ 0.5	57	61	180
250C	0.2 ～ 0.5	95	99	240
300C	0.2 ～ 0.4	118	122	300
400C	0.2 ～ 0.4	202	206	400
600C	0.2 ～ 0.4	446	450	600

Remarks: 1. The contact resistance was measured between the terminals of the power source and the load sides after the 50 thousand cycle electrical endurance test.

2. The power consumption of the contactor represents the sum of power consumption of the current-flowing section and the coil, and the power consumption of the starter represents the sum of power consumption of the contactor and thermal overload relay.

2-3-5 Endurance to Over-current

When the squirrel-cage motor is direct-on-1ine started, a starting current of 5 to 6 times the rated current flows for 1 to 2 seconds, and in some of the load types, such a current may flow for longer than 5 to 6 seconds. The thermal overload relay works at overload and the circuit is broken, during which an over-current exceeding the rated current flows. Accordingly, it is necessary to select the starter, fuse, breaker, etc. corresponding to the load characteristics, and also to know the endurance to over-current.

In Fig. 15, they indicate the allowable times for which the contactor can be continuously used although the temperature rise of contacts is more than the specified value in standard. Note that after the large current flows, a time interval of more than 2 hours should be provided.

(Note: The endurance to over-current does not depend on power source voltage.)

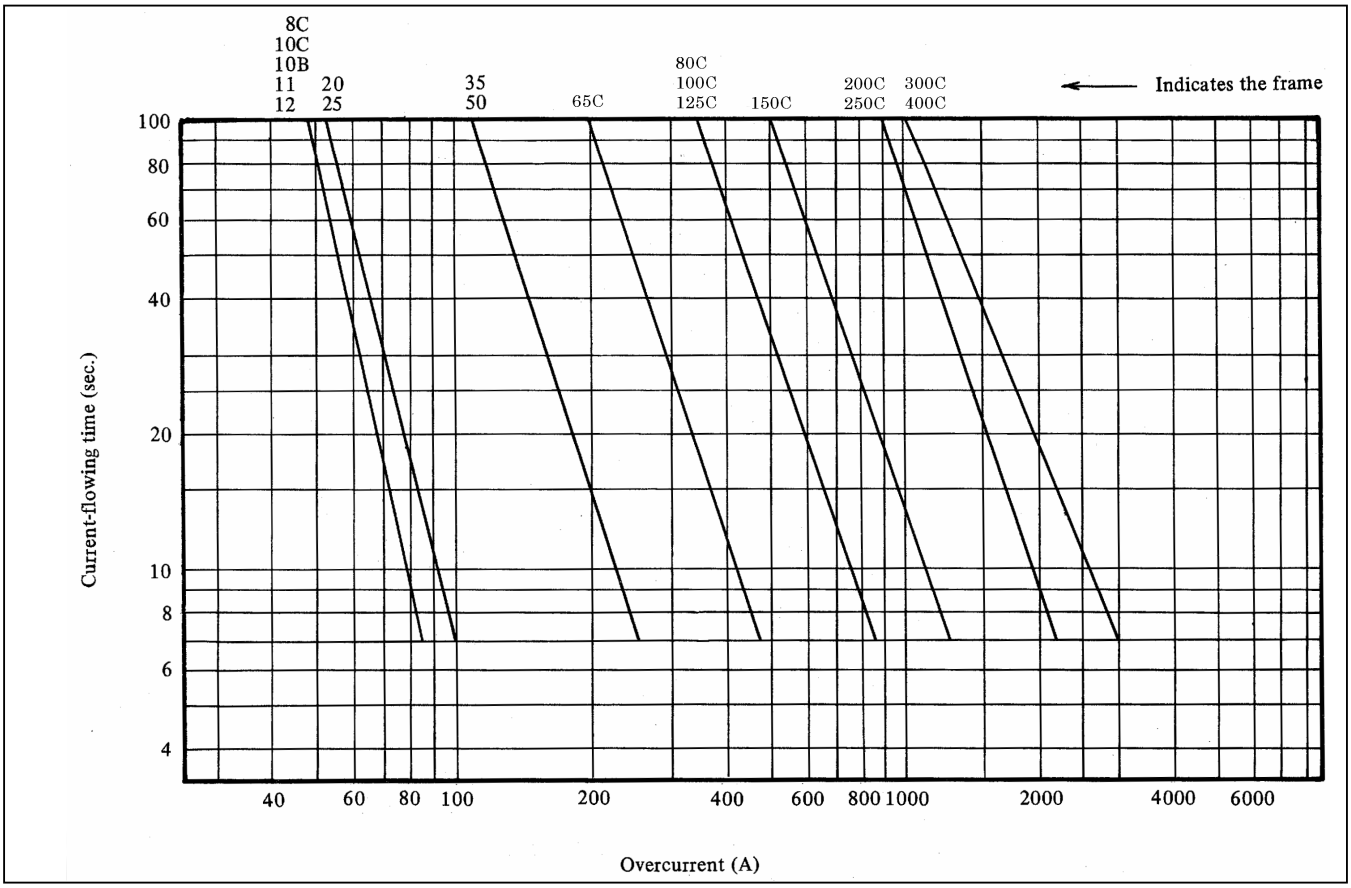


Fig. 15 Endurance to over-current

2-3-6 Vibration-proof Characteristics

When a strong vibration is applied to the mounting board, the contacts of the contactor and the thermal overload relay may cause malfunction. Therefore, try to prevent vibration to the mounting board by all means.

The malfunction limits of starter, contactor and thermal overload relay are over 2 (g).

Vibration acceleration (g) = 0.002 × (Frequency (Hz))^2 × Double amplitude (mm)

2-4 APPLICATION AND SELECTION

The contactors should be selected according to the types of their loads. The loads are classified in IEC60947 as shown in the following table, and include those of the transformer, condenser, etc. in other category. Table 13 provides references for the selection of contactors.

Table 13. Reference for selection

Category		Typical applications	Selection
IEC 60947-4-1	AC1	Non-inductive or slightly inductive load, resistance furnaces	Refer to 2-4-3.
	AC2	Slip-ring motors : Starting , plugging	The same as paragraph 24-l unless plugging is included.
	AC3	Squirrel-cage motors : Starting, switching off motors during running	Refer to 2-4-1.
	AC4	Squirrel-cage motors: Starting, plugging, inching	Refer to 2-4-2.
		DC load	Refer to 2-4-4.
		Star-delta starter	Refer to 2-4-5.
		Condenser load	Refer to 2-4-6.
		Opening/closing of primary side of transformer	Refer to 2-4-7.

2-4-1 Application of AC3

(1) Standard for selection

When controlling the motor by the contactor, the load current shown in Fig. 16 flows, so a contactor corresponding to this current is selected. The key points of the selection are given in Table 14 according to the main items.

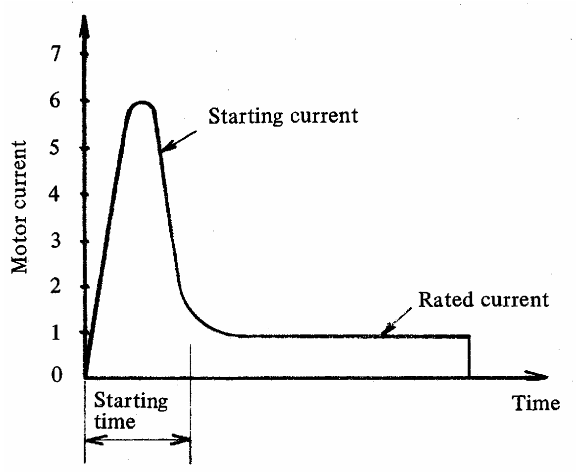


Fig. 16 Motor current

Table 14. Selection of starter and contactor for motor (As to main items)

Item	General standard for selection			
	Motor	Starter and contactor	Standard for selection	Evaluation
Electrical endurance	Starting current : Is Load current: I_f	Rated operational current : I	Is ≦ 6I I_f ≦ I	
Electrically allowable performance for the rush current and accident current which rarely occur.	Rush current and allowable accident current: I_R	Making capacity: Im Breaking capacity : Ib	I_R ≦ Im I_R ≦ Ib	・ When I_R> Im, the contact may be welded. ・ When I_R > Ib, breaking may become impossi-ble .
Mechanical endurance	Start / stop frequency: n Necessary endurance times: N	Opening / closing frequency : m Mechanical endurance: M	n ≦ m N ≦ M	
Overload protection (thermal overload relay)	Load current of motor: I_f	RC value of thermal overload relay: I_{RC}	$I_f = I_{RC}$	

(2) Selection

The starters and contactors whose capacity is respectively equal to or more than the capacity (kW) of motor are selected from the table in Page 8 and 9 of the catalogue.

(3) Electrical endurance curve

When long electrical endurance is required, select electromagnetic contactors using following endurance curve.

(a) AC200V class motor (AC3)

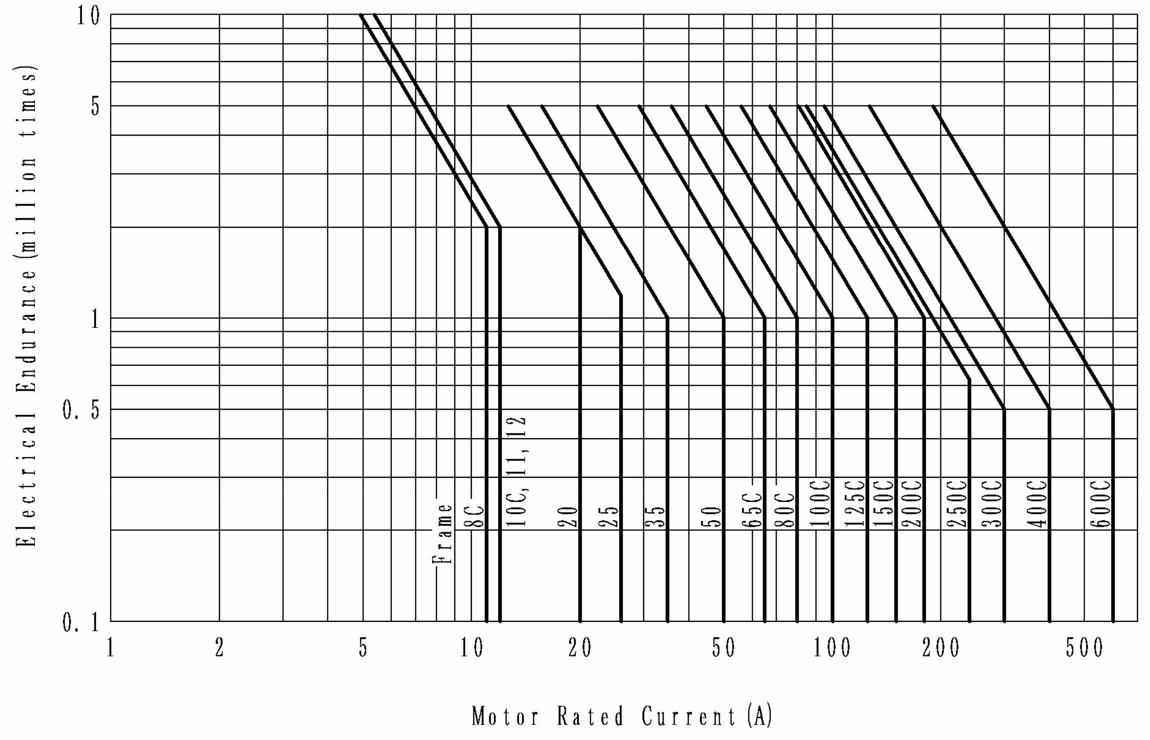


Fig. 17 Endurance curve (AC200V)

