MITSUBISHI

MAGNETIC MOTOR STARTERS
AND MAGNETIC CONTACTORS

TECHNICAL NOTES

MS-N Series

MAGNETIC STARTERS,
CONTACTORS AND RELAYS

INSTRUCTION MANUAL

MS-N Series
SR-N Series
SD-M Series

CONTENTS

Kinds and Ratings of Magnetic Motor Starters and Contactors

1. Kinds and Ratings

Type MS-N magnetic motor starter consists of a type S-N magnetic contactor, type TH-N thermal overload relay and an outer case. Type MSO-N magnetic motor starters are also available as a unit for power distributor panels and control panels.

Table 1 Constitutional elements of type MS-N magnetic motor starter

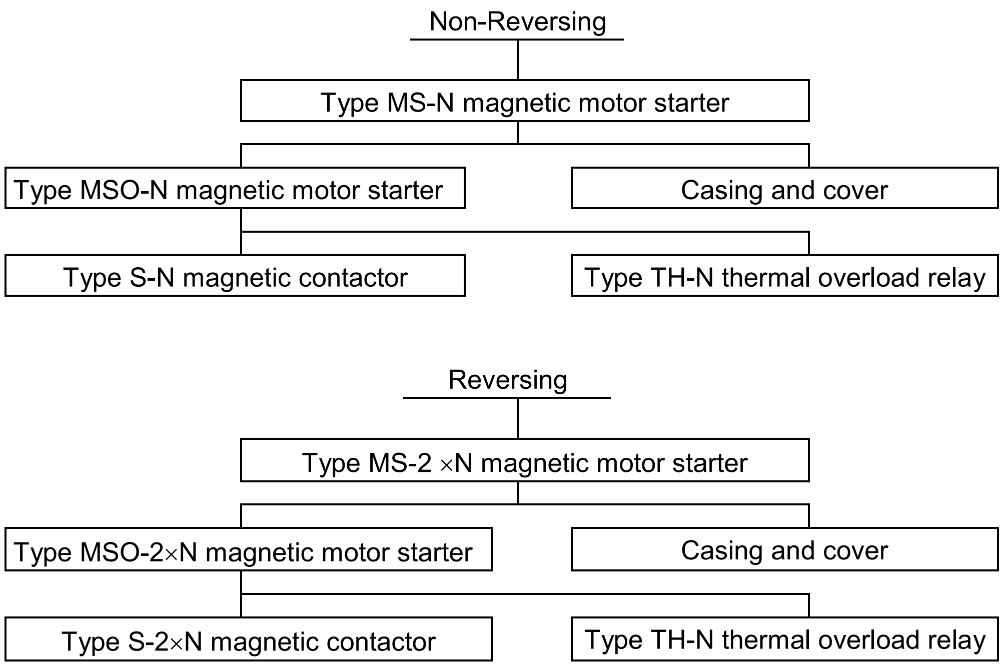


Table 2 Kinds and configuration of type MS-N and MSO-N magnetic motor starters

Type	MS-, with enclosure	Non-Reversing	N10	N11	N12	–	N20	N21	N25	N35	N50	N65	N80	N95	N125	N150	N180	N220	N300	N400	–	–
		Reversing	–	–	–	–	2 × N20	2 × N21	2 × N25	2 × N35	2 × N50	2 × N65	2 × N80	2 × N95	2 × N125	2 × N150	2 × N180	2 × N220	2 × N300	2 × N400	–	–
	MSO-, with-out enclosure	Non-Reversing	N10	N11	N12	N18	N20	N21	N25	N35	N50	N65	N80	N95	N125	N150	N180	N220	N300	N400	–	–
		Reversing	2 × N10	2 × N11	–	2 × N18	2 × N20	2 × N21	2 × N25	2 × N35	2 × N50	2 × N65	2 × N80	2 × N95	2 × N125	2 × N150	2 × N180	2 × N220	2 × N300	2 × N400	–	–
Constituent elements	S- magnetic contactor	Non-Reversing	N10	N11	N12	N18	N20	N21	N25	N35	N50	N65	N80	N95	N125	N150	N180	N220	N300	N400	N600	N800
		Reversing	2 × N10	2 × N11	–	2 × N18	2 × N20	2 × N21	2 × N25	2 × N35	2 × N50	2 × N65	2 × N80	2 × N95	2 × N125	2 × N150	2 × N180	2 × N220	2 × N300	2 × N400	2 × N600	2 × N800
	TH- thermal overload relay		N12	N12	N12	N18	N20	N20	N20 N20 TA	N20 N20 TA	N60	N60	N60 N60 TA	N60 N60 TA	N120 N120 TA	N120 N120 TA	N220 RH	N220 RH	N400 RH	N400 RH	N600	N600

Table 3 Rated capacity

Application / Frame size	Motor load (kW)												Resistance load (kW)	
	Rated capacity category AC-3 and AC-2								Rated capacity category AC-4 [∗1]				Rated capacity Category AC-1	
	3-phase squirrel-cage type (AC-3)				3-phase slip-ring type (AC-2)				3-phase squirrel-cage type		3-phase slip-ring type		3-phase resistance	
	200~240V	380~440V	500V	690V	200~240V	380~440V	500V	690V	200~240V	380~500V	200~240V	380~500V	200~240V	380~440V
N10	2.5	4	4	4.0	2.5	4	4	4.0	1.5	2.2 [∗2]	1.5	2.2 [∗2]	7.5	7
N11, N12	3.5	5.5	5.5	5.5	3.5	5.5	5.5	5.5	2.2	4 [∗3]	2.2	4 [∗3]	7.5	8.5
N18	4.5	7.5	7.5	7.5	4.5	7.5	7.5	7.5	3.7	4 [∗3]	3.7	4 [∗3]	9.5	13
N20, N21	5.5	11	11	7.5	5.5	11	11	7.5	3.7	5.5	3.7	5.5	12	20
N25	7.5	15	15	11	7.5	15	15	11	4.5	7.5	4.5	7.5	18	30
N35	11	18.5	18.5	15	11	18.5	18.5	15	5.5	11	5.5	11	20	35
N50	15	22	22	22	15	22	22	22	7.5	15	7.5	15	30	50
N65	18.5	30	30	30	18.5	30	30	30	11	22	11	22	35	65
N80	22	45	45	45	22	45	45	45	15	30	15	30	50	85
N95	30	55	55	55	30	55	55	55	19	37	19	37	55	90
N125	37	60	60	60	37	60	60	60	22	45	22	45	55	90
N150	45	75	90	90	45	75	90	90	30	55	30	55	75	130
N180	55	90	110	110	55	90	110	110	37	75	37	75	95	170
N220	75	132	132	132	75	132	132	132	45	90	45	90	95	170
N300	90	160	160	200	90	160	160	200	55	110	55	110	130	230
N400	125	220	225	250	125	220	225	250	75	150	75	150	170	290
N600	190	330	330	330	190	330	330	330	110	200	110	200	280	430
N800	220	440	500	500	220	440	500	500	160	300	160	300	300	530

Notes: ∗1, Category AC-4 electrical endurance is 30,000 operations. (N35 to N800: 15,000 operations at 380VAC or more)
∗2, 500V 2.7kW ∗3, 500V 5.5kW

Table 4 Rated operational current

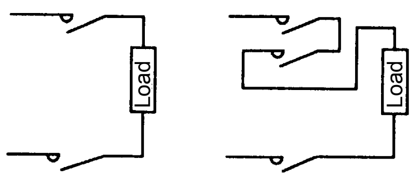
Application / Frame size	Motor load							Resistance load		Rated Continuous current Ith (A)
	Category AC-3 and AC-4 (A)				Category AC-4 (A) [∗1]			Category AC-1 (A)		
	200~240V	380~440V	500V	690V	200~240V	380~440V	500V	200~240V	380~440V	
N10	11	9	7	5	8	6	6	20	11	20
N11, N12	13	12	9	7	11	9	9	20	13	20
N18	18	16	13	9	18	9	9	25	20	25
N20, N21	22	22	17	9	18	13	10	32	32	32
N25	30	30	24	12	20	17	12	50	50	50
N35	40	40	32	17	26	24	17	60	60	60
N50	55	50	38	26	35	32	24	80	80	80
N65	65	65	60	38	50	47	38	100	100	100
N80	85	85	75	52	65	62	45	135	135	135
N95	105	105	85	65	80	75	55	150	150	150
N125	125	120	90	70	93	90	65	150	150	150
N150	150	150	140	100	125	110	80	200	200	200
N180	180	180	180	120	150	150	140	260	260	260
N220	250	250	200	150	180	180	140	260	260	260
N300	300	300	250	220	220	220	200	350	350	350
N400	400	400	350	300	300	300	250	450	450	450
N600	630	630	500	420	400	400	350	660	660	800 ∗1
N800	800	800	720	630	630	630	500	800	800	1000 ∗2

Notes: ∗1, Category AC-4 electrical endurance is 30,000 operations. (N35 to N800: 15,000 operations at 380VAC or more)
∗2, 660A at ambient temperature 40 to 55°C ∗3, 800A at ambient temperature 40 to 55°C

Table 5 DC rated working current

Frame size	Rated voltage DC (V)	Category DC-3 and DC-5 (DC motor load) (A)		Category DC-1 (resistance load) (A)		Category DC-13 (DC electromagnet load) (A)		
		2-pole series	3-pole series	2-pole series	3-pole series	Single pole	2-pole series	3-pole series
N10	24	8	8	10	10	5	8	8
	48	4	6	10	10	3	4	6
	110	2.5	4	6	8	0.6	2	3
	220	0.8	2	3	8	0.1	0.3	0.8
N11 N12 N18	24	12	12	12	12	7	12	12
	48	6	10	12	12	5	6	10
	110	4	8	10	12	1.2	3	5
	220	1.2	4	7	12	0.2	0.5	2
N20·N21	24	20	20	20	20	12	20	20
	48	15	20	20	20	8	12	15
	110	8	15	15	20	1.5	3	10
	220	2	8	10	20	0.25	1.2	4
N25 (N35)	24	25 (35)	25 (35)	25 (35)	25 (35)	15	25 (35)	25 (35)
	48	20	25 (30)	25 (35)	25 (35)	10	15	25
	110	10	20	25	25 (35)	1.5	4	12
	220	3	10	12	22 (30)	0.25	1.2	4
N50 (N65)	24	45	50	50	50 (65)			
	48	25	35 (40)	40	50 (65)			
	110	15	30 (35)	35	50 (65)			
	220	3.5	12 (15)	15	40 (50)			
N80	24	65	80	80	80			
	48	40	60	65	80			
	110	20	50	50	80			
	220	5	20	20	60			
N95	24	93	93	93	93			
	48	60	90	93	93			
	110	40	80	80	93			
	220	30	50	50	70			
N125	24	120	120	120	120			
	48	60	90	100	120			
	110	40	80	80	100			
	220	30	50	50	80			
N150	24	150	150	150	150			
	48	100	130	120	150			
	110	80	120	100	150			
	220	60	80	100	150			
N180 (N220)	24	180 (220)	180 (220)	180 (220)	180 (220)			
	48	150	180 (220)	180	180 (220)			
	110	120	150	150	180 (220)			
	220	80	100	150	180 (220)			
N300 (N400)	24	300 (400)	300 (400)	300 (400)	300 (400)			
	48	200	280	240	300 (400)			
	110	150	200	200	300 (400)			
	220	90	150	200	300			
N600 (N800)	24	630 (800)	630 (800)	630 (800)	630 (800)			
	48	630	630	630 (800)	630 (800)			
	110	630	630	630	630 (800)			
	220	630	630	630	630 (800)			

Notes:
1. The class designations are according to IEC where category DC-3 is applied to starting and stopping DC shunt motors, Category DC-5 to starting and stopping DC series motors and category DC-1 to opening and closing resistance loads.
2. Ctegory DC-13 is a class designation according to IEC where it is applied to DC induction loads (control of DC electromagnets).
3. The electrical endurance is 500,000 times.
4. Making current for category DC-3 and DC-5 are 4 times the capacities listed in the table above and 100 times of operation, respectively. Breaking current for category DC-3 and DC-5 are 4 times the capacities listed in the table above and 25 times of operation.
5. The connections of two-pole series and 3-pole series are as shown in the figures on the right.