(b) AC400V class motor (AC3)

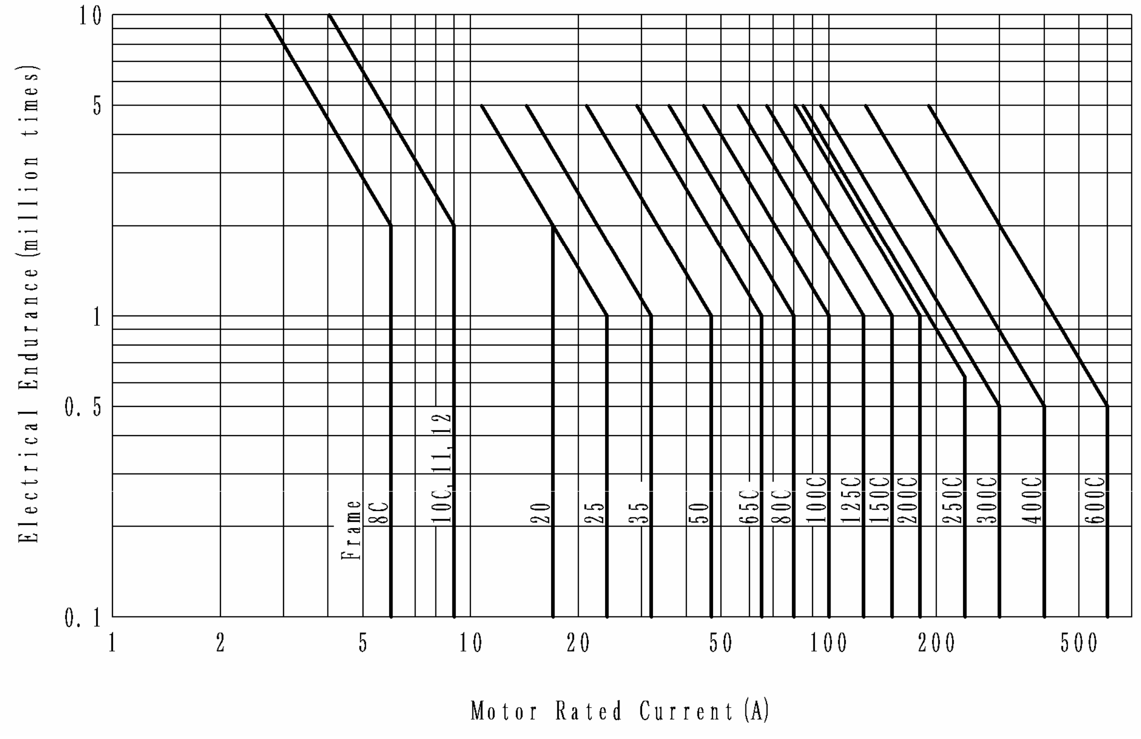


Fig. 18 Endurance curve (AC400V)

2-4-2 Application of AC4 (Application of Cases Including Inching and Plugging)

In equipment and machinery which include inching and plugging (negative-phase braking), make and break of large starting rush current of the motor will occur frequently. Category AC4 is applied for such usage. Application of AC4 is shown in Tables 1 and 2 in page 12 of the catalogue.

2-4-3 Application of AC1 (Application to AC Resistance Load)

Category AC1 is applied when using a resistance load which does not necessitate consideration of rush current at starting such as the incandescent light, electric heater, etc.

Application of AC1 is shown in Table 3 in page 13 of the catalogue.

2-4-4 Application of DC Load

The breaking category of DC load becomes far more severe in comparison with AC load. However, contactor can be applied as shown in Table 4 in page 13 of the catalogue.

2-4-5 Application for Star-Delta Starters

Delta motor is star-connected during starting, and reduces starting current and torque to one-third of full-voltage starting values.

(1) Loads applied to star-delta starters and electrical endurance of starter

Table 15. Load and electrical endurance

Load	Example of load	Electrical endurance
unloaded start	machine tools, lathe, general industrial machines, etc.	500,000
square torque	vortex pumps, turbine pumps, fans, blowers, dehydrators, centrifugal dehydrators, etc.	50,000

(2) Kinds of star-delta starters

- Star-delta starter
  - Phase-current detecting method
    - 2 Contactors method
    - 3 Contactors method
  - Line-current detecting method
    - 2 Contactors method
    - 3 Contactors method

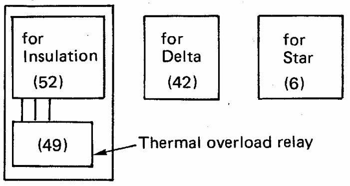
(3) Component number explanation and symbol explanation

Table 16.

No.	Name	Mark	Name
2	Timer	IM	Motor
6	Contactor for star	BS	Push button (start)
22	Circuit breaker (FFB)	BSS	Push button (stop)
42	Contactor for delta	a	Normally open contact
49	Thermal overload relay	b	Normally closed contact
52	Contactor for insulation	EF	Fuse

(a) Phase-current detecting method

3 Contactor Method



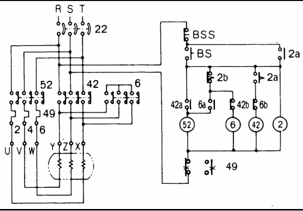


Fig. 19 Connection diagram

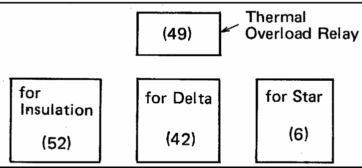
Table 17. Selection (Phase-current detecting method)

Voltage	Motor Capacity (kW)	Starter for insulation (52+49)	Contactor for Star (6)	Contactor For Delta (42)	Thermal Overload Relay		
					RC(A)	Adjustable Range (A)	Type
200V	5.5	H20-T,HS20-T	H20,HS20	H20,HS20	15	12 ~ 18	TR20B-1E
	7.5	H25-T,HS25-T		H25,HS25			
	11	H35-T,HS35-T		H35,HS35	28	22 ~ 34	TR50B-1E
	15	H50-T,HS50-T	H25,HS25	H50,HS50			
	18.5		H35,HS35		40	32 ~ 48	
	22	H65C-T		H65C	55	45 ~ 65	TR80B-1E
	30	H80C-T	H50,HS50	H80C	67	55 ~ 80	
	37	H100C-T	H65C	H100C	80	65 ~ 95	TR150B-1E
	45	H125C-T		H125C			
	55	H150C-T	H80C	H150C	105	90 ~ 120	
	75	H200C-T	H125C	H200C	1.4	1.1 ~ 1.7	TR250B-1E
	90	H250C-T	H150C	H250C	2.4	1,7 ~ 2.9	
	110	H300C-T	H200C	H300C	2.4	1,7 ~ 2.9	TR400B-1E
	132	H400C-T	H250C	H400C			
	150		H300C		3.8	2.8 ~ 4.4	
400V	5.5	H20-T,HS20-T	H20,HS20	H20,HS20	6.8	4.5 ~ 9.0	TR20B-1E
	7.5				9	7 ~ 11	
	11						
	15	H25-T,HS25-T		H25,HS25	15	12 ~ 18	
	18.5	H35-T,HS35-T	H25,HS25	H35,HS35	20	16 ~ 24	TR50B-1E
	22	H50-T,HS50-T	H35,HS35	H50,HS50			
	30				28	22 ~ 34	
	37	H65C-T	H50,HS50	H65C	40	32 ~ 48	TR80B-1E
	45		H65C				
	55	H80C-T		H80C	55	45 ~ 65	
	75	H100C-T	H80C	H100C	80	65 ~ 95	TR150B-1E
	90	H125C-T	H100C	H125C			
	110	H150C-T	H125C	H150C	105	90 ~ 120	
	132	H200C-T	H200C	H200C	1.4	1.1 ~1.7	TR250B-1E
	150	H250C-T		H250C	1.8	1.4〜2.2	
	190	H300C-T		H300C	2.4	2.0 ~ 2.8	TR400B-1E
	260	H400C-T	H300C	H400C			

Note: The RC values of thermal overload relays are based on Hitachi general-purpose squirrel cage motors (Rated current × 0.58).

(b) Line-current detecting method

3 Contactor Method



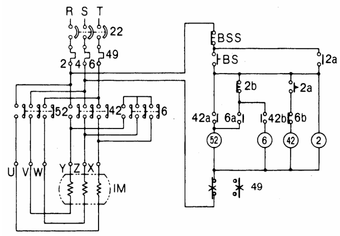


Fig. 20 Connection diagram

Table 18. Selection (line-current detecting method)

Voltage	Motor Capacity (kW)	Contactor for insulation (52)	Contactor for Star (6)	Contactor for Delta (42)	Thermal Overload Relay (49)	Thermal Overload Relay RC(A)	Thermal Overload Relay Adjustable Range (A)
200V	5.5	H20,HS20	H20,HS20	H20,HS20	TR25B-1E Single installation	20	16 ~ 24
	7.5	H25,HS25		H25,HS25	TR50B-1E	28	22 ~ 34
	11	H35,HS35		H35,HS35		40	32 ~ 48
	15	H50,HS50	H25,HS25	H50,HS50	TR80B-1E	55	45 ~ 65
	18.5		H35,HS35			67	55 ~ 80
	22	H65C		H65C	TR150B-1E Single installation	80	65 ~ 95
	30	H80C	H50,HS50	H80C		105	90 ~ 120
	37	H100C	H65C	H100C		130	110 ~ 150
	45	H125C		H125C	TR400B-1E Single installation	1.4	1.0 ~ 1.8
	55	H150C	H80C	H150C		2.4	1.6 ~ 3.2
	75	H200C	H125C	H200C			
	90	H250C	H150C	H250C			
	110	H300C	H200C	H300C		3.8	2.5 ~ 5.0
	132	H400C	H250C	H400C			
	150		H300C			6.8	4.5 ~ 9
400V	5.5	H20,HS20	H20,HS20	H20,HS20	TR20B-1E	9	6 ~ 12
	7.5				〃	15	12 ~ 18
	11				TR25B-1E Single installation	20	16 ~ 24
	15	H25,HS25		H25,HS25	TR50B-1E	28	22 ~ 34
	18.5	H35,HS35	H35,HS35	H35,HS35		40	32 ~ 48
	22	H50,HS50	H50,HS50	H50,HS50			
	30				TR80B-1E	55	45 ~ 65
	37	H65C	H50	H65C		67	55 ~ 80
	45		H65C		TR150B-1E Single installation	80	65 ~ 95
	55	H80C		H80C		105	90 ~ 120
	75	H100C	H80C	H100C		130	110 ~ 150
	90	H125C	H100C	H125C	TR400B-1E Single installation	1.4	110 ~ 1.8
	110	H150C	H125C	H150C		2.4	1.6 ~ 3.2
	132	H200C	H200C	H200C			
	150	H250C		H250C		3.8	2.5 ~ 5.0
	190	H300C		H300C			
	260	H400C	H300C	H400C			

Note: The RC values of thermal overload relays are based on Hitachi general-purpose squirrel-cage motors.

2-4-6 Application for Condenser Load

When closing the condenser circuit, the electric charge Q = CE of the condenser corresponding to the instantaneous value of power source voltage at closing of circuit is promptly supplied, and rush current flows.

The size of this rush current is limited by the line resistance and inductance, and further limited by insertion of series reactor (6 percent of condenser capacity, kvar)

The following table gives the condenser load applications when rush current is less than 10 times the rated current of condenser by insertion of series reactor.