2-pole series **3-pole series**

Characteristics and Performance
(Type test results)

1. Structure

1.1 Structure in general

The structure passes IEC 60947-4-1 (1990).

1.2 Insulation distance

Criteria (specification values) mm

Category	Specification and category	Space distance		Creeping distance		Applicable types
		Between live portion	Between ground	Between live portion	Between ground	
A	∗1 JEM 660V 63A or larger	8	10	10	10	MS, MSO, S-N50 - N800 TH-N60 - N400RH
	∗2, ∗3 IEC · EN 690V 63A or larger	8	10	10	10	
	∗4, ∗5 UL · CSA 600V	9.5	9.5	12.7	12.7	
B	JEM 660V 63A or less	6	8	8	8	MS, MSO, S-N10 - N35 TH-N12 - N20 (TA) TH-N600
	IEC · EN 690V 63A or less	6	8	8	8	
	UL · CSA 600V	9.5	9.5	12.7	12.7	

Note: ∗1: JEM 1103 (1996) ∗2: IEC 60947-4-1 (1990)
∗3: EN 60947-4-1 (1992) ∗4: UL 508 (1993)
∗5: CSA 22.2 No.14-95 (1995)

All the types pass the requirements as they mark the values greater than the specifications listed above.

2. Temperature Rise

Ambient temperature at 40°C

Model name		Test conditions					Temperature rise (°C [K])			
		Thermal overload relay Heater nominal size /setting (A)	Connecting wire size (mm^2)	Main circuit current (A)	Coil voltage (V)	Coil frequency (Hz)	Coil	Contact	Line terminal	Load terminal
Standard values		–	–	–	–	–	100∗	∗∗	65	65
Magnetic motor starter with enclosure	MS-N10	9/11	2	11	200	50	68	62	35	42
	MS-N11	11/13	2	13	200	50	76	71	40	50
	MS-N12	11/13	2	13	200	50	76	71	40	50
	MS-N20	15/18	2	18	200	50	72	54	42	50
	MS-N21	15/18	2	18	200	50	72	54	42	50
	MS-N25	22/26	5.5	26	200	50	69	62	44	49
	MS-N35	29/34	8	34	200	50	73	71	57	55
	MS-N50	42/50	14	50	240	60	68	60	45	46
	MS-N65	54/65	22	65	240	60	70	65	50	53
	MS-N80	67/80	22	80	240	60	54	53	36	35
	MS-N95	82/100	38	100	240	60	62	80	58	58
	MS-N125	105/125	60	125	240	60	62	85	48	49
	MS-N150	125/150	60	150	240	60	65	87	58	59
	MS-N180	150/180	100	180	240	60	68	65	41	31
	MS-N220	180/220	150	220	240	60	68	69	43	33
	MS-N300	250/300	200	300	240	60	67	66	40	34
	MS-N400	300/400	150 × 2	400	240	60	71	70	45	38
Magnetic motor starter without enclosure	MSO-N10	9/11	2	11	200	50	60	53	31	39
	MSO-N11	11/13	2	13	200	50	64	58	35	42
	MSO-N12	11/13	2	13	200	50	64	58	35	42
	MSO-N18	15/18	3.5	18	200	50	60	27	28	42
	MSO-N20	15/18	3.5	18	200	50	66	40	37	42
	MSO-N21	15/18	3.5	18	200	50	66	40	37	42
	MSO-N25	22/26	5.5	26	200	50	57	48	37	43
	MSO-N35	29/34	8	34	200	50	60	57	49	49
	MSO-N50	42/50	14	50	240	60	55	50	34	43
	MSO-N65	54/65	22	65	240	60	57	60	39	49
	MSO-N80	67/80	22	80	240	60	45	50	33	32
	MSO-N95	82/100	38	100	240	60	51	70	43	56
	MSO-N125	105/125	60	125	240	60	54	75	40	45
	MSO-N150	125/150	60	150	240	60	56	78	52	54
	MSO-N180	150/180	100	180	240	60	53	60	30	24
	MSO-N220	180/220	150	220	240	60	53	60	31	26
	MSO-N300	250/300	200	300	240	60	58	56	31	28
	MSO-N400	300/400	150 × 2	400	240	60	64	66	37	33
Magnetic contactor with enclosure	S-N10CZ	–	3.5	20	200	50	58	63	44	42
	S-N11CZ	–	3.5	20	200	50	58	63	44	42
	S-N12CZ	–	3.5	20	200	50	58	63	44	42
	S-N18	–	3.5	25	200	50	58	29	26	26
	S-N20CZ	–	5.5	32	200	50	61	44	38	36
	S-N21CZ	–	5.5	32	200	50	61	44	38	36
	S-N25CZ	–	14	50	200	50	68	49	42	40
	S-N35CZ	–	14	60	200	50	70	57	51	49
	S-N50CZ	–	22	80	240	60	63	56	42	40
	S-N65CZ	–	38	100	240	60	65	65	46	45
	S-N80CZ	–	60	135	240	60	48	78	48	46
	S-N95CZ	–	60	150	240	60	56	96	59	57
	S-N125CZ	–	60	150	240	60	55	79	54	52
	S-N150CZ	–	100	200	240	60	55	80	54	52
	S-N180CZ	–	150	260	240	60	64	76	49	47
	S-N220CZ	–	150	260	240	60	64	76	49	47
	S-N300CZ	–	250	350	240	60	68	72	50	48
	S-N400CZ	–	150 × 2	450	240	60	71	80	56	53
	S-N600	–	50 × 5 copper flat bar × 2	800	240	60	68	59	44	42
	S-N800	–	60 × 5 copper flat bar × 2	1000	240	60	70	62	45	44

Notes: 1. Nominal rating of the coil: AC200V.
2. ∗ Indicates IEC 60947-4-1 class E insulation.
3. ∗∗ Up to a temperature not harmful to items around (approximately 100°C [K]).
4. Type S-N☐CZ is what type S-N☐ housed in a box.

3. Operation

3.1 Operating voltage and operating time

The operating voltages when the temperature is stabilized in the temperature test in section 2 are 170 V or less for all the frames. (This is referred to as "hot characteristics at 40°C".) The table below shows the operating characteristics at 25°C (or 25°C cold characteristics).

Nominal ratings of the coil: AC200V

Model name	Frequency (Hz)	Pick-up voltage (V)	Drop-out voltage (V)	Operating time (ms)					
				Coil ON →			Coil OFF →		
				Auxiliary b contact OFF	Auxiliary a contact ON	Main contact ON	Main contact OFF	Auxiliary a contact OFF	Auxiliary b contact ON
S-N10 (with 1NO)	50	103 ~ 111	80 ~ 102	–	11 ~ 17	11 ~ 17	7 ~ 14	7 ~ 14	–
	60	113 ~ 120	86 ~ 106	–	13 ~ 17	12 ~ 18	7 ~ 14	7 ~ 14	–
S-N11 (with 1NO)	50	103 ~ 111	80 ~ 102	–	11 ~ 17	11 ~ 17	7 ~ 14	7 ~ 14	–
	60	113 ~ 120	86 ~ 106	–	13 ~ 17	12 ~ 18	7 ~ 14	7 ~ 14	–
S-N12 (with 1NO +1NC)	50	118 ~ 130	91 ~ 101	7 ~ 14	13 ~ 18	12 ~ 18	7 ~ 16	6 ~ 15	14 ~ 21
	60	130 ~ 142	96 ~ 106	7 ~ 13	13 ~ 18	13 ~ 18	7 ~ 15	7 ~ 13	13 ~ 20
S-N18	50	112 ~ 128	85 ~ 114	–	–	8 ~ 17	7 ~ 16	–	–
	60	124 ~ 137	100 ~ 125	–	–	8 ~ 16	6 ~ 16	–	–
S-N20	50	125 ~ 136	88 ~ 99	8 ~ 13	12 ~ 18	12 ~ 17	8 ~ 16	7 ~ 15	16 ~ 25
	60	135 ~ 144	95 ~ 110	7 ~ 13	13 ~ 19	12 ~ 18	6 ~ 13	6 ~ 12	14 ~ 23
S-N21	50	120 ~ 126	90 ~ 104	7 ~ 13	11 ~ 16	10 ~ 16	7 ~ 17	7 ~ 17	15 ~ 25
	60	129 ~ 135	100 ~ 114	8 ~ 13	13 ~ 18	12 ~ 16	8 ~ 14	8 ~ 14	15 ~ 24
S-N25	50	115 ~ 130	90 ~ 105	7 ~ 13	10 ~ 19	10 ~ 19	5 ~ 14	5 ~ 14	11 ~ 23
	60	127 ~ 143	95 ~ 115	8 ~ 14	11 ~ 20	11 ~ 20	5 ~ 14	5 ~ 14	11 ~ 23
S-N35	50	115 ~ 130	90 ~ 105	7 ~ 13	10 ~ 19	10 ~ 19	5 ~ 14	5 ~ 14	11 ~ 23
	60	127 ~ 143	95 ~ 115	8 ~ 14	11 ~ 20	11 ~ 20	5 ~ 14	5 ~ 14	11 ~ 23
S-N50	50	115 ~ 125	55 ~ 75	13 ~ 23	16 ~ 26	15 ~ 25	35 ~ 60	34 ~ 59	36 ~ 61
	60	115 ~ 125	45 ~ 65	11 ~ 22	14 ~ 24	13 ~ 24	40 ~ 65	39 ~ 64	41 ~ 66
S-N65	50	115 ~ 125	55 ~ 75	13 ~ 23	16 ~ 26	15 ~ 25	35 ~ 60	34 ~ 59	36 ~ 61
	60	115 ~ 125	45 ~ 65	11 ~ 22	14 ~ 24	13 ~ 24	40 ~ 65	39 ~ 64	41 ~ 66
S-N80	50	110 ~ 130	80 ~ 105	22 ~ 32	27 ~ 37	26 ~ 36	37 ~ 87	37 ~ 87	39 ~ 89
	60	110 ~ 130	75 ~ 100	18 ~ 28	22 ~ 32	22 ~ 32	48 ~ 98	46 ~ 96	50 ~ 100
S-N95	50	110 ~ 130	80 ~ 105	22 ~ 32	27 ~ 37	26 ~ 36	37 ~ 87	37 ~ 87	39 ~ 89
	60	110 ~ 130	75 ~ 100	18 ~ 28	22 ~ 32	22 ~ 32	48 ~ 98	46 ~ 96	50 ~ 100
S-N125	50	110 ~ 135	90 ~ 120	18 ~ 28	21 ~ 31	22 ~ 32	48 ~ 98	49 ~ 99	51 ~ 101
	60	110 ~ 135	70 ~ 105	16 ~ 26	19 ~ 29	20 ~ 30	56 ~ 106	57 ~ 107	59 ~ 109
S-N150	50	115 ~ 140	95 ~ 125	20 ~ 28	25 ~ 35	26 ~ 36	44 ~ 94	45 ~ 95	49 ~ 99
	60	115 ~ 140	75 ~ 100	18 ~ 28	23 ~ 33	24 ~ 34	51 ~ 101	53 ~ 103	57 ~ 107
S-N180	50	120 ~ 125	87 ~ 102	21 ~ 31	26 ~ 36	25 ~ 35	75 ~ 92	73 ~ 90	78 ~ 95
	60	124 ~ 131	71 ~ 90	20 ~ 31	25 ~ 36	25 ~ 35	85 ~ 102	84 ~ 101	89 ~ 106
S-N220	50	120 ~ 125	87 ~ 102	21 ~ 31	26 ~ 36	25 ~ 35	75 ~ 92	73 ~ 90	78 ~ 95
	60	124 ~ 131	71 ~ 90	20 ~ 31	25 ~ 36	25 ~ 35	85 ~ 102	84 ~ 101	89 ~ 106
S-N300	50	111 ~ 130	80 ~ 125	30 ~ 40	37 ~ 47	35 ~ 45	112 ~ 132	109 ~ 129	114 ~ 134
	60	111 ~ 130	70 ~ 104	30 ~ 40	36 ~ 46	35 ~ 45	121 ~ 151	119 ~ 149	130 ~ 150
S-N400	50	111 ~ 130	80 ~ 125	30 ~ 40	37 ~ 47	35 ~ 45	112 ~ 132	109 ~ 129	114 ~ 134
	60	111 ~ 130	70 ~ 104	30 ~ 40	36 ~ 46	35 ~ 45	121 ~ 151	119 ~ 149	130 ~ 150
S-N600	50	108 ~ 130	75 ~ 106	42 ~ 71	49 ~ 78	51 ~ 80	48 ~ 84	49 ~ 85	52 ~ 88
	60	108 ~ 130	60 ~ 90	42 ~ 71	49 ~ 78	51 ~ 80	57 ~ 93	58 ~ 94	61 ~ 97
S-N800	50	108 ~ 130	75 ~ 106	42 ~ 71	49 ~ 78	51 ~ 80	48 ~ 84	49 ~ 85	52 ~ 88
	60	108 ~ 130	60 ~ 90	42 ~ 71	49 ~ 78	51 ~ 80	57 ~ 93	58 ~ 94	61 ~ 97

Notes: 1. Approximate pick-up voltages and drop-out voltages for coil ratings other than AC200V can be calculated by multiplying the values in the table above by the ratio of that particular voltage to AC200V.
2. Operating times for coil ratings other than AC200V are approximately the same as the values listed in the table above.

3.2 Operating coil characteristics

Model name	Coil rating		Characteristics			Inrush VA	Impedance (sealed)		
	Voltage (V)	Frequency (Hz)	Coil sealed current (mA)	Sealed VA	Sealed watts		DC resistance (Ω)	Effective resistance (Ω)	Reactance (Ω)
S-N10 S-N11	100 110	50 60	98 ~ 106 90 ~ 96	9.8 ~ 10.6 9.9 ~ 10.6	3.2 ~ 3.4 3.5 ~ 3.7	51 ~ 64 58 ~ 69	117	320 420	970 1200
S-N12	100 110	50 60	98 ~ 106 90 ~ 96	9.8 ~ 10.6 9.9 ~ 10.6	3.2 ~ 3.4 3.5 ~ 3.7	51 ~ 64 58 ~ 69	117	320 420	970 1200
S-N18	100 110	50 60	98 ~ 106 90 ~ 96	9.8 ~ 10.6 9.9 ~ 10.6	3.2 ~ 3.4 3.5 ~ 3.7	51 ~ 64 58 ~ 69	117	320 420	970 1200
S-N20	100 110	50 60	136 ~ 142 120 ~ 126	13.6 ~ 14.2 12.1 ~ 12.6	4.2 ~ 4.4 4.4 ~ 4.5	80 ~ 93 85 ~ 99	71	230 300	720 890
S-N21	100 110	50 60	136 ~ 142 120 ~ 126	13.6 ~ 14.2 12.1 ~ 12.6	4.2 ~ 4.4 4.4 ~ 4.5	80 ~ 93 85 ~ 99	71	230 300	720 890
S-N25 S-N35	100 110	50 60	114 ~ 144 102 ~ 134	11.4 ~ 14.4 11.2 ~ 14.7	3.5 ~ 4.4 3.7 ~ 4.6	100 ~ 113 105 ~ 119	62	240 300	840 930
S-N50 S-N65	100 110	50 60	86 ~ 104 116 ~ 130	8.6 ~ 10.4 12.8 ~ 14.3	1.2 ~ 1.8 1.7 ~ 2.3	100 ~ 120 100 ~ 120	69	170 140	1000 900
S-N80 S-N95	100 110	50 60	118 ~ 134 157 ~ 173	11.8 ~ 13.4 17.3 ~ 19.0	1.6 ~ 2.2 2.5 ~ 3.1	140 ~ 180 180 ~ 210	42	115 100	790 660
S-N125	100 110	50 60	210 ~ 230 157 ~ 177	15.8 ~ 17.8 23.4 ~ 25.3	2.0 ~ 2.6 3.0 ~ 3.7	200 ~ 240 230 ~ 270	34	90 75	600 500
S-N150	100 110	50 60	210 ~ 230 157 ~ 177	15.8 ~ 17.8 23.4 ~ 25.3	2.0 ~ 2.6 3.0 ~ 3.7	210 ~ 250 240 ~ 280	34	90 75	600 500
S-N180 S-N220	100 110	50 60	218 ~ 242 290 ~ 316	21.0 ~ 25.0 32.0 ~ 36.0	2.8 ~ 3.1 4.7 ~ 5.1	435 ~ 490 520 ~ 585	22.5	60 50	440 370
S-N300 S-N400	100 110	50 60	285 ~ 310 380 ~ 405	29.0 ~ 31.0 40.0 ~ 46.0	3.6 ~ 3.9 5.7 ~ 6.7	415 ~ 480 510 ~ 555	19.5	55 45	340 280
S-N600 S-N800	100 110	50 60	430 ~ 510 590 ~ 660	43.0 ~ 51.0 65.0 ~ 72.0	8.0 ~ 10.5 12.5 ~ 14.5	500 ~ 700 600 ~ 800	11.0	40 35	210 180
S-N10 S-N11	200 220	50 60	49 ~ 53 45 ~ 48	9.8 ~ 10.6 9.9 ~ 10.6	3.2 ~ 3.4 3.5 ~ 3.7	51 ~ 64 58 ~ 69	453	1270 1710	3900 4700
S-N12	200 220	50 60	49 ~ 53 45 ~ 48	9.8 ~ 10.6 9.9 ~ 10.6	3.2 ~ 3.4 3.5 ~ 3.7	51 ~ 64 58 ~ 69	453	1270 1710	3900 4700
S-N18	200 220	50 60	49 ~ 53 45 ~ 48	9.8 ~ 10.6 9.9 ~ 10.6	3.2 ~ 3.4 3.5 ~ 3.7	51 ~ 64 58 ~ 69	453	1270 1710	3900 4700
S-N20	200 220	50 60	68 ~ 71 60 ~ 63	13.6 ~ 14.2 12.1 ~ 12.6	4.2 ~ 4.4 4.4 ~ 4.5	80 ~ 93 85 ~ 99	293	910 1200	2900 3600
S-N21	200 220	50 60	68 ~ 71 60 ~ 63	13.6 ~ 14.2 12.1 ~ 12.6	4.2 ~ 4.4 4.4 ~ 4.5	80 ~ 93 85 ~ 99	293	910 1200	2900 3600
S-N25 S-N35	200 220	50 60	57 ~ 72 51 ~ 67	11.4 ~ 14.4 11.2 ~ 14.7	3.5 ~ 4.4 3.7 ~ 4.6	100 ~ 113 105 ~ 119	249	980 1210	3100 3700
S-N50 S-N65	200 220	50 60	43 ~ 52 58 ~ 65	8.6 ~ 10.4 12.8 ~ 14.3	1.2 ~ 1.8 1.7 ~ 2.3	100 ~ 120 100 ~ 120	327	680 540	4200 3600
S-N80 S-N95	200 220	50 60	60 ~ 70 80 ~ 90	12.0 ~ 14.0 17.6 ~ 19.8	1.5 ~ 2.1 2.4 ~ 3.0	140 ~ 180 180 ~ 210	210	430 370	3000 2600
S-N125	200 220	50 60	72 ~ 82 96 ~ 106	14.4 ~ 16.4 21.2 ~ 23.3	1.6 ~ 2.2 2.6 ~ 3.2	200 ~ 240 230 ~ 270	159	360 300	2600 2200
S-N150	200 220	50 60	72 ~ 82 96 ~ 106	14.4 ~ 16.4 21.2 ~ 23.3	1.6 ~ 2.2 2.6 ~ 3.2	210 ~ 250 240 ~ 280	159	360 300	2600 2200
S-N180 S-N220	200 220	50 60	126 ~ 131 167 ~ 174	24.0 ~ 27.0 36.0 ~ 40.0	2.6 ~ 2.9 4.4 ~ 4.8	435 ~ 490 520 ~ 585	78	180 150	1600 1300
S-N300 S-N400	200 220	50 60	155 ~ 162 205 ~ 213	31.0 ~ 33.0 44.0 ~ 48.0	3.4 ~ 3.7 5.4 ~ 6.4	415 ~ 480 510 ~ 555	76	180 150	1300 1100
S-N600 S-N800	200 220	50 60	230 ~ 270 310 ~ 350	46.0 ~ 54.0 69.0 ~ 77.0	7.5 ~ 10.0 11.0 ~ 14.0	500 ~ 700 600 ~ 800	48.0	140 115	800 660