Table 19. Application to condenser load

Type	Applied capacity to 3-phase condenser circuit kvar (A)		Applied capacity to single-phase condenser circuit kvar (A)	
	Insertion of series reactor		2-pole series	
	200～220V	380～440V	220～240V	380～440V
H10C, H11,HS10	3(9)	4(6)	1.8(9)	2.4(6)
H20,HS20	5(14)	8(12)	2.8(14)	4.8(12)
H25,HS25	7(20)	12(17)	4(20)	6.8(17)
H35,HS35	10(29)	18(26)	5.5(28)	10.5(26)
H50HS50	13(38)	26(38)	7.5(38)	15(38)
H65C	18(52)	35(51)	10(50)	20(50)
H80C	22(64)	45(65)	12(60)	26(65)
H100C	29(84)	55(79)	16(80)	31(78)
H125C	34(98)	70(101)	19(95)	40(100)
H150C	44(127)	88(127)	25(125)	50(125)
H200C	53(153)	105(152)	30(150)	60(150)
H250C	65(188)	130(188)	37(185)	75(188)
H300C	80(231)	160(231)	46(230)	92(230)
H400C	100(289)	200(289)	57(285)	115(288)
H600C	150(433)	300(433)	86(430)	173(433)

Reference: Conversion of kvar and μF

Single-phase: $[\text{kvar}] = 2\pi \times 10^{-9} \times (\text{Frequency}) \times (\mu\text{F}) \times (\text{Voltage})^2$

3-phase: $[\text{kvar}] = \sqrt{3} \times 2\pi \times 10^{-9} \times (\text{Frequency}) \times (\mu\text{F}) \times (\text{Voltage})^2$

2-4-7 Application to Opening/Closing of Primary Side of Transformer

When applying voltage to the primary side of the transformer, magnetic saturation phenomenon occurs at the iron core of transformer and a rush current of excitation flows. The amount of this rush current varies with the voltage phase and load when closing the contactor; the amount of rush current will be about 20 times the rated current of the transformer. The contactor should be selected that is not welded by this rush current.

Table 20. Application to opening/closing of primary side of transformer

Frame	Single-phase transformer A (kVA)			3-phase transformer A (kVA)		
	200 ～ 240V	380 ～ 440V	500 ～ 550V	200 ～ 240V	380 ～ 440V	500 ～ 550V
H20,HS20	8 (1.6)	6.8 (2.5)	4.8 (2.4)	10 (3.4)	8.5 (5.6)	6 (5.2)
H25,HS25	10.5 (2)	9.6 (3.6)	4.8 (2.4)	13 (4.5)	12 (7.9)	6 (5.2)
H35,HS35	14 (2.8)	12.5 (4.8)	9.2 (4.6)	17.5 (6)	16 (10.5)	11.5 (10)
H50,HS50	20 (4)	18.5 (7)	14.5 (7.4)	25 (8.6)	23 (15)	18.5 (16)
H65C	26 (5.2)	26 (9.8)	20 (10.5)	32 (11)	32 (21)	26 (22)
H80C	32 (6.4)	32 (12)	28 (14.5)	40 (13.5)	40 (26)	36 (31)
H100C	40 (8)	40 (15)	28 (14.5)	50 (17)	50 (33)	36 (31)
H125C	50 (l0)	50 (19)	32 (16)	62 (21)	62 (41)	40 (34)
H150C	60 (12)	60 (22)	32 (16)	75 (26)	75 (50)	40 (34)
H200C	72 (14.5)	72 (27)	58 (29)	90 (31)	90 (60)	72 (62)
H250C	96 (19)	96 (36)	58 (29)	120 (41)	120 (80)	72 (62)
H300C	120 (24)	120 (45)	100 (50)	150 (52)	150 (100)	125 (110)
H400C	160 (32)	160 (60)	140 (70)	200 (70)	200 (130)	175 (150)
H600C	240 (48)	240 (90)	200 (100)	300 (105)	300 (200)	250 (215)

Remarks : 1. Applicable to the case where the rush current of transformer is less than 20 times the rated current.

2. In case the rush current of transformer is more than 20 times the rated current or considerably small, please consult with us.

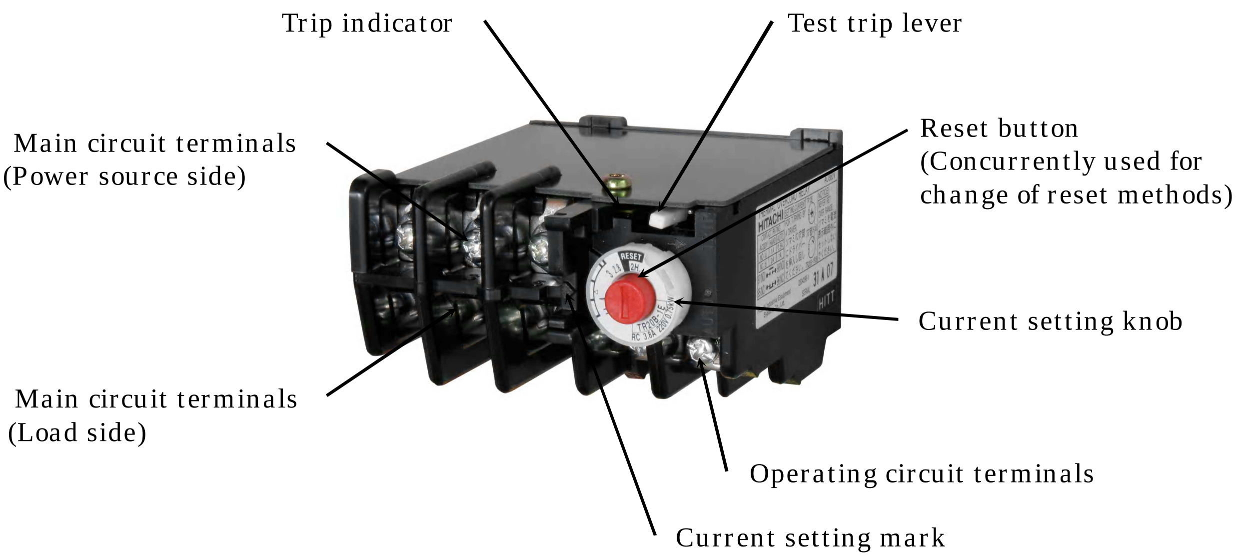
3. THERMAL OVERLOAD RELAY

3-1 STRUCTURE AND OPERATION

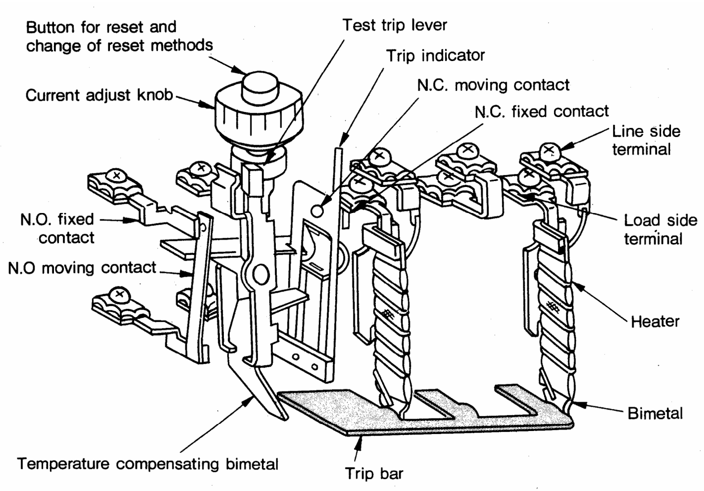
3-1-1 Standard Type (1E) and Phase Failure Protected Type (2E)

(1) External structure

Fig. 21 External structure



(2) Internal structure



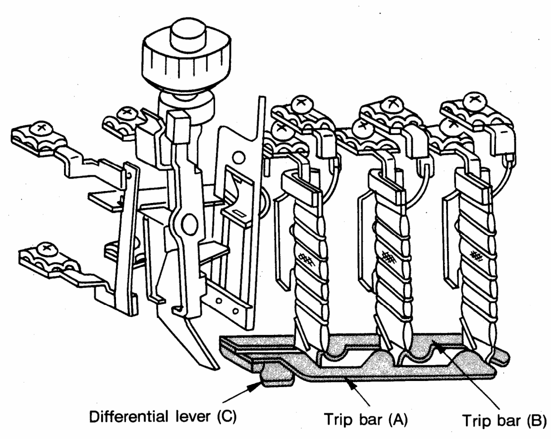


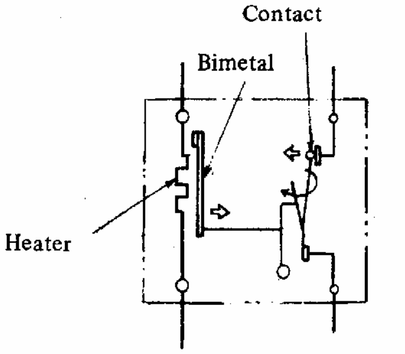
Fig. 22 Internal structure of standard type (1E) thermal overload relay
(This contains high-performance bimetals and contact mechanism applicable to the thermal overload relay (2E).)

Fig. 23 Internal structure of thermal overload relay (2E)
(This 2E thermal overload relay is the same as the standard type as regards the external structure , but different from the internal structure in the differential mechanism.)

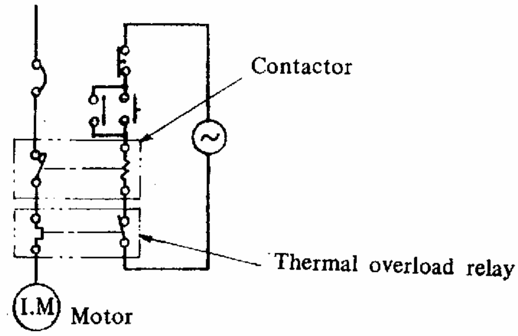
(3) Operation

(a) Operation of 1E thermal overload relay

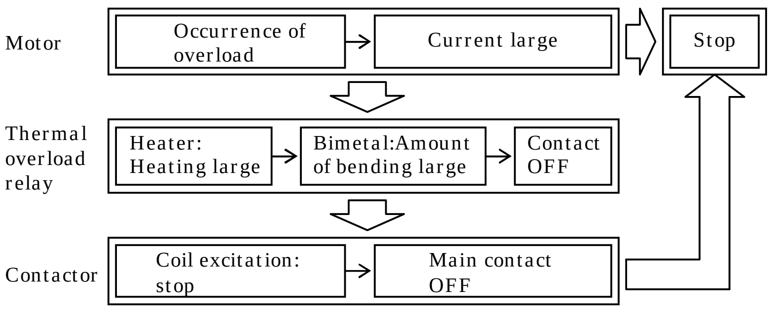
As shown in Fig. 24, the thermal overload relay contains an over-current detector consisting of bimetals, and heaters, and a contact actuated corresponding to bimetals. Where the load current of the motor is made to flow to the heaters placed near the bimetals, they bends corresponding to the amount of load current, with the result that the contact can be actuated. If this contact is connected to the coil exciting circuit of the contactor, when the bending amount of bimetals becomes more than the predetermined value (when over-current flows), it is possible to stop the motor.



(a) Operation diagram



(b) Connection diagram



(c) Operation sequence

Fig. 24 Protective operation of thermal overload relay

(b) Operation of 2E thermal overload relay

Refer to the catalogue page 24.

3-2 PERFORMANCE

(1) Standards for thermal overload relay

The standard type (1 E) thermal overload relay and 2E thermal overload relay conform to the JIS, JEM and IEC standards in table in page 26 of the catalogue.