Model name	Coil rating		Characteristics			Inrush VA	Impedance (sealed)		
	Voltage (V)	Frequency (Hz)	Coil sealed (mA)	Sealed VA	Sealed watts		DC resistance (Ω)	Effective resistance (Ω)	Reactance (Ω)
S-N10 S-N11	400 440	50 60	24 ~ 27 22 ~ 24	9.8 ~ 10.6 9.9 ~ 10.6	3.2 ~ 3.4 3.5 ~ 3.7	51 ~ 64 58 ~ 69	1929	5100 6800	15500 19000
S-N12	400 440	50 60	24 ~ 27 22 ~ 24	9.8 ~ 10.6 9.9 ~ 10.6	3.2 ~ 3.4 3.5 ~ 3.7	51 ~ 64 58 ~ 69	1929	5100 6800	15500 18000
S-N18	400 440	50 60	24 ~ 27 22 ~ 24	9.8 ~ 10.6 9.9 ~ 10.6	3.2 ~ 3.4 3.5 ~ 3.7	51 ~ 64 58 ~ 69	1929	5100 6800	15500 18000
S-N20	400 440	50 60	34 ~ 36 30 ~ 32	13.6 ~ 14.2 12.1 ~ 12.6	4.2 ~ 4.4 4.4 ~ 4.5	80 ~ 93 85 ~ 99	1222	3500 4650	11000 14000
S-N21	400 440	50 60	34 ~ 36 30 ~ 32	13.6 ~ 14.2 12.1 ~ 12.6	4.2 ~ 4.4 4.4 ~ 4.5	80 ~ 93 85 ~ 99	1222	3500 4650	11000 14000
S-N25 S-N35	400 440	50 60	28 ~ 36 25 ~ 34	11.4 ~ 14.4 11.2 ~ 14.7	3.5 ~ 4.4 3.7 ~ 4.6	100 ~ 113 105 ~ 119	1020	3900 4800	12500 15000
S-N50 S-N65	400 440	50 60	22 ~ 27 29 ~ 34	8.6 ~ 10.4 14.3	1.1 ~ 1.7 1.6 ~ 2.2	100 ~ 120 100 ~ 120	1093	2400 1920	16000 14000
S-N80 S-N95	400 440	50 60	39 ~ 49 53 ~ 63	15.5 ~ 20.0 23.0 ~ 28.0	2.1 ~ 2.9 3.3 ~ 4.1	190 ~ 260 250 ~ 290	590	1300 1100	9000 7500
S-N125	400 440	50 60	51 ~ 61 68 ~ 78	20.5 ~ 24.5 29.5 ~ 34.5	2.6 ~ 3.4 3.9 ~ 4.7	240 ~ 290 280 ~ 320	450	1000 850	7300 6100
S-N150	400 440	50 60	51 ~ 61 68 ~ 78	20.5 ~ 24.5 29.5 ~ 34.5	2.6 ~ 3.4 3.9 ~ 4.7	240 ~ 290 280 ~ 320	450	1000 850	7300 6100
S-N180 S-N220	400 440	50 60	66 ~ 76 89 ~ 99	26.0 ~ 33.0 39.0 ~ 44.0	3.2 ~ 4.0 4.9 ~ 5.7	435 ~ 490 520 ~ 585	300	700 600	5600 4600
S-N300 S-N400	400 440	50 60	93 ~ 105 125 ~ 137	37.0 ~ 42.0 55.0 ~ 58.0	4.5 ~ 5.3 6.7 ~ 7.5	415 ~ 480 510 ~ 555	245	500 400	4000 3300
S-N600 S-N800	400 440	50 60	145 ~ 170 195 ~ 220	58.0 ~ 68.0 86.0 ~ 97.0	9.0 ~ 11.5 13.5 ~ 16.5	550 ~ 750 650 ~ 850	152	420 350	2500 2100

Note: The impedance values are for reference purposes only. (The values for type S-N50 to N800 are for would coils only. Impedance-related values are unable to measure because of a built-in rectifier circuit.)

4. Insulation Resistance

Specification value : Greater than 5MΩ

Measurement point : (a) With the contacts closed, between all the terminals and earth and control circuits (grounded)
(b) With the contacts closed, between the poles.
(c) With the contacts opened, between the electrically live parts and grounding metal parts and control circuits (grounded)
(d) With the contacts opened, between the line terminals and load terminals.
(e) Between the electrically live parts of the control circuit and grounding metal parts.
(f) Measure between one circuit and all other circuits in the control circuit (grounded).

Results : The all frames were over 100MΩ.

5. Dielectric Withstanding Strength

Specification value : To withstand for one minute under 2500V 50Hz or 60Hz.

Measurement point : Same points as for section 4.

Results : The all frames were not abnormal for one minute under 2500V 60 Hz.

6. Operating Characteristics of Thermal Overload Relays

(1) Operation in 3-phase balanced (ambient temperature at 20°C)

(a) Apply 720% of the setting current. The thermal overload relay is to operate within 2 to 15 seconds.

(b) Apply the set current until the temperature of the thermal overload relay is saturated.
Then, apply 150% of the set current. The thermal overload relay is to operate within 8 minutes.

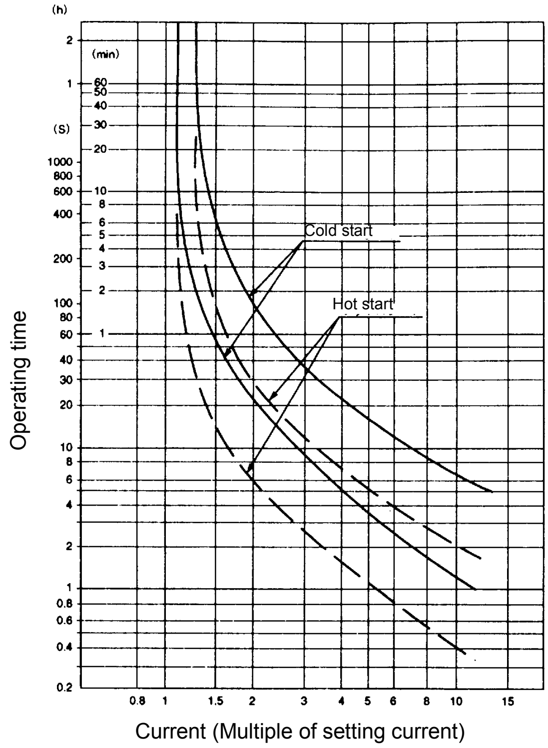
(c) Apply 105% of the setting current for 2 hours. The thermal overload relay is not to operate.
After the temperature is saturated, apply 120% of the setting current. It is to operate within 2 hours.

(2) Operation in 3-phase unbalanced (ambient temperature at 20°C)

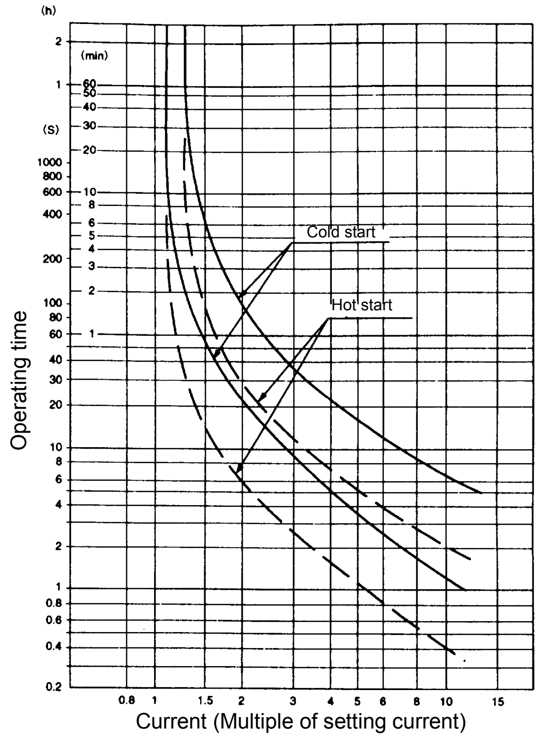
Apply all the poles with the setting current for 2 hours to saturated the temperature of the thermal overload relay.
For the thermal relay with 3-pole heating element, disconnect one of the poles. Apply 132% of the setting current for the rest 2 pole. The thermal overload relay is to operate within 2 hours.

Results: The all frames were satisfied with the above conditions.

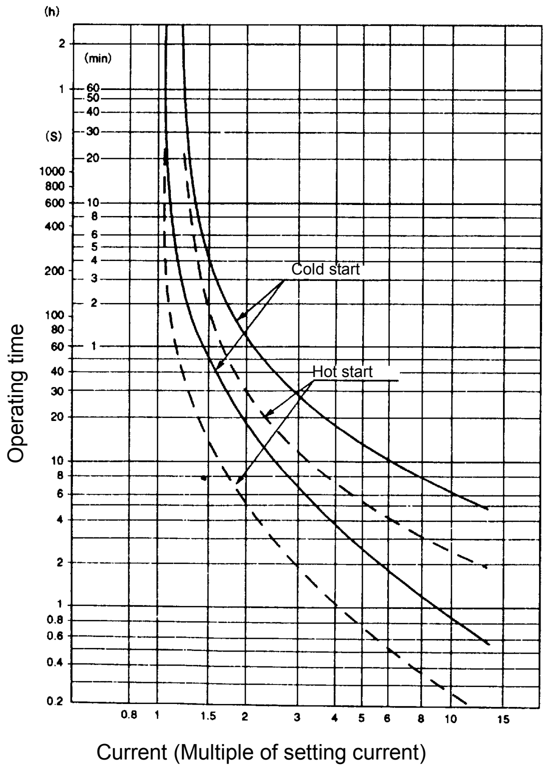
The operating characteristics curves are shown on the following pages.



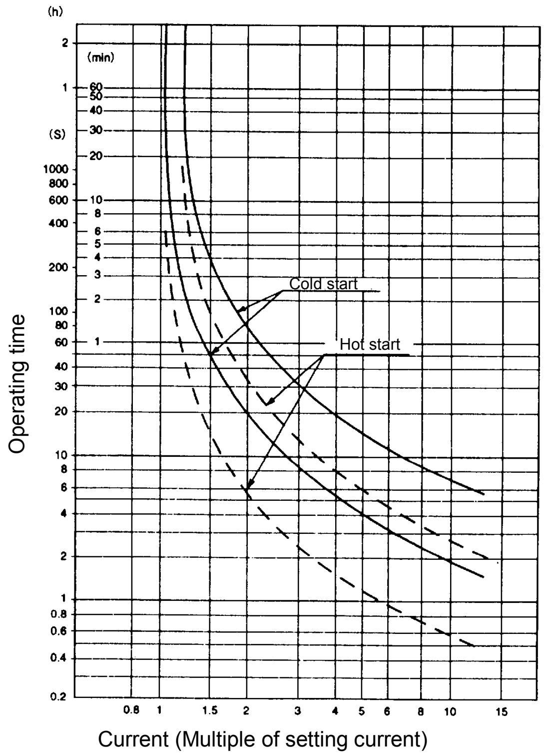
MS/MSO-N10 (TP/KP)
MS/MSO-N11 (TP/KP)
MS/MSO-N12 (TP/KP)
With TH-N12 (TP/KP) thermal overload relay



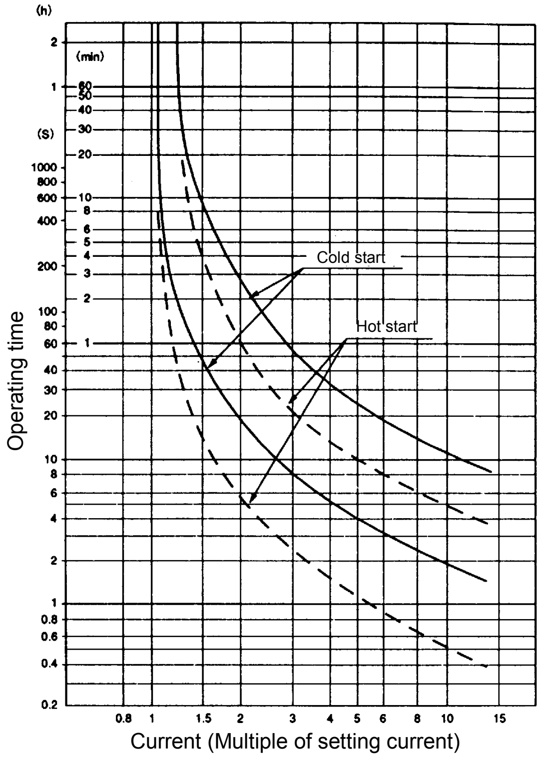
MSO-N18 (KP) With TH-N18 (KP) thermal overload relay



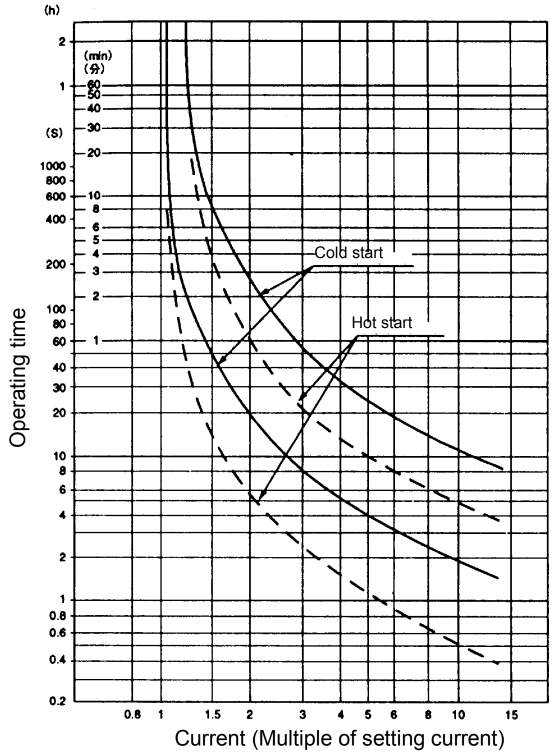
MS/MSO-N20 (KP)
MS/MSO-N21 (KP)
With TH-N20 (KP) thermal overload relay



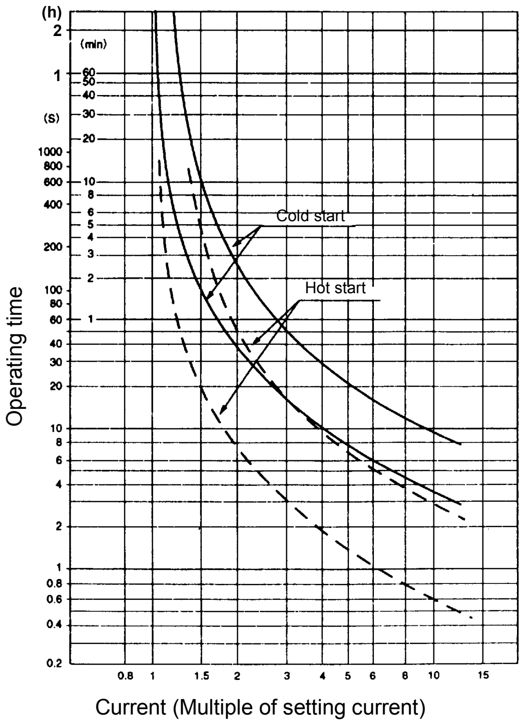
MS/MSO-N25 (KP)
MS/MSO-N35 (KP)
With TH-N20TA (KP) thermal overload relay



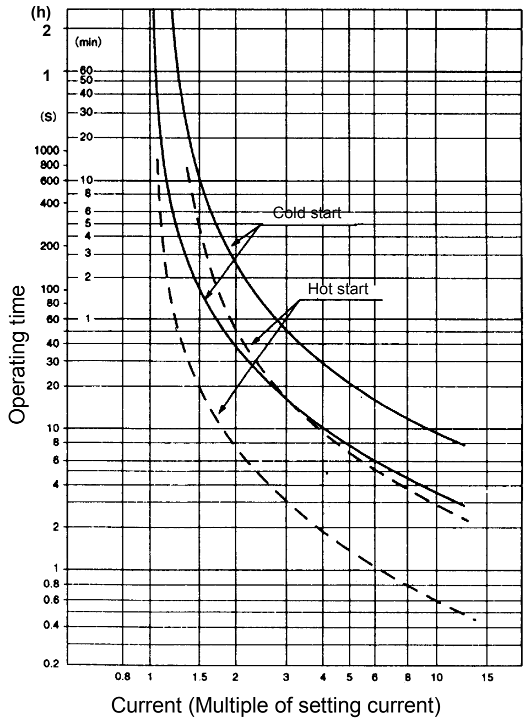
MS/MSO-N50 (KP)
MS/MSO-N65 (KP) With TH-N60 (KP) thermal overload relay



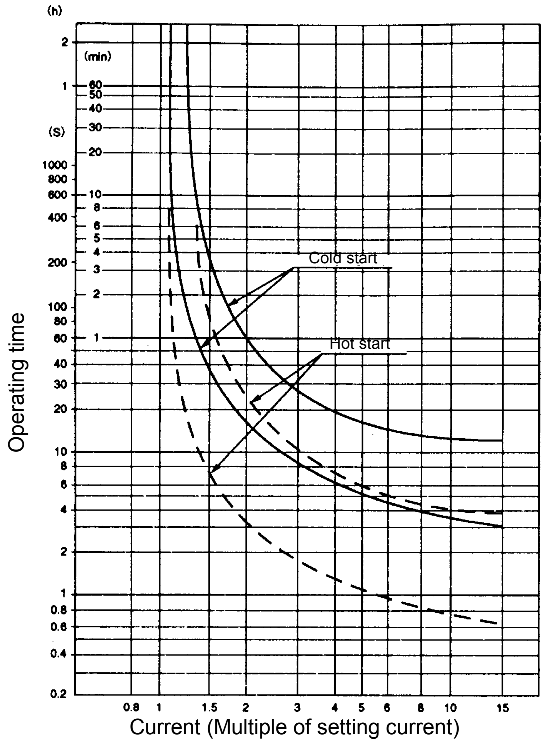
MS/MSO-N80 (KP)
MS/MSO-N95 (KP) With TH-N60 (TA, KP) thermal overload relay



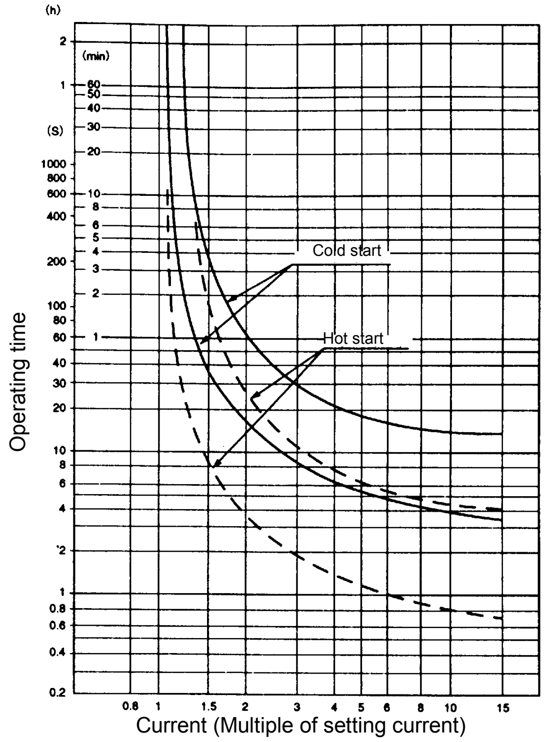
MS/MSO-N125 (KP) With TH-N120 (TA, KP) thermal overload relay



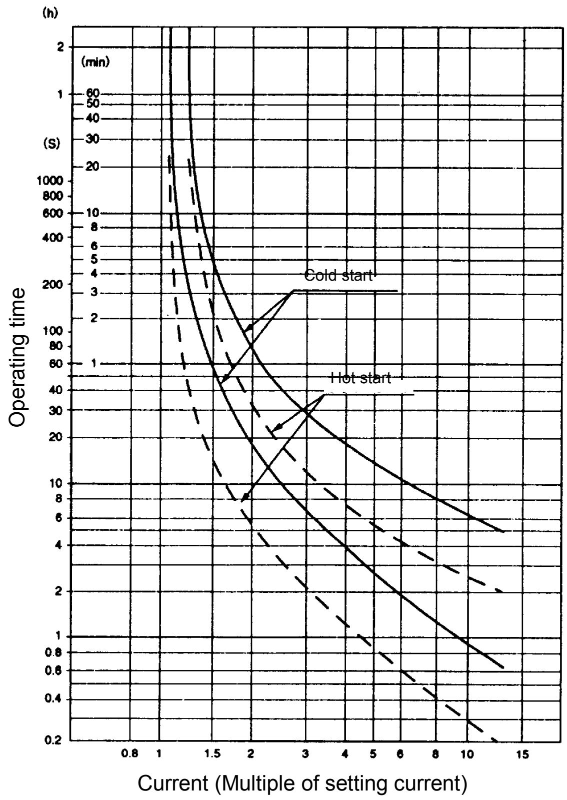
MS/MSO-N150 (KP) With TH-N120 (TA, KP) thermal overload relay