(2) Ambient temperature characteristics

Refer to the catalogue, page 25.

3-3 APPLICATION AND SELECTION

Selection of thermal overload relays must be determined by taking into consideration the type of motor, required function, type of load and starting method, etc.

3-3-1 General Selection

Table 21 gives the general selection in case running and stopping do not include inching and plugging and the starting time is not so long.

If the probability of phase failure and negative phase trouble is considered to be extremely low, selection of standard type (1E) thermal overload relay makes it possible to protect the motor almost completely.

Table 21. General selection

<table>
<tr><td colspan="2">Submerged pump
and motor</td><td>Quick response type
1E thermal overload relay</td><td>Quick response type
2E thermal overload relay</td><td rowspan="4">Static 3E relay</td></tr>
<tr><td rowspan="3">General-purpose
motor</td><td>Motor up to
200kW</td><td>3 -element
1E thermal overload relay</td><td rowspan="3">2E thermal overload relay</td></tr>
<tr><td>Motor of less than
3.7 kW</td><td>2-element
1E thermal overload relay</td></tr>
<tr><td>Very small capacity
motor</td><td>3-lement
1E thermal overload relay</td></tr>
<tr><td colspan="2" rowspan="3">Object
Required
function</td><td colspan="2">–</td><td></td></tr>
<tr><td>Rough protection to
Phase failure</td><td colspan="2">More stringent phase-failure protection</td></tr>
<tr><td colspan="3">Overload/restriction protection</td></tr>
</table>

3-3-2 Selection for Small Capacity Motor

The reasons why a 2-element 1E thermal overload relay is selected for a small capacity motor of less than 3.7kW in Table 21 are as follows :

- Even in the case of 2-element thermal overload relay, the phase-failure operating performance is extremely high. The 2-elernent thermal overload relay has the same phase-failure operating performance (conform to IEC standard) as the 3-element type.
- The small capacity motor has a characteristic that the winding temperature rise is lower at phase-failure running compared with medium- or large capacity motors due to structural reasons, such as star-connection of motor winding.

Fig. 25 indicates the experimental values of the temperature rise ratio at phase-failure. Fig. 26 indicates conversion of the experimental values in Fig. 25 into temperature rise ratio at operation of thermal overload relay. When using the 2-element type with high performance, it is possible judging from the figure to make protection at phase-failure.

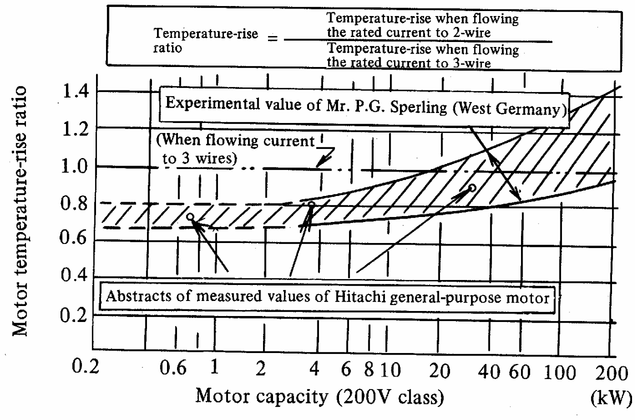


Fig. 25 Motor temperature-rise ratio at phase-failure

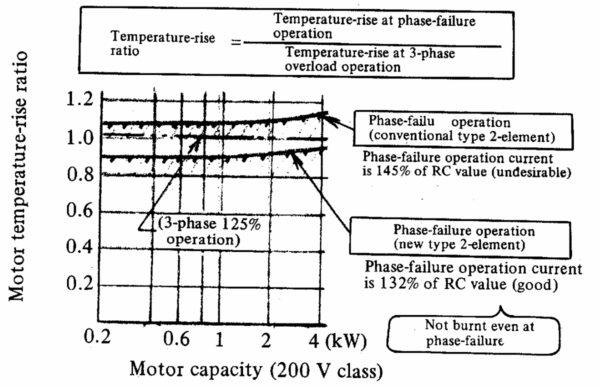


Fig. 26 Motor temperature-rise ratio at phase-failure operation

When a strict phase-failure protection is necessary that includes also such a special case as over-current flows only to l wire at the secondary side due to phase-failure at the primary side of the transformer, 3-element thermal overload relay or 2E thermal overload relay should be selected.

3-3-3 Selection for Very Small Capacity Motor

The rated current of a very small capacity motor like the hydraulic pump motor is extremely small, so the heaters of thermal overload relay corresponding to this rated current have a very high resistance value. Therefore, a voltage drop caused by the thermal overload relay becomes large, so that full attention must be paid to insufficient starting torque and voltage unbalance when using 2-element type thermal overload relay.

Where the load is light, unbalance of current due to voltage unbalance tends to become large. It is recommended that 3-element type thermal overload relay be selected.

Where only a small-sized 2-element thermal overload relay can be installed due to limited space, its rated current should be about twice the rated current of the motor exclusively for protection of restriction.

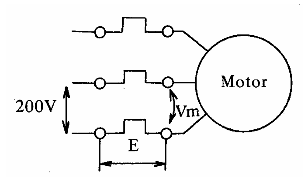


Fig. 27

Reference 1. Insufficient starting torque

Example of RC0.1A ······ Motor: 200V, 0.lA (rating)

E (Heater voltage drop) = Is (Motor starting current) × R (Heater resistance value)

$= 6 \times 0.1 \times 130 = 78$ (V)

Vm (Motor input voltage) $\fallingdotseq 200 - (\sqrt{3} \times 78) \fallingdotseq 65$ (V)

input voltage ···· 38%
starting torque ··· 15%

The starting torque becomes extremely small, so that starting will be impossible unless the load is a considerably light one.

Reference 2. Effect due to voltage unbalance (Where 2-element thermal overload relay is used)

Even in case the load is light and starting is possible, if a 2-element thermal overload relay of a low rating is used, there remains a problem of voltage unbalance. The lower the rating (heater resistance is large), the greater the voltage unbalance. Therefore, undesirable motor running conditions will continue, such as current unbalance, abnormal temperature rise, etc.

When using a 2-element thermal overload relay (RC 0.1A) to the motor (0.1A rating), current unbalance of a little over 50% may occur.

Reference 3. Heater resistance of thermal overload relay

The thermal overload relay is designed to actuate the contact mechanism by driving the bimetal using the heating of the internal heater arising from overload current of the motor.

The minimum power necessary for this heating should be more than 1.3W (one phase component when the rated current is flowing).

$$\boxed{W \text{ (power)} = I^2 \text{ (rated current}^2\text{)} \times R \text{ (heater resistance value)} = 1.3 \text{ to } 8 \text{ (W)}}$$

・ Heater resistance value: In the case of a low rating, the heater resistance values can be calculated from above power as shown in the following table.

Table 22. Heater resistance

Rated current (RC)	Heater resistance value (one phase)	Condition
0.3A	14.4Ω	W (Power) ・・・・・ 1.3 W (minimum value)
0.2A	32.5Ω	
0.15A	57.8Ω	Rated current ・・・・・ A low rating less than RC0.3A.
0.10A	130Ω	

When the rated current becomes small, the heater resistance value is indicated to become extremely large.

3-3-4 Inching and Plugging Operation

Since frequent inching and plugging operations actuate the thermal overload relay, continuous operation becomes impossible .

In order to avoid this, the setting value of current of the thermal overload relay may be increased over the rated current of motor; however, it is not advisable to protect the motor.

In the case of inching and plugging operation, the starting current flows intermittently and the self-cooling effect of the cooling fan decreases. In this state the temperature rise is different from that of normal operation.

Taking into consideration the above, in order to protect the motor when carrying out inching and plugging operations, it is most suitable to protect the motor directly detecting the temperature by incorporating the thermistor in the motor winding.

In the case of slip-ring motor, the rotor must be protected from burnt-out. In addition to the thermistor incorporated in the stator winding, the thermal overload relay should be concurrently used for restraint protection, thus ensuring perfect protection.

3-3-5 Where Starting Time is Long

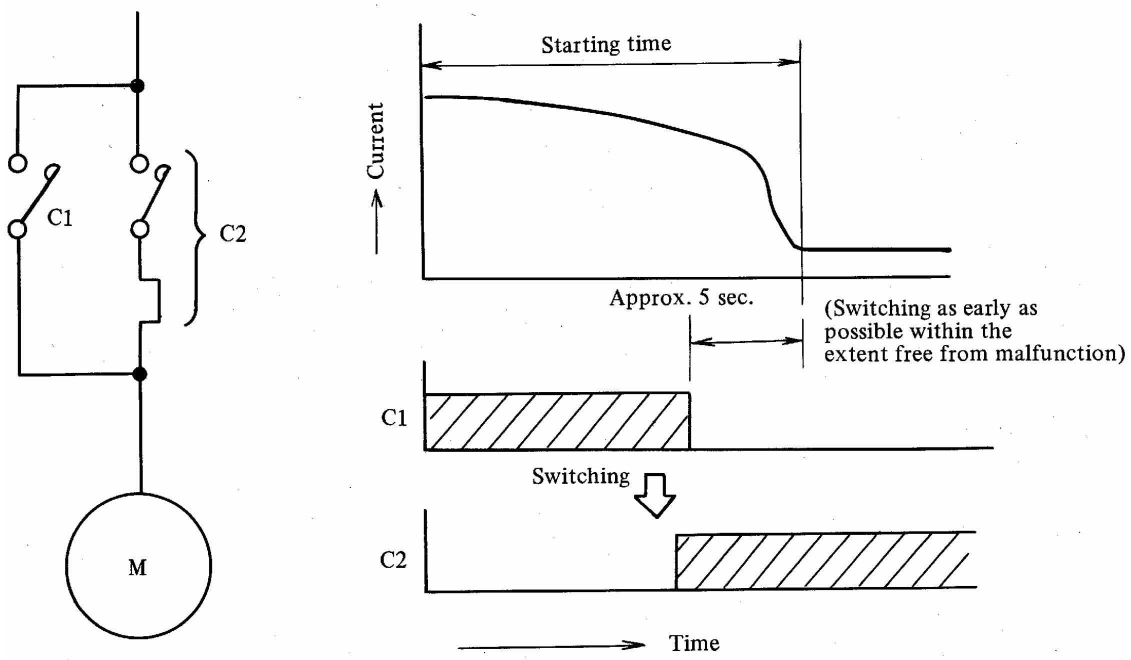
For the fan, press machine, etc. whose mechanical inertia (GD^2) of load is great, the starting time is long.

If the starting time is long, it is very difficult to achieve compatibility of prevention from malfunction with protection of motor, so that for practical purposes, such a method is adopted that the protective performance at restraint is somewhat lowered (since the probability of restraint troubles is low).

The following table classifies the general countermeasures.

Table 23. General countermeasure

Starting time	Applicable thermal overload relay	Connection	Merit	Demerit
Approx. 5 to 15 sec.	Thermal overload relay with saturation reactor (Please consult with us)	Same as standard	Simple circuit	In both starting and running times, the protective perform-ance at restraint is insufficient .
15 sec. or longer	Standard thermal overload relay Timer and contactor are additionally used.	Refer to Fig. 28.	The protection during operation is certain. The restraint protection at starting can be carried out to some extent by changing the setting of the time .	The circuit is complicated.



C1: Contactor for starting
C2: Starter for running

Fig.28

4. CONTACTOR RELAY

4-1 TYPES OF CONTACTOR RELAYS

Refer to catalogue page 38.

4-2 PERFORMANCE

The performance of the contactor relay is subjected to tests according to the testing conditions specified by standards (IEC, JEM, etc.), and must satisfy the values set forth in them to secure guarantee. The testing conditions vary with the types of loads, which are classified into categories AC15 and DC11 as given in Table 24.

Table 24. Utilization categories (IEC 60947-5-1)

Kind of current	Category	Typical applications
Alternating current	AC15	Control of a.c. electromagnets
Direct current	DC11	Control of d.c. electromagnets

The major test items of the contactor relay are as follows, and in all of the tests the specified values are fully satisfied.

(1) Temperature rise test

Same as that of contactors (see page 10).

(2) Making and breaking capacities test

The test conditions of making capacity and breaking capacity test are the abnormal conditions of use shown in Table 25.

Table 25. Conditions for making and breaking corresponding to the utilization categories (IEC 60947-5-1)

Kind of current	Category	Normal conditions of use						Abnormal conditions of use					
		Make			Break			Make			Break		
Alternating current	AC15	I	U	cos ϕ	I	Ur	cos ϕ	I	U	cos ϕ	I	Ur	cos ϕ
		10Ie	Ue	0.7(1)	Ie	Ue	0.4(1)	11Ie	1.1Ue	0.7(1)	11Ie	1.1Ue	0.7(1)
Direct current	DC11	I	U	$T_{0.95}$	I	Ur	$T_{0.95}$	I	U	$T_{0.95}$	I	Ur	$T_{0.95}$
		Ie	Ue	$6 \times P$(2)	Ie	Ue	$6 \times P$(2)	1.1Ie	1.1Ue	$6 \times P$(2)	1.1Ie	1.1Ue	$6 \times P$(2)

Ie = rated operational current　　I = current to be made or broken

Ue = rated operational voltage　　U = voltage before make

Ur = recovery voltage

$T_{0.95}$ = time to reach 95% of the steady-state current, in milliseconds,

P = UeIe = steady-state power consumption, in watts.

(1) The power-factors indicated are conventional values and apply only to the test circuits which simulate the electrical characteristics of coil circuits. It should be noted that, for the circuit with power-factor 0.4 (normal conditions of use), shunt resistors are used in the test circuit to simulate the damping effect of the eddy current losses of the actual electromagnet.

(2) The value "6 × P" results from an empirical relationship which is found to represent most d.c. magnetic loads to an upper limit of P = 50W, viz. 6 × P = 300ms. Loads having power-consumption greater than 50W are assumed to consist of smaller loads in parallel. Therefore, 300 ms is to be an upper limit, irrespective of the power consumption value.

· Normal conditions of use

The normal use of a contactor relay is to close, maintain and open circuits which contain an electromagnet the magnetic circuit of which is open at the time when the coil current is made and closed when the coil current is broken.

· Abnormal conditions of use

Abnormal conditions may arise when an electromagnet, although energized, has failed to close.

A contactor relay is required to be able to break the current corresponding to such abnormal conditions of use.

(3) Mechanical endurance test

With respect to its resistance to mechanical wear, a contactor relay is characterized by the number of on-load operating cycles, i.e. operating cycles with no current flowing, which can be made without any mechanical failure. The standard numbers of no-load operating cycles, expressed in millions, are given in the first column of Table 26.

Table 26.

Class of mechanical endurance (in millions of no-load operating cycles)	Number of no-load operating cycles per hour
0.01	12
0.03	12
0.1	12
0.3	30
1	120
3	300
10	1200
30	3600
100	12000

(4) Electrical endurance test

The test condition of the electrical endurance test is the normal conditions of use in Table 25 and the maximum frequencies of on-load operating cycles are given in the second column of Table 26.

4-3 CONTACTOR RELAY WITH TWIN CONTACT

The contactor relay is usually composed of single contact. If this contact is used at 48V or higher under ordinary environmental conditions, it can be used almost free from contact failure such as unsatisfactory contact, etc.

When it is intended to use the contactor relay at low voltage and current, if the contactor relay with twin contact is used, the contact reliability will be improved. As shown in Fig. 30, this contact is divided into two parts, so that they help each other to prevent occurrence of contact failure and improve the contact reliability.

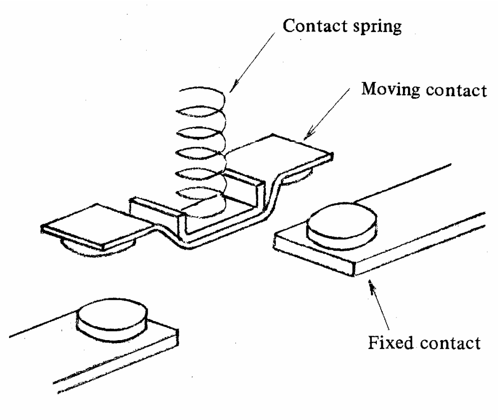


Fig. 29 Single contact
(Standard contact)

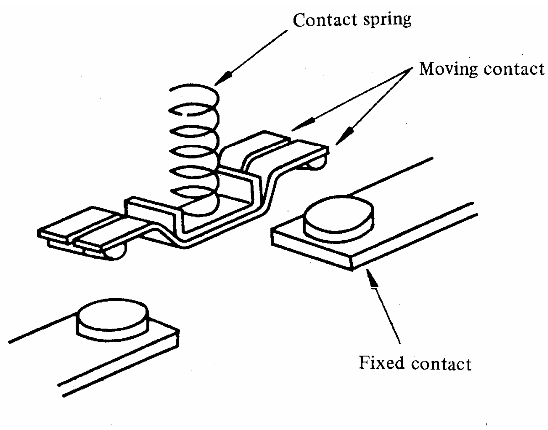


Fig. 30 Twin contact

4-4 CONTACT RELIABILITY

The maps of contact reliability of contactor relays are as shown in Fig. 31 and Fig. 32.

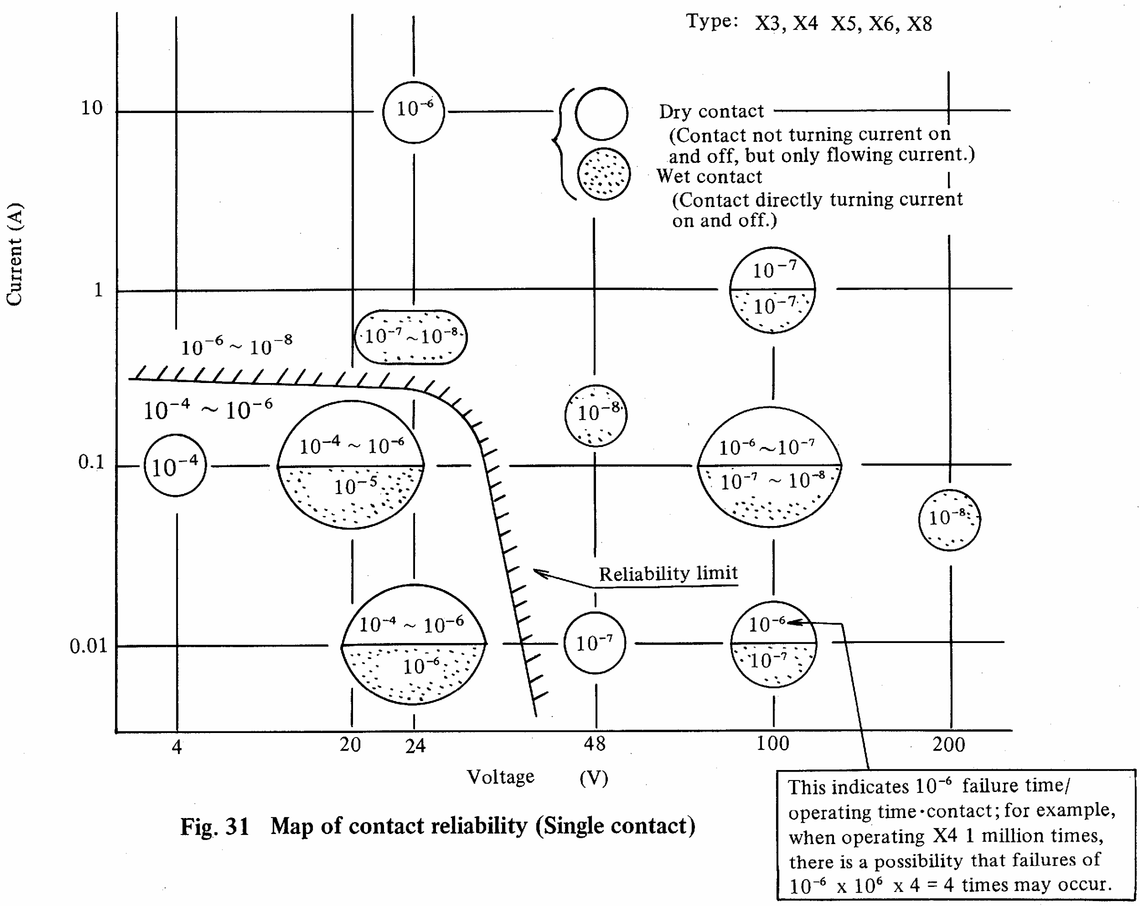


Fig. 31 Map of contact reliability (Single contact)

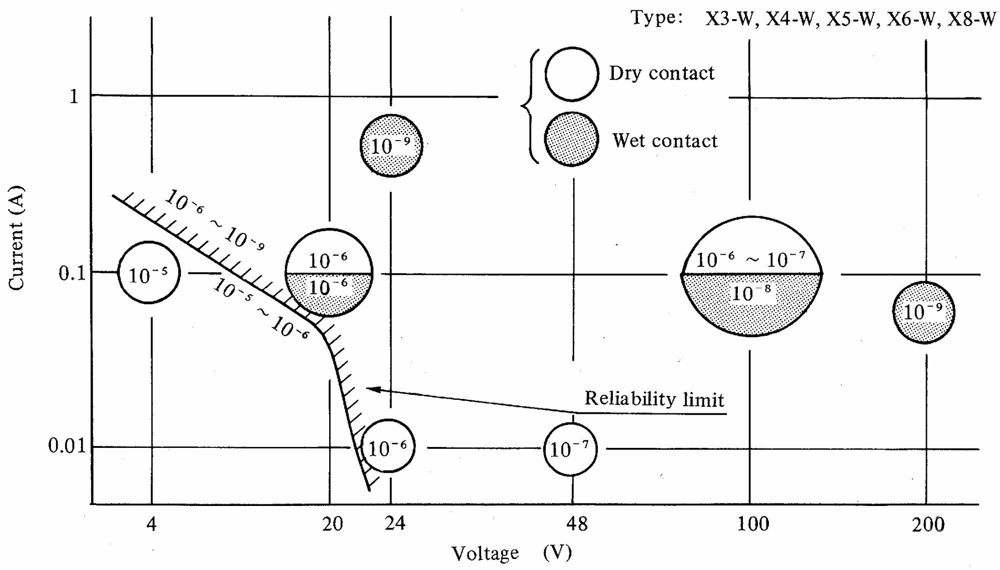


Fig. 32 Map of contact reliability (Twin contact)