MS/MSO-N180(KP)
MS/MSO-N220(KP)
With TH-N220RH (KP) thermal overload relay



MS/MSO-N300 (KP)
MS/MSO-N400 (KP)
With TH-N400RH (KP) thermal overload relay



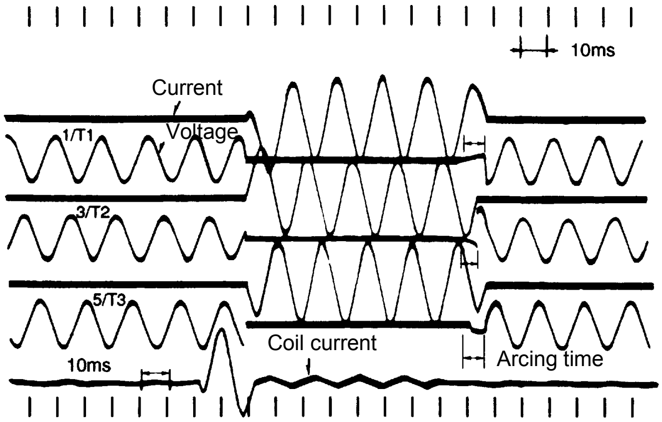
TH-N600 (KP)
thermal overload relay

7. Making Current Capacity

Model name	Test conditions				Making operation (times)				Contact welding
	Voltage (3øV)	Frequency (Hz)	Making current (A)	Power factor (lag)	Total	Applied voltage			
						170V 60Hz	∗ 60Hz	220V 60Hz	
S-N10	484	60	125	0.34	200	50	50	100	None
S-N11	484	60	140	0.35	200	50	50	100	None
S-N12	484	60	140	0.35	200	50	50	100	None
S-N18	484	60	220	0.35	200	50	50	100	None
S-N20	484	60	286	0.32	200	50	50	100	None
S-N21	484	60	286	0.32	200	50	50	100	None
S-N25	484	60	312	0.33	200	50	50	100	None
S-N35	484	60	416	0.33	200	50	50	100	None
S-N50	484	60	500	0.35	200	50	50	100	None
S-N65	484	60	650	0.38	200	50	50	100	None
S-N80	484	60	800	0.35	200	50	50	100	None
S-N95	484	60	1000	0.35	200	50	50	100	None
S-N125	484	60	1250	0.33	200	50	50	100	None
S-N150	484	60	1500	0.35	200	50	50	100	None
S-N180	484	60	1800	0.35	200	50	50	100	None
S-N220	484	60	2200	0.33	200	50	50	100	None
S-N300	484	60	3000	0.35	200	50	50	100	None
S-N400	484	60	4000	0.33	200	50	50	100	None
S-N600	484	60	6300	0.35	200	50	50	100	None
S-N800	484	60	8000	0.35	200	50	50	100	None

Notes:
1. The making current capacity tests were conducted at the maximum rated operational currents between 200V and 500V.
2. Nominal ratings of the operating coil are AC200V.
3. ∗S-N10 to N35 are applied with 242VAC. S-N50 to N800 are applied with 264VAC.

8. Breaking Current Capacity



Example of oscillogram of breaking current capacity test

Model name	Test conditions					Arcing time (ms)	Test results
	Voltage (3ø V)	Frequency (Hz)	Braking current (A)	Power factor (lag)	Braking operation (times)		
S-N10	484 605 726	60 60 60	110 60 40	0.35 0.35 0.33	25 25 25	4 ~ 10 4 ~ 12 6 ~ 22	Good
S-N11	484 605 726	60 60 60	120 92 57	0.35 0.37 0.35	25 25 25	4 ~ 10 4 ~ 16 6 ~ 25	Good
S-N12	484 605 726	60 60 60	120 92 57	0.35 0.37 0.35	25 25 25	4 ~ 10 4 ~ 16 6 ~ 25	Good
S-N18	484 605 726	60 60 60	144 130 72	0.33 0.35 0.33	25 25 25	4 ~ 12 4 ~ 17 10 ~ 30	Good
S-N20	484 605 726	60 60 60	225 170 72	0.33 0.32 0.33	25 25 25	4 ~ 10 4 ~ 13 10 ~ 30	Good
S-N21	484 605 726	60 60 60	225 170 72	0.33 0.32 0.33	25 25 25	4 ~ 10 4 ~ 13 10 ~ 30	Good
S-N25	484 605 726	60 60 60	270 200 100	0.33 0.32 0.33	25 25 25	4 ~ 11 4 ~ 13 10 ~ 25	Good
S-N35	484 605 726	60 60 60	360 260 140	0.33 0.33 0.33	25 25 25	4 ~ 11 4 ~ 13 10 ~ 30	Good
S-N50	484 605 726	60 60 60	480 380 310	0.35 0.35 0.35	25 25 25	3 ~ 12 8 ~ 20 10 ~ 30	Good
S-N65	484 605 726	60 60 60	650 450 310	0.38 0.35 0.35	25 25 25	5 ~ 18 10 ~ 25 10 ~ 30	Good
S-N80	484 605 726	60 60 60	800 750 520	0.32 0.33 0.35	25 25 25	4 ~ 12 10 ~ 17 8 ~ 25	Good
S-N95	484 605 726	60 60 60	1000 750 520	0.35 0.33 0.35	25 25 25	5 ~ 15 8 ~ 16 8 ~ 25	Good
S-N125	484 605 726	60 60 60	1250 900 560	0.36 0.38 0.32	25 25 25	5 ~ 15 4 ~ 15 9 ~ 16	Good
S-N150	484 605 726	60 60 60	1500 1400 800	0.32 0.34 0.36	25 25 25	5 ~ 14 10 ~ 18 9 ~ 17	Good

Model name	Test conditions					Arcing time (ms)	Test results
	Voltage (3ø V)	Frequency (Hz)	Braking current (A)	Power factor (lag)	Braking operation (times)		
S-N180	484 605 726	60 60 60	1800 1800 1200	0.32 0.32 0.33	25 25 25	5 ~ 18 5 ~ 18 5 ~ 16	Good
S-N220	484 605 726	60 60 60	2200 2000 1200	0.34 0.32 0.31	25 25 25	5 ~ 18 5 ~ 16 5 ~ 16	Good
S-N300	484 605 726	60 60 60	3000 2500 1800	0.35 0.33 0.35	25 25 25	7 ~ 16 5 ~ 13 7 ~ 15	Good
S-N400	484 605 726	60 60 60	4000 3500 2400	0.33 0.35 0.31	25 25 25	7 ~ 16 8 ~ 17 9 ~ 16	Good
S-N600	484 605 726	60 60 60	6300 5000 3400	0.36 0.35 0.32	25 25 25	6 ~ 17 5 ~ 15 5 ~ 12	Good
S-N800	484 605 726	60 60 60	8000 7200 5100	0.32 0.32 0.35	25 25 25	6 ~ 17 6 ~ 15 7 ~ 15	Good

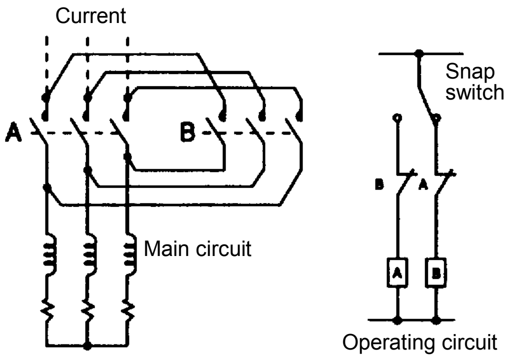
9. Reverse Switching

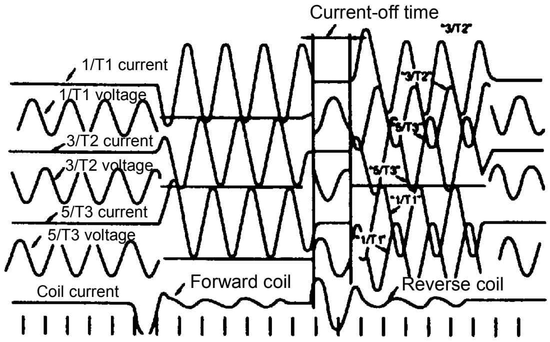
Define the following procedure as one cycle: Closing contacts A – opening contacts A, immediately*1 after this, closing contacts B – opening contacts B – rest for 10 seconds (Ie*2: 100A or less) or for 30 seconds (Ie: over 100A) – closing contacts B – opening contacts B, immediately after this, closing contacts A - opening contacts A – rest for 10 or 30 seconds. Repeat 10 cycles of this.
Here, "A" and "B" are forward and reverse contactors, respectively.

∗1 "Immediately" means the shortest reverse switching time.

∗2 Ie = rated operational current

Test circuit :





Example of oscillogram of reverse switching test

Model name	Test conditions					Test results	
	Voltage (3ø, V)	Frequency (Hz)	Current (A)	Power factor (lag)	Cycle	Arcing time (ms)	Current-off time (ms)
MSO-2 × N10	484 605	60 60	90 90	0.36 0.35	10 10	4 ~ 7 4 ~ 7	7 ~ 15 7 ~ 15
MSO-2 × N11	484 605	60 60	90 90	0.36 0.35	10 10	4 ~ 7 4 ~ 7	7 ~ 15 7 ~ 15
MSO-2 × N18	484 605	60 60	130 100	0.33 0.35	10 10	4 ~ 10 4 ~ 13	6 ~ 13 3 ~ 12
MSO-2 × N20	484 605	60 60	130 100	0.33 0.32	10 10	4 ~ 10 4 ~ 13	6 ~ 13 3 ~ 13
MSO-2 × N21	484 605	60 60	130 100	0.33 0.32	10 10	4 ~ 10 4 ~ 13	6 ~ 13 3 ~ 13
MSO-2 × N25	484 605	60 60	170 120	0.33 0.34	10 10	4 ~ 10 4 ~ 13	6 ~ 16 3 ~ 15
MSO-2 × N35	484 605	60 60	240 170	0.33 0.34	10 10	4 ~ 10 4 ~ 13	6 ~ 16 3 ~ 16
MSO-2 × N50	484 605	60 60	480 380	0.35 0.35	10 10	3 ~ 12 5 ~ 18	6 ~ 17 4 ~ 13
MSO-2 × N65	484 605	60 60	650 450	0.38 0.35	10 10	5 ~ 18 5 ~ 19	4 ~ 12 4 ~ 12
MSO-2 × N80	484 605	60 60	800 750	0.35 0.35	10 10	4 ~ 12 8 ~ 16	15 ~ 23 11 ~ 19
MSO-2 × N95	484 605	60 60	930 750	0.35 0.35	10 10	5 ~ 15 8 ~ 16	12 ~ 22 11 ~ 19
MSO-2 × N125	484 605	60 60	1200 900	0.36 0.38	10 10	5 ~ 15 4 ~ 15	9 ~ 19 9 ~ 20
MSO-2 × N150	484 605	60 60	1500 1400	0.32 0.34	10 10	5 ~ 14 10 ~ 18	10 ~ 19 6 ~ 14
MSO-2 × N180	484 605	60 60	1800 1800	0.35 0.35	10 10	5 ~ 18 7 ~ 18	12 ~ 25 12 ~ 27
MSO-2 × N220	484 605	60 60	2200 2000	0.34 0.32	10 10	5 ~ 18 5 ~ 16	12 ~ 25 12 ~ 25
MSO-2 × N300	484 605	60 60	3000 2500	0.35 0.35	10 10	7 ~ 16 7 ~ 16	14 ~ 33 14 ~ 33
MSO-2 × N400	484 605	60 60	4000 3500	0.33 0.35	10 10	7 ~ 16 8 ~ 17	14 ~ 33 13 ~ 32
S-2 × N600	484 605	60 60	6300 5000	0.36 0.35	10 10	6 ~ 17 5 ~ 15	50 ~ 60 50 ~ 60
S-2 × N800	484 605	60 60	8000 7200	0.32 0.32	10 10	6 ~ 17 6 ~ 15	50 ~ 60 50 ~ 60