5. MOUNTING AND CONNECTION

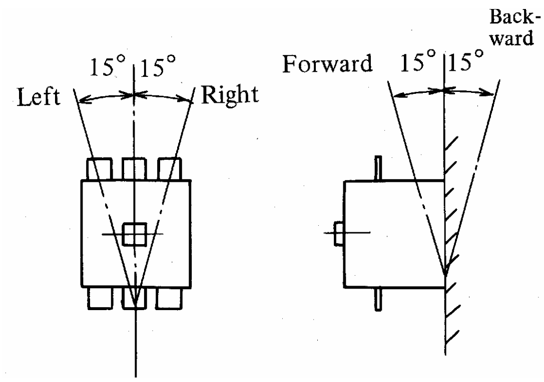
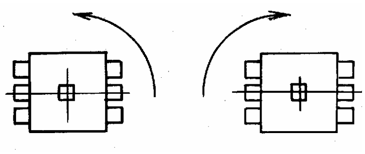
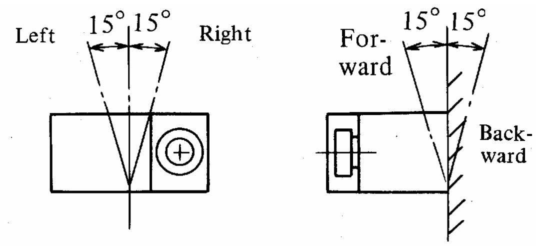
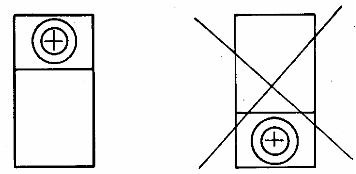
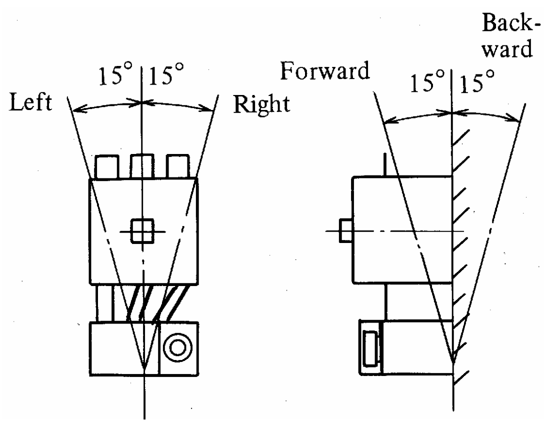
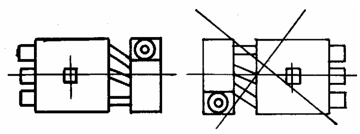
5-1 MOUNTING

5-1-1 Mounting State

The starter and contactor should in principle be mounted on a flat vertical plane as shown in Table 27. If circumstances demand, they may be mounted with a tilt, forward or backward, and right or left, of at most 15 degrees.

The contactor with horizontal plunger structure can be mounted crosswise, but the one with link structure uses the weight of the moving core for a part of the energy of the release operation, so that it cannot be mounted crosswise. The thermal overload relay can be mounted only crosswise by counterclockwise rotating it 90 degrees because of heat conduction of the heater.

Table 27. Mounting state

Type	Frame	Standard mounting and allowable mounting angle	Crosswise mounting
Contactor and contactor relay	Contactor relay and 8C～125C		 Reversible type with mechanical interlock cannot be mounted crosswise.
	150C～600C		Mounting is impossible.
Thermal overload relay	All frames		
Starter	8C～125C		 Reversible type with mechanical interlock cannot be mounted crosswise.
	150C～600C		Mounting is impossible.

5-1-2 Clamping Torque of Mounting Screws

The starter and contactor should be securely mounted to a flat surface with the fixing screws stated in the dimensions column of the catalogue. As to the clamping torque to be applied them, refer to Table 28.

Table 28. Appropriate clamping torque

Diameter of thread	Clamping torque (kg-cm)	
	Screw	Bolt
M4	10 ～ 15	—
M5	25 ～ 35	—
M6	40 ～ 50	—
M8	80 ～ 100	100 ～ 150
M10	—	150 ～ 250
M12	—	350 ～ 450

5-1-3 Mounting Space

When mounting the starter and contactor, it is necessary to provide an appropriate space between them and anything nearby. The size of this space should be determined considering the following items.

(1) Sufficient space to prevent a short circuit accident due to arc produced when opening and closing.

(2) Space necessary for normal radiation of heat generated by the starter and contactor and for holding down the temperature rise below the allowable value.

(3) Space for securing the insulation distance specified in the standard.

Regarding the mounting space, refer to the dimension column of each type in the catalogue.

5-2 WIRING (CONNECTION)

5-2-1 Clamping Torque

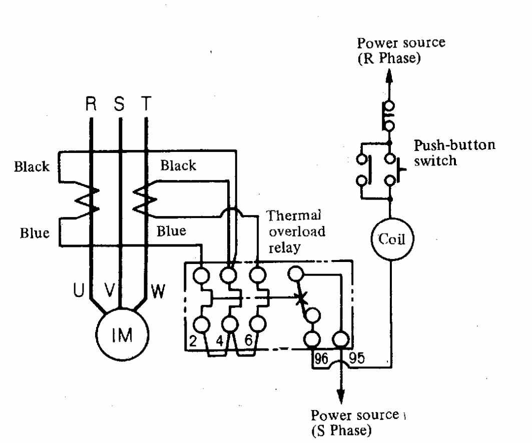
For accurate wiring to terminals, refer to the clamping torque given in table in page 44 of the catalogue.

5-2-2 Connectable Wire and Usable Pressure-Type Wire Connector

The connectable wires and the widths of usable pressure-type wire connectors for the respective frames are given in table in page 44 of the catalogue.

5-2-3 Connection of Thermal Overload Relay with CT

When CT side is V-connected, 2 set of CT can make 3-phase protection. Then, in order to ensure correct operation, make wiring as shown in Fig. 33 and Fig. 34 by paying attention to the mounting direction and polarity.



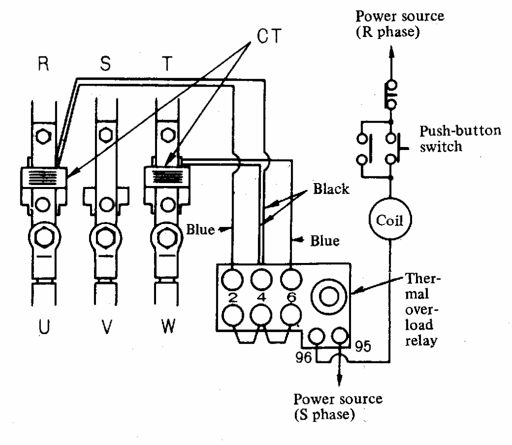


Fig. 33 Connection diagram　　　　Fig. 34 Mounting of CT and wiring

A current flows to the 3 heaters of the thermal overload relay at 3-phase overload.

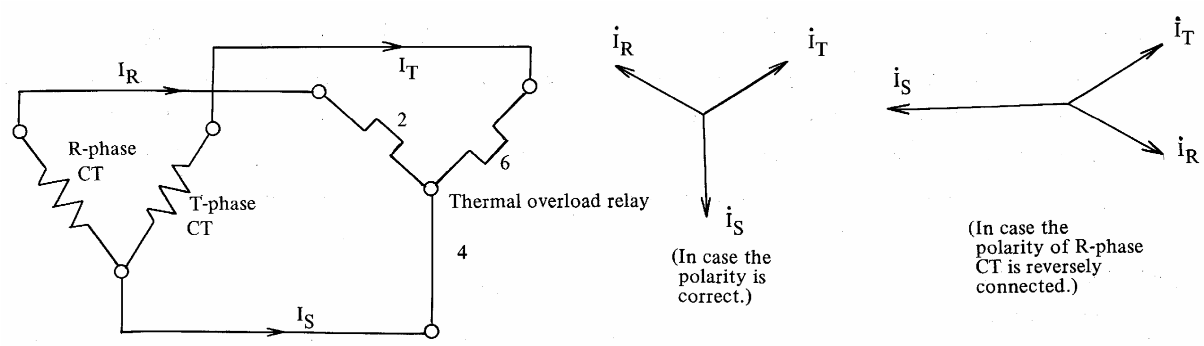


Fig. 35

Even if phase failure occurs, current flows to the 2 heaters without phase failure, regardless of the insertion phase of CT; the same operation is made as the 3-phase thermal overload relay not using CT.

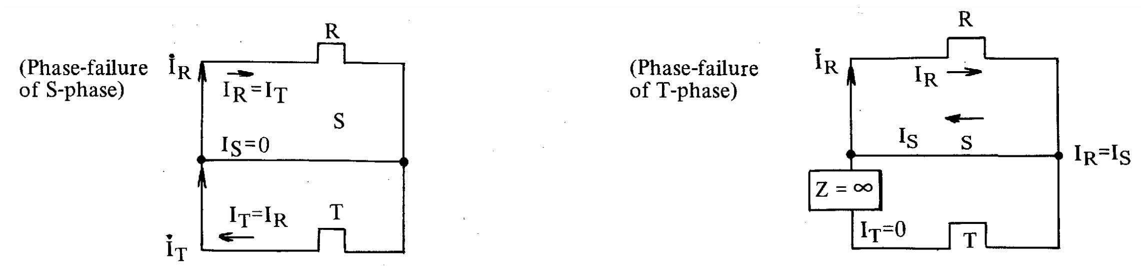


Fig. 36

Where 3sets of CT are used, individual CT's are connected to the respective heaters of the thermal overload relay as shown in Fig. 37 and Fig. 38.

Then, even if the CT polarities are arranged uniformly, protection can be ensured.

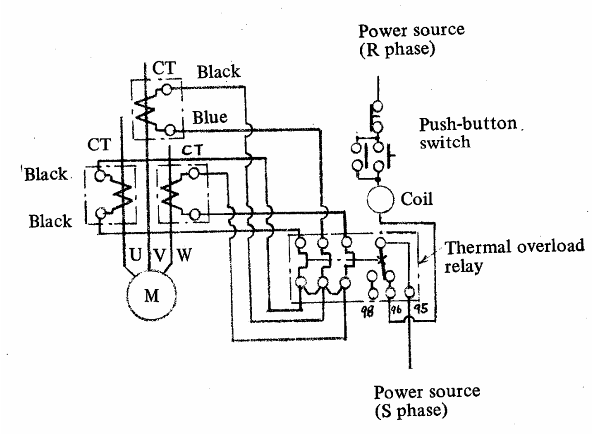


Fig.37 Connection diagram

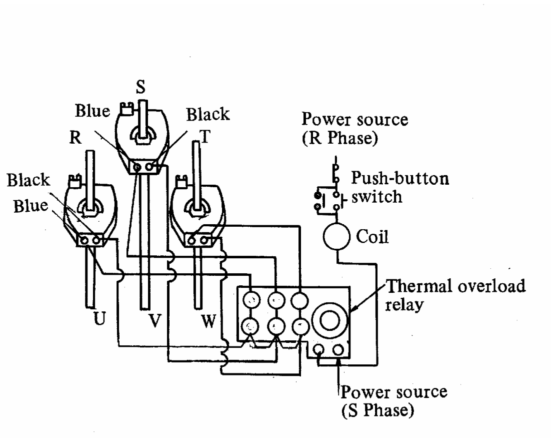


Fig.38 Mounting of CT and wiring

5-2-4 Connection When Single-Phase or DC Motor is Applied

When using the thermal overload relay to a single-phase motor or DC motor connection should be made as shown below in order to maintain the operating performance of the thermal overload relay.

(1) In case of 2-element thermal overload relay: (TR12B-lE)

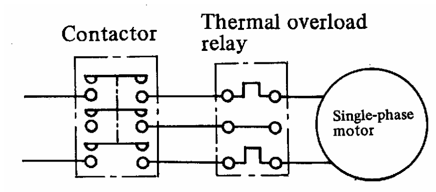


Fig. 39

(2) In case of 3-element thermal overload relay

Connect wires so that a current flows to 3 heaters.