10. Operating Frequency

Model name	Test conditions							Temperature rise (°C [K])		
	Making			Braking			Operations per hour	Operating coil	Contacts	Terminals
	Voltage (V)	Current (A)	Power factor (lag)	Voltage (V)	Current (A)	Power factor (lag)				
MSO-N10	220 440	66 42	0.35 0.35	37 75	11 7	0.35 0.35	1800 1800	19 19	35 37	18 18
MSO-N11	220 440	78 54	0.35 0.35	37 75	13 9	0.35 0.35	1800 1800	19 19	40 41	20 21
MSO-N12	220 440	78 54	0.35 0.35	37 75	13 9	0.35 0.35	1800 1800	19 19	40 41	20 21
MSO-N18	220 440	108 78	0.35 0.35	37 75	18 13	0.35 0.35	1800 1800	22 22	44 44	17 17
MSO-N20	220 440	108 108	0.35 0.35	37 75	18 18	0.35 0.35	1800 1800	23 26	44 48	17 21
MSO-N21	220 440	108 108	0.35 0.35	37 75	18 18	0.35 0.35	1800 1800	23 26	44 48	17 21
MSO-N25	220 440	156 144	0.35 0.35	37 75	26 24	0.35 0.35	1800 1800	30 31	35 40	21 28
MSO-N35	220 440	204 192	0.35 0.35	37 75	34 32	0.35 0.35	1800 1800	31 32	40 44	28 30
MSO-N50	440	300	0.35	75	50	0.35	1200	38	60	30
MSO-N65	440	390	0.35	75	65	0.35	1200	39	62	32
MSO-N80	440	480	0.35	75	80	0.35	1200	30	70	31
MSO-N95	440	600	0.35	75	100	0.35	1200	32	72	33
MSO-N125	440	750	0.35	75	125	0.35	1200	40	66	36
MSO-N150	440	900	0.35	75	150	0.35	1200	40	58	30
MSO-N180	440	1080	0.35	75	180	0.35	1200	50	80	51
MSO-N220	440	1320	0.35	75	220	0.35	1200	50	79	50
MSO-N300	440	1800	0.35	75	300	0.35	1200	50	83	50
MSO-N400	440	2400	0.35	75	400	0.35	1200	52	87	57
S-N600	440	3780	0.35	75	630	0.35	1200	60	52	39
S-N800	440	4800	0.35	75	800	0.35	1200	60	57	41

Note: For MSO-N50 to N400, S-N600 and N800, the tests were conducted at the maximum rated operational currents between 200V and 440V.

11. Mechanical Endurance

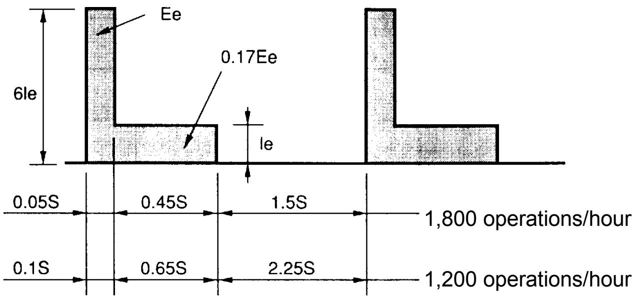
Criteria : No damage on parts

Test conditions : Apply the AC200V operating coils with the following voltages: 210V 50Hz for MSO-N10 to MSO-N35, 252V 60Hz for MSO-N50 to MSO-N400, S-N600 and S-N800. Measure the pick-up voltages and drop-out voltages when applying 60Hz. Measure the pick-up times and drop-out times when applying 220V 60Hz.

Model name	Operating frequency (cycles/h)	Before test		After 2,000,000 operatings		After 5,000,000 operatings		After 10,000,000 operatings		Test result
		Pick-up voltage/ Drop-out voltage (V)	Pick-up time/ Drop-out time (ms)	Pick-up voltage/ Drop-out voltage (V)	Pick-up time/ Drop-out time (ms)	Pick-up voltage/ Drop-out voltage (V)	Pick-up time/ Drop-out time (ms)	Pick-up voltage/ Drop-out voltage (V)	Pick-up time/ Drop-out time (ms)	
MSO-N10	14400	113~120/ 86~106	12~18/ 7~14	114~120/ 84~106	12~18/ 7~14	112~122/ 85~108	12~18/ 7~14	111~121/ 86~108	12~18/ 7~14	OK
MSO-N11	14400	113~120/ 86~106	12~18/ 7~14	114~120/ 84~106	12~18/ 7~14	112~122/ 85~108	12~18/ 7~14	111~121/ 86~108	12~18/ 7~14	OK
MSO-N12	14400	130~142/ 96~106	13~18/ 7~15	131~143/ 97~107	13~18/ 7~15	130~145/ 97~108	13~18/ 7~15	132~145/ 98~109	13~18/ 7~15	OK
MSO-N18	14400	124~137/ 100~125	8~16/ 6~16	124~138/ 100~126	8~17/ 6~16	123~138/ 98~122	8~17/ 7~17	123~138/ 99~123	8~17/ 7~17	OK
MSO-N20	14400	135~144/ 95~110	12~18/ 6~13	137~145/ 97~111	12~20/ 6~13	136~146/ 97~111	12~20/ 6~14	137~147/ 97~112	12~20/ 6~14	OK
MSO-N21	14400	129~135/ 100~114	12~16/ 8~14	130~137/ 101~115	12~18/ 8~14	129~138/ 99~115	12~18/ 8~15	131~139/ 100~114	12~18/ 8~15	OK
MSO-N25	14400	127~143/ 95~115	11~20/ 5~14	125~143/ 95~115	11~20/ 5~15	125~143/ 90~110	11~20/ 5~16	123~143/ 89~108	11~20/ 5~16	OK
MSO-N35	14400	127~143/ 95~115	11~20/ 5~14	125~143/ 95~115	11~20/ 5~15	125~143/ 90~110	11~20/ 5~16	123~143/ 89~108	11~20/ 5~16	OK
MSO-N50	7200	115~125/ 45~65	13~24/ 40~65	117~127/ 37~55	13~25/ 45~75	108~118/ 35~50	13~26/ 50~80	–	–	OK
MSO-N65	7200	115~125/ 45~65	13~24/ 40~65	117~127/ 37~55	13~25/ 45~75	108~118/ 35~50	13~26/ 50~80	–	–	OK
MSO-N80	7200	110~130/ 75~100	22~32/ 48~98	108~128/ 60~90	22~32/ 60~100	106~122/ 55~85	22~32/ 62~102	–	–	OK
MSO-N95	7200	110~130/ 75~100	22~32/ 48~98	108~128/ 60~90	22~32/ 60~100	106~122/ 55~85	22~32/ 62~102	–	–	OK
MSO-N125	3600	110~135/ 70~105	20~30/ 56~106	110~132/ 73~107	19~29/ 58~110	110~132/ 77~111	19~29/ 58~110	–	–	OK
MSO-N150	3600	115~140/ 75~110	24~34/ 51~101	113~138/ 75~112	24~34/ 50~102	111~137/ 75~115	23~33/ 50~105	–	–	OK
MSO-N180	3600	124~131/ 71~90	25~35/ 85~102	123~130/ 75~95	24~34/ 80~102	121~128/ 75~100	24~34/ 80~105	–	–	OK
MSO-N220	3600	124~131/ 71~90	25~35/ 85~102	123~130/ 75~95	24~34/ 80~102	121~128/ 75~100	24~34/ 80~105	–	–	OK
MSO-N300	3600	111~130/ 70~104	35~45/ 121~151	110~129/ 72~106	33~43/ 117~148	108~127/ 74~110	33~43/ 117~148	–	–	OK
MSO-N400	3600	111~130/ 70~104	35~45/ 121~151	110~129/ 72~106	33~43/ 117~148	108~127/ 74~110	33~43/ 117~148	–	–	OK
S-N600	3600	108~130/ 60~90	51~80/ 57~93	106~129/ 60~85	51~80/ 60~93	104~127/ 59~83	51~80/ 63~94	–	–	OK
S-N800	3600	108~130/ 60~90	51~80/ 57~93	106~129/ 60~85	51~80/ 60~93	104~127/ 59~83	51~80/ 63~94	–	–	OK