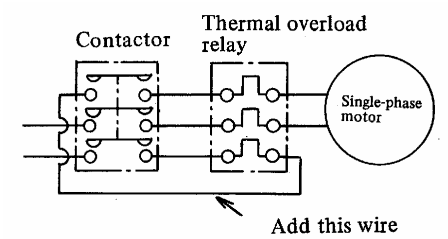


Fig. 40

・ Wrong connection

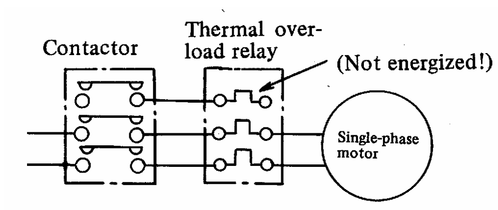


Fig. 41 Wrong connection

The 3-element thermal overload relay is so adjusted that it can normally operate in a state where current flows to all 3 elements.
In the case shown in Fig. 41, the protection characteristic is deteriorated.
The protection characteristic indicates a deviation of 12% in the worst case as shown by the dotted line in Fig. 42.

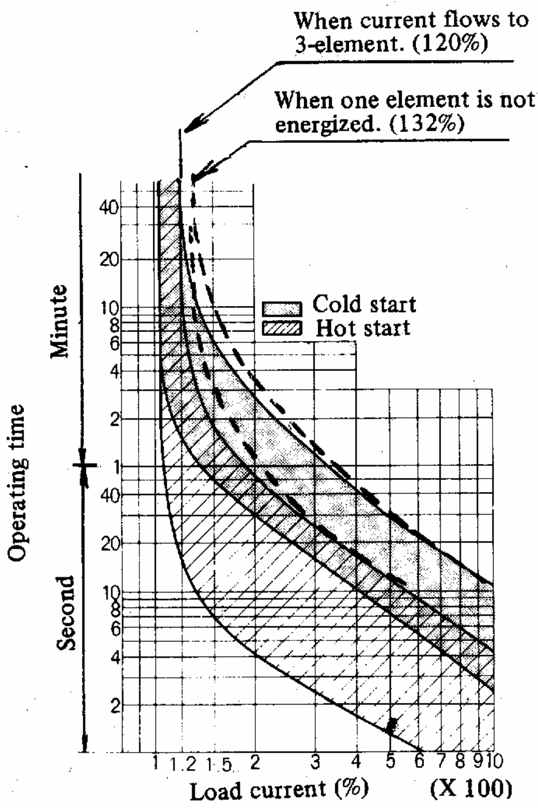


Fig. 42 Operating characteristic in wrong connection

6. HANDLING MAINTENANCE AND INSPECTION

6-1 STORAGE AND CONVEYANCE

Starter, contactor and thermal overload relay should be stored or carried under the following conditions.

Table 29.

Conditions		Remarks
Ambient temperature	Upper limit : 70℃ Lower limit: -30℃	Limited by a change in the characteristic due to bending of bimetal of thermal overload relay, deterioration of PVC wire, and the like.
Humidity	Upper limit : 85% Lower limit: 45%	If the devices are left for a long time at a place where the humidity is high, the insulation may be deteriorated when they are used.
Atmosphere	· A condition where the devices are free from abnormal vibration or shock . · A condition where the devices are not splashed with water, oil, etc. · A condition free of corrosive gas, combustible gas, dust, vapor, salt, etc.	Use special care for the storage after unpacking.
Conveyance	Carefully handle and carry the devices .	The devices are carefully packed; however, if they should be dropped from a high place, a part of the case, etc. may be damaged.

6-2 MAINTENANCE AND INSPECTION

6-2-1 Inspection

In order to prevent troubles and maintain the performance of the starter and contactor, it is recommended that initial and periodical inspections are performed. Most unexpected troubles take place at the start of operation, so that the initial inspection is particularly significant.

(1) Initial inspection

It is recommended that the following items be inspected before and after, 3 to 10 days after and 3 months after operation, respectively. Periodical inspections should be carried out after the above inspections.

Table 30. Initial inspection

Time of initial inspection		Major inspection items
Starting time of operation	Immediately before	· Check whether screws are fully tightened. Confirm not only the terminals to which wires are connected but also those to which no wire is connected. · Check whether small items such as a screw, washer, chip, wire waste, etc. have infiltrated the switch. · Check whether there is any erroneous wiring.
	Immediately after	· Check whether the contactor is closed perfectly . · Check whether the electromagnet produces abnormal beats. · Check whether there occurs instantaneous arcing from arc suppressing chamber due to starting current of motor when closing the contactor. If the arcing is greater than at the breaking time, it is necessary to check.
After entering normal operation, · 3 to 10 days after · 3 months after		· Check screws for loosening. · Check whether dust or oil are adhering to any part. If any foreign matter is found to be adhering, investigate the cause. · Turn off the power and move the moving part by hand. · Check whether the contact is worn. If abnormal wear is found, investigate the cause. · Re-confirm the inspection items required immediately before and after operation.

(2) Periodical inspection

(a) Time of periodical inspection

When the inspection is carried out taking into consideration the environment and the frequency of use as given in Table 31 , appropriate security and prevention may be expected.

Table 31. Time of periodical inspection

Environment of use		Interval of periodical inspection	
		Contact part	Operating part
Inspection time according to environment	A clean and dry place	Every 12 to 36 months	
	A place which is relatively free of dust, humidity, salt, corrosive gas, vapor, etc.	Every 12 months	
	Places other than the above.	Every 3 to 6 months	
When operating frequency is great	100-times/hr (30,000-times/month) or less	Every 12 months	Every 36 months
	200-times/hr (60,000-times/month) or less	Every 6 months	Every 24 months
	600-times/hr (200,000-times/month) or less	Every 2 months	Every 12 months
	1,200-times/hr (360,000 times/month) or less	Every month	Every 6 months
For severe use such as inching, plugging, etc.		Determined corresponding to the actual state of use.	

(b) Periodical inspection items

The periodical inspection should be carried out for the items given in Table 32.

Table 32. Periodical inspection items

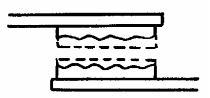
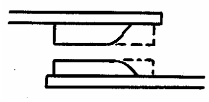
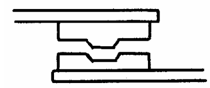
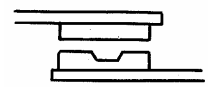
Periodical inspection item	Contents of inspection
1. Tightening of screws	· Check the terminal clamping screw and conductor connecting screw for loosening, and tighten them further. Also check the terminals to which no wire is connected; unless checked, there is a possibility that they will fall out and cause troubles.
2. Removal of dropped foreign substances, such as dust, chip, wiring waste, screw washer, etc.	· Confirm that there are no conductive foreign substances in the molded part between the terminals or in other places. · Check for adherence of dust, oil, etc. If such foreign matters are found, investigate the cause of their presence. · Check whether the window of the arc suppressing chamber of contactor is blocked by a foreign substance .
3. Check of abnormal temperature rise	· Check whether there is discoloration of the conductive part due to abnormal temperature rise, or discoloration and crack of the molded part due to overheating.
4. Check of thermal overload relay	· Check the terminal screws for loosening. · Check the operating state by performing test trip and resetting. · When the contact of the contactor is almost melted due to short circuit, the thermal overload relay must be considerably damaged, so that it should be replaced. (Excluding those which are protected by CT or saturation reactor.)
5. Check of manual operation, and check of operational sound or beat at time of automatic operation	· Turn off the power and move the moving part by hand. Check whether the moving part moves smoothly . · Check whether abnormal operational sound or beat are generated by automatic operation. If the operation is done by opening the insulated cover, troubles such as short circuit, etc. may occur, so absolutely avoid initiating the above operation .
6. Check of contact and time of replacement	· Check whether the contact is abnormally worn. When the contact is remarkably worn, replace the contacts of all phases even if the contact of only one phase is worn. If only the contact of one phase is replaced, a failure will occur because the thickness of the contact of one phase is difference from that of the other phase.

Periodical inspection item	Contents of inspection
	・ When the contact is blackened: Even if somewhat blackened, no trouble occurs; however, if the blackening is abnormal, there may be a problem about the atmosphere, so that investigation and countermeasures should be carried out. ・ Foreign matters adhered to the contact, such as dust, etc. should be wiped off with a cloth dipped in alcohol. Use of an organic solvent such as trichloroethylene may cause contact failure. ・ Check contact over travel. When over travel is little, replace the contacts.
7. Check of contacting face of electromagnet (When there is an abnormality referring to para. 5.)	・ Check when there is an abnormality such as beat, etc. ・ Check whether a foreign substance such as dust, etc. is adhered to the contacting face. When a foreign substance is adhered to the face, wipe it off with a cloth. ・ Check whether there is any rust. If it is found, remove it by rubbing with dry cloth. Use of sandpaper or file will result in producing beats.
8. Check of voltage applied to coil	・ Check whether the voltage is too high or too low. The voltage should be adjusted so that it attains the rated voltage after operation. Take care that the voltage when closing does not become less than 85% of the rated voltage. Unsuitable voltage of the operating coil will cause various troubles, so that special care should be taken to ensure suitable voltage .
9. Measurement of insulation resistance	・ Measure insulation resistance with the 500V insulation resistance meter, and if its measured value is less than 1MΩ, immediately replace with new one. If the insulation resistance is less than 5MΩ but more than 1MΩ, it can be temporarily used; however, replace as soon as possible.

6-2-2 Replacement of Contacts of Contactor

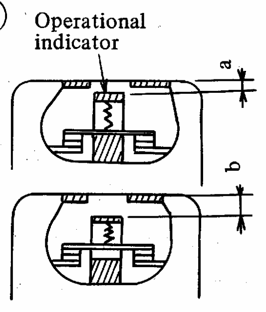
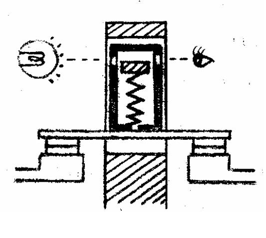
The electrical endurance of the contactor depends mainly upon the wear of the contacts and deteriorated insulation of arc suppressing chamber. Contacts wear is classified into the modes given in Table 33, according to which the conditions requiring contacts replacement are determined.

Table 33. Wear of contacts

Mode	Simple wear	Peeling wear	Transiting wear	Crack wear
				
Conditions of contacts replacement	General wear. When the contact over travel, thickness of moving contact or thickness of fixed contact become less than the allowable values given in Table 34, replace the contacts.	This wear takes place in applications including inching. When the contact area becomes less than 50% of the whole area, replace the contacts.	This wear is often found in DC application. When the area of a transiting part is less than 30% of the entire contact area, remove the transited projection, and the contact can be re-used.	This wear is found in case of large-capacity models over 100A frame. When the area of crack is more than 30% of the entire area, replace the contact.

Remark: The contact over travel is the amount of movement of the insulated crossbar from the beginning of contact of the moving and fixed contacts to the complete end of their contact.

Table 34. Allowable minimum over travel and allowable minimum thickness of contacts

Frame	Allowable min. over travel (mm)	Allowable min. thickness of contact (mm)		Measuring method of over travel
		Moving contact	Fixed contact	
H8C	0.5	0.6	0.6	Ⓐ  Measure the position of operational indicator at the front of contactor with slide calipers. Measure the position, a, of the operational indicator when contact is started by manual closing, and the position, b , of the operational indicator when the coil is excited, then find the over travel. Over travel = b - a
H10C,11,12 HS10	0.5	0.6	0.6	
H20,HS20	1	0.3	0.3	
H25,HS25	1	0.3	0.3	
H35,HS35	1	0.3	0.3	
H50,HS50	1	0.3	0.3	
H65C	1	0.5	0.5	
H80C	1	0.5	0.5	Ⓑ  After the power of main circuit is turned off, the coil is excited and contactor is closed, remove the cover and look at the hole on spring holder. ◒ ; Where the opposite side can be seen through hole, the amount of over travel is more than the allowable value and contactor can be used. ● ; Where the opposite side can not be seen through hole, the amount of over travel is less than allowable value, then replace the contacts.
H100C	1	0.5	0.5	
H125C	1	0.5	0.5	
H150C	1	0.5	0.5	
H200C	1	1	1	
H250C	1	1	1	
H300C	1	1	1	
H400C	1	1	1	
H600C	2	1.5	1.5	Measure the position of operational indicator of auxiliary contact assembly in the same manner as (A).

When it is necessary to replace the contact of one of three phases, the contacts of all phases should be replaced at the same time. Note that after replacement of contacts, the following items should be executed to check the products.

(1) Measure the insulation resistance between phases, and between the terminals of power source and load to confirm that the insulation resistance is more than 100MΩ.

(2) The closing voltage should be less than 85% of the rated voltage of coil.

6-2-3 Cautions in Handling

Items which should be avoided when handling the switch are as follows:

(1) The wire to be connected to the terminal should not be soldered.
The soldered wires become loosened with the passage of time and the contact will become imperfect, so that they should be absolutely avoided.

(2) Do not close the window of the arc suppressing chamber.
The breaking performance may be deteriorated.

(3) Do not mount on an area which is less than the dimensions of the specified minimum mounting space.
There are possibilities that temperature rise may increase and grounding or short circuit may take place at the time of breaking. (see page 37)

(4) Do not use the switch without an enclosure outdoors.
Mount the switch in a proper enclosure such as water-proof box, etc.

(5) Avoid mounting the switch at a place directly exposed to the rays of the sun, and at a hot place near a boiler, furnace, etc. Mounting of the switch at such places may cause troubles such as malfunction of thermal overload relay, burnt-out of operating coil and the like.

(6) The switch should be protected from direct splash of water drops or oil and dust. Place the switch in a water-proof, drip-proof and dust-proof box during use.

(7) Do not use the switch without an enclosure at a place where there is a concentration of corrosive gas, combustible gas, salt and the like.

(8) Do not mount the switch at a place subject to abnormal vibration or shock.

(9) Do not apply excessive tensile force to the lead wires or terminals of the operating circuit and the main circuit.

(10) With respect to the wire diameter and length of the operating circuit and the main circuit, their resistance values should be kept below such resistance values as may impair the performance of the operating coil. Imperfect closing of electromagnet will cause troubles.

(11) Closing and releasing coils of latched contactor are rated for a short time, so they should be connected to the protection circuit without fail, so that voltage is not continuously applied.

(12) Do not turn on and off the power source when the insulated cover is opened.
The insulated cover serves as a barrier between phases; therefore, if the power source is turned on or off while the insulated cover is opened, there is a possibility that a short circuit between phases may take place.

(13) Do not use the starter for protection against short circuit current.
The contactor and thermal overload relay can only withstand over-current of about 10 times the rated current. Usually, the short circuit current is 10 to 100 times the rated current, so that the contact is melted and the heaters of the thermal overload relay are fused by Joule heat. For protection against short circuit, FFB or fuse are used.

(14) After an accident current flows, do not use the switch without checking.

Investigate the cause of accident to remedy it, and also confirm that the equipment is free from damage ; then, use the switch again. When a short circuit current flows, it is necessary to pay attention to the melting of contact of the contactor, wire-breaking of the heater and change of tripping characteristic of thermal overload relay.

(15) When connecting a power condenser, do not connect it to the primary side of the starter.

The power condenser is connected to the secondary side of the starter or the terminals of the motor. Where the power condenser is connected to the primary side of the starter and the circuit is phase failure due to one phase fusing, a roundabout circuit is made up passing the power condenser and a voltage of about 50 to 60% of the power source voltage is applied to the coil; this causes flapping of the contactor.

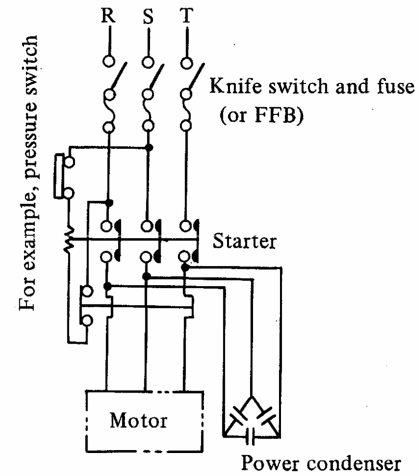


Fig. 43 Correct insertion of power condenser

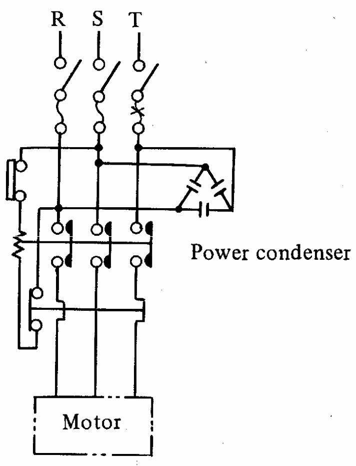


Fig. 44 Incorrect insertion of power condenser

(16) Do not remove the cover of thermal overload relay, or touch its internal mechanism.

As the thermal overload relay is strictly adjusted at the factory, be sure not to touch the internal mechanism.

(17) Do not set the current of thermal overload relay at a point higher than needed.

Even in case of motors with the same capacity (kW), the load current varies with the number of poles and types, so that it is necessary to set correctly the adjusting knob to the motor current.

Do not raise the set value to prevent occasional operation. Since the occurrence of operation must be due to some cause, first, investigate the cause and remedy it. Otherwise, there is a possibility that a major trouble may take place.

(18) The thermal overload relay should not be reset when the power is left on.

It is necessary to reset the thermal overload relay after turning off the power source for safety. Resetting must be made after the cause of trip is eliminated.

(19) For the wiring to the thermal overload relay, a wire with an appropriate diameter should be used.

If the wire is fine, the operating time becomes fast and if it is thick, the operating time, slow.

(20) Do not mount the starter and contactor upside down, or horizontally.

Firmly mount the starter and contactor to avoid operating failure or lowered breaking capacity. (see page 36)

(21) If the contactor closes in a flapping manner (a state where the contactor is not perfectly closed, but vibrates greatly during closing), do not use the contactor continuously.

This will cause melting of contact, release failure, and other troubles. Investigate their causes and eliminate this erroneous closing.

(22) Do not remove unnecessary contacts.

Their removal may result in a loss of balance of the mechanism and have an adverse effect on the performance of the contactor. (Be sure to fully tighten the terminal screws.)

6-2-4 Trouble Diagnosis

Table 35. Trouble diagnosis

Mutual relation / Phenomenon \ Cause of trouble	Power source: Melting of power source fuse	Power source: Drop of power source voltage.	Power source: Power source voltage is too high.	Power source: Operation of fuse-free breaker	Contactor: Failure of sliding (moving) part	Contactor: Melting of contact	Contactor: Adherence of tacky substances to the contacting face of iron core	Contactor: Wear of the contacting face of iron core	Contactor: Damage of return spring	Contactor: Defective contact Spring	Contactor: Dust or rust on the contacting face of iron core	Contactor: Difective shading coil	Contactor: Wire-breaking of coil	Contactor: Rare short of coil	Contactor: Adherence of oil to contact
Contactor does not close.	■	■		■	■								■	■	
It can close, but cannot self-hold.		■												■	
Contactor does not open and close.					■	■	■	■	■						
Beats are produced.		■			■						■	■		■	
Burn-out of coil			■		■									■	
Melting of contact		■	■							■					
Abnormal wear of contact			■												■
Short circuit between phases.															
Thermal overload relay easily operates.		■													
Thermal overload relay does not operate.															
Fusing of thermal overload relay heater.															
Contactor closes, but motor does not rotate.	■	■													
Overheat of contact															■
Countermeasures	There is a case of phase failure. Investigate the cause and replace the fuse with one with a correct capacity.	Investigate the capacity of power source, tap voltage and thickness and length of wire. Consult with power company, our company's agent, sales store, and service station about the troubles.		Investigate the cause, remove it and again turn on power.	Disassemble the contactor, remove foreign sub-stances, or replace defective parts.	Replace parts around the contact. (fixed, moving contacts and contact spring)	Clean the contacting face of iron core with cloth.	The mechanical endurance has reached its limit. Replace iron core.	Replace parts. (return spring)	Replace parts. (contact spring)	Place the starter in dust-proof or anti-corrosion box. Clean the contacting face of iron core with cloth.	Replace parts. (fixed and moving iron cores)	Replace parts. (coil)	Replace parts. (coil)	Clean it with cloth.

How to read this Table:
Read the Table from the phenomenon column at the left end toward the right, and select the causes from the black portion, then find the counter-measures from the counter-measures column below the black portions.

Reset it.														Thermal overload relay operates.	Thermal overload relay
Set the current value with load current, or replace thermal overload relay.														Miss-selection of thermal overload relay current	
Replace thermal overload relay, and moreover, use protective box suitable for environment.														Corrosion of heater due to oxidation	
Replace thermal overload relay.														Operating failure of thermal overload relay	
Remove the cause and replace thermal overload relay. Thermal overload relay dose not protect large current like short circuit.														Fusing of heater	
Check the circuit and match it with connection diagram. Concurrently, check grounding and dis-connection of circuit, or tightening of connection terminals.														Wiring failure of operating circuit	Others
Connect it to motor terminals or load terminals of starter. (see page 47)														Installing method of power condenser	
Repair or replace the operating switch. (push-button switch, float-free switch, limit switch, etc.)														Bounce of operating switch	
Check the limit switch, pressure switch, etc.														Operating and contact failure of operating switch	
Replace parts. (coil)														Miss-application of operating circuit voltage	
Correctly mount it to the vertical face (see page 36)														Error in mounting condition	
Select the suitable starter.														Miss-selection of capacity	
Re-examine the application. In case of plugging and inching, it is necessary to limit the rated capacity.														Operating (open/close) frequency is too high.	
Use one with protective structure suitable for environment.														Miss-selection of protective structure from dust or gas.	
Remove the cause and provide a reliable, protective device against short circuit.														Short circuit or grounding of the load side	
Change it to a correct wiring.														Miss-connection for reversible type	
Replace coil or change the connection of wire for coil tap.														Miss-connection of wire for coil tap	
Change to thermal overload relay with saturation reactor; there is another method to use timer. (see page 31)														The starting time of load is long.	
Examine and change the mounting method and place of starter.														Vibration and shock are great.	
Check the circuit and match it with the connection diagram. At the same time, check the grounding and disconnection of circuit and tightening of connection terminals.														Wiring failure	
Consult with our company's agent, sales store and service station about the troubles, and change the installation place of thermal overload relay or replace it with one with appropriate characteristics.														Ambient temperature is too high.	
														Ambient temperature is too low .	
Taking into consideration the sequence of overload → operation of thermal overload relay → incapability of closing, investigate the cause and remove it, then reset the relay.														Overload of machine	
Eliminate the cause and install a protective device against short circuit, for instance, fuse-free breaker and the like.														short circuit trouble of wiring	

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