12. Electrical Endurance

Category AC-3



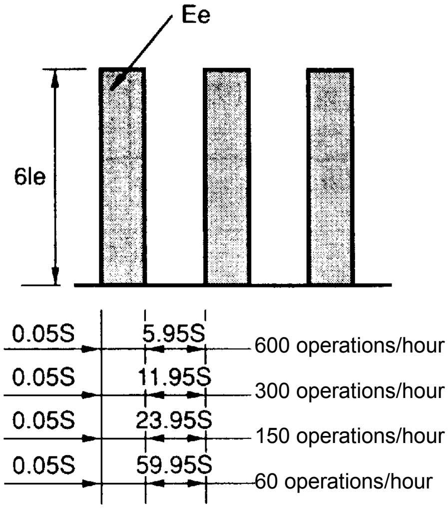
220V

Model name	Test conditions				Operations (x10^6)	Maximum contact wear (%)		Insulation resistance (MΩ)	Dielectric with-stand voltage (for 1 minute)
	Voltage Ee (V)	Current Ie (A)	Power factor (lag)	Operations per hour		500,000 operatings	After test		
S-N10	220 220	11 8	0.34 0.32	1800 1800	1 1	16 11	25 20	100 or over	2500 good
S-N11	220 220	13 8	0.35 0.34	1800 1800	1 1	13 10	30 19	100 or over	2500 good
S-N12	220 220	13 8	0.35 0.34	1800 1800	1 1	12 10	31 20	100 or over	2500 good
S-N18	220 220	18 13	0.34 0.35	1800 1800	1 1	10 5	31 13	100 or over	2500 good
S-N20	220 220	20 14	0.34 0.37	1800 1800	1 1	10 5	31 14	100 or over	2500 good
S-N21	220 220	20 14	0.34 0.37	1800 1800	1 1	8 4	30 13	100 or over	2500 good
S-N25	220 220	26 20	0.36 0.34	1800 1800	1 1	11 7	31 19	100 or over	2500 good
S-N35	220 220	35 25	0.37 0.33	1800 1800	1 1	12 7	30 14	100 or over	2500 good
S-N50	220 220	50 35	0.35 0.36	1200 1200	1 1	12 8	41 19	100 or over	2500 good
S-N65	220 220	65 50	0.34 0.32	1200 1200	1 1	17 12	39 25	100 or over	2500 good
S-N80	220 220	80 65	0.35 0.37	1200 1200	1 1	23 15	43 28	100 or over	2500 good
S-N95	220 220	100 70	0.37 0.32	1200 1200	1 1	17 9	38 21	100 or over	2500 good
S-N125	220 220	125 100	0.35 0.35	1200 1200	1 1	15 9	33 22	100 or over	2500 good
S-N150	220 220	150 120	0.34 0.33	1200 1200	1 1	20 11	42 22	100 or over	2500 good
S-N180	220 220	180 140	0.37 0.35	1200 1200	1 1	20 12	42 25	100 or over	2500 good
S-N220	220 220	220 150	0.35 0.37	1200 1200	1 1	15 8	37 16	100 or over	2500 good
S-N300	220 220	300 220	0.37 0.33	1200 1200	1 1	16 5	39 13	100 or over	2500 good
S-N400	220 220	400 300	0.35 0.35	1200 1200	0.5 1	– 7	25 20	100 or over	2500 good
S-N600	220 220	630 500	0.33 0.37	1200 1200	0.5 1	– 8	38 23	100 or over	2500 good
S-N800	220 220	800 630	0.36 0.33	1200 1200	0.5 1	– 21	35 44	100 or over	2500 good
Criteria	–					50 or less		1 or over	2500VAC or over

440V

Model name	Test conditions				Operations ($\times 10^6$)	Maximum contact wear (%)		Insulation resistance (MΩ)	Dielectric with-stand voltage (for 1 minute)
	Voltage Ee (V)	Current Ie (A)	Power factor (lag)	Operations per hour		500,000 operatings	After test		
S-N10	440 440	7 5	0.32 0.36	1800 1800	1 1	10 7	20 14	100 or over	2500 good
S-N11	440 440	9 6	0.34 0.32	1800 1800	1 1	12 6	30 15	100 or over	2500 good
S-N12	440 440	9 6	0.34 0.32	1800 1800	1 1	13 7	31 14	100 or over	2500 good
S-N18	440 440	13 9	0.33 0.34	1800 1800	1 1	12 6	31 12	100 or over	2500 good
S-N20	440 440	20 17	0.34 0.31	1800 1800	1 1	14 10	32 18	100 or over	2500 good
S-N21	440 440	20 17	0.34 0.31	1800 1800	1 1	13 8	30 18	100 or over	2500 good
S-N25	440 440	25 19	0.35 0.33	1800 1800	1 1	11 7	30 17	100 or over	2500 good
S-N35	440 440	32 24	0.35 0.37	1800 1800	1 1	12 6	32 16	100 or over	2500 good
S-N50	440 440	48 32	0.34 0.35	1200 1200	1 1	16 10	47 21	100 or over	2500 good
S-N65	440 440	65 48	0.34 0.34	1200 1200	1 1	18 11	42 21	100 or over	2500 good
S-N80	440 440	80 65	0.39 0.34	1200 1200	1 1	19 12	44 28	100 or over	2500 good
S-N95	440 440	93 75	0.34 0.39	1200 1200	1 1	17 12	43 28	100 or over	2500 good
S-N125	440 440	120 90	0.33 0.35	1200 1200	1 1	22 14	40 25	100 or over	2500 good
S-N150	440 440	150 120	0.37 0.33	1200 1200	1 1	18 12	46 28	100 or over	2500 good
S-N180	440 440	180 140	0.34 0.37	1200 1200	1 1	20 2	41 24	100 or over	2500 good
S-N220	440 440	220 150	0.35 0.33	1200 1200	1 1	19 5	41 15	100 or over	2500 good
S-N300	440 440	300 220	0.36 0.37	1200 1200	1 1	21 8	42 18	100 or over	2500 good
S-N400	440 440	400 300	0.37 0.34	1200 1200	0.5 1	– 14	32 31	100 or over	2500 good
S-N600	440 440	630 500	0.37 0.35	1200 1200	0.5 0.7	– 19	43 30	100 or over	2500 good
S-N800	440 440	800 630	0.34 0.37	1200 1200	0.5 0.7	– 31	44 42	100 or over	2500 good
Criteria	–					50 or less		1 or over	2500VAC or over

Category AC-4



220V

Model name	Test conditions				Operations ($x10^6$)	Maximum contact wear (%)	Insulation resistance (MΩ)	Dielectric with-standing voltage (for 1 minute)
	Voltage Ee (V)	Current Ie (A)	Power factor (lag)	Operations per hour		After test		
S-N10	220 220	8 6	0.33 0.36	600 600	0.03 0.05	26 22	100 or over	2500 good
S-N11	220 220	11 8	0.35 0.35	600 600	0.03 0.05	32 27	100 or over	2500 good
S-N12	220 220	11 8	0.35 0.35	600 600	0.03 0.05	33 28	100 or over	2500 good
S-N18	220 220	18 11	0.37 0.35	600 600	0.03 0.05	20 15	100 or over	2500 good
S-N20	220 220	18 11	0.37 0.35	600 600	0.03 0.05	23 25	100 or over	2500 good
S-N21	220 220	18 11	0.37 0.35	600 600	0.03 0.05	23 25	100 or over	2500 good
S-N25	220 220	20 11	0.36 0.35	600 600	0.03 0.05	22 15	100 or over	2500 good
S-N35	220 220	26 18	0.33 0.37	600 600	0.03 0.05	25 23	100 or over	2500 good
S-N50	220 220	35 26	0.38 0.33	300 300	0.03 0.05	26 26	100 or over	2500 good
S-N65	220 220	50 35	0.35 0.35	300 300	0.03 0.05	29 26	100 or over	2500 good
S-N80	220 220	65 50	0.35 0.35	300 300	0.03 0.05	32 34	100 or over	2500 good
S-N95	220 220	80 65	0.35 0.35	300 300	0.03 0.05	33 39	100 or over	2500 good
S-N125	220 220	93 80	0.35 0.36	300 300	0.03 0.05	30 40	100 or over	2500 good
S-N150	220 220	125 93	0.37 0.33	300 300	0.03 0.05	30 30	100 or over	2500 good
S-N180	220 220	150 125	0.35 0.35	300 300	0.03 0.05	25 30	100 or over	2500 good
S-N220	220 220	180 150	0.36 0.35	300 300	0.03 0.05	27 31	100 or over	2500 good
S-N300	220 220	220 180	0.34 0.35	300 300	0.03 0.05	25 31	100 or over	2500 good
S-N400	220 220	300 220	0.35 0.33	300 300	0.03 0.05	35 33	100 or over	2500 good
S-N600	220 220	400 300	0.35 0.37	150 150	0.03 0.05	30 30	100 or over	2500 good
S-N800	220 220	630 400	0.37 0.35	60 60	0.03 0.05	34 25	100 or over	2500 good
Criteria	–					50 or less	1 or over	2500AC or over

440V

Model name	Test conditions				Operations ($x10^6$)	Maximum contact wear (%)	Insulation resistance (MΩ)	Dielectric with-standing voltage (for 1 minute)
	Voltage Ee (V)	Current Ie (A)	Power factor (lag)	Operations per hour		After test		
S-N10	440 440	6 4	0.33 0.34	600 600	0.03 0.05	26 22	100 or over	2500 good
S-N11	440 440	9 6	0.34 0.33	600 600	0.03 0.05	32 27	100 or over	2500 good
S-N12	440 440	9 6	0.34 0.33	600 600	0.03 0.05	33 27	100 or over	2500 good
S-N18	440 440	9 6	0.34 0.35	600 600	0.03 0.05	20 17	100 or over	2500 good
S-N20	440 440	13 9	0.35 0.34	600 600	0.03 0.05	25 23	100 or over	2500 good
S-N21	440 440	13 9	0.35 0.34	600 600	0.03 0.05	25 23	100 or over	2500 good
S-N25	440 440	17 13	0.35 0.35	600 600	0.03 0.05	20 22	100 or over	2500 good
S-N35	440 440	24 17	0.37 0.35	600 600	0.015 0.03	25 28	100 or over	2500 good
S-N50	440 440	32 24	0.33 0.37	300 300	0.015 0.03	25 31	100 or over	2500 good
S-N65	440 440	47 32	0.36 0.33	300 300	0.015 0.03	27 27	100 or over	2500 good
S-N80	440 440	62 47	0.34 0.35	300 300	0.015 0.03	30 37	100 or over	2500 good
S-N95	440 440	75 62	0.35 0.34	300 300	0.015 0.03	30 40	100 or over	2500 good
S-N125	440 440	90 75	0.34 0.35	300 300	0.015 0.03	27 38	100 or over	2500 good
S-N150	440 440	110 90	0.33 0.33	300 300	0.015 0.03	25 35	100 or over	2500 good
S-N180	440 440	150 110	0.34 0.33	300 300	0.015 0.03	25 29	100 or over	2500 good
S-N220	440 440	180 150	0.35 0.35	300 300	0.015 0.03	27 38	100 or over	2500 good
S-N300	440 440	220 180	0.35 0.33	300 300	0.015 0.03	25 35	100 or over	2500 good
S-N400	440 440	300 220	0.34 0.35	300 300	0.015 0.03	35 39	100 or over	2500 good
S-N600	440 440	400 300	0.33 0.36	150 150	0.015 0.03	30 35	100 or over	2500 good
S-N800	440 440	630 400	0.34 0.35	60 60	0.015 0.03	34 29	100 or over	2500 good
Criteria	–					50 or less	1 or over	2500VAC or over

13. Resistance to Vibration

13.1 Resonance and erroneous operation test

Maintain the constant acceleration of 19.8 m/s^2. Increase the frequency gradually from 10 Hz to 55 Hz. Then, decrease it gradually from 55 Hz to 10 Hz. Check if the contacts have parted.

13.2 Endurance test durability

Conduct a vibration test at vibration frequency of 16.7 Hz and magnitude of 4 mm for one hour in each direction, 6 hours in total. Check the changes in the characteristics, damage and mechanical looseness before and after the testing.

Conditions :

Magnetic contactor	:	Check NC contact for erroneous contact with the operating coil off. Check the main and auxiliary NO contacts for erroneous contact. With the operating coil on (with 85% of the rated voltage applied),
Thermal overload relay	:	Apply the thermal overload relay with the current corresponding to the minimum division. When the temperature becomes saturated, check NC contact for erroneous contact.
Direction of applying vibration	:	Fore and aft, left and right, and up and down
Detection of erroneous contact	:	The contacts is considered to be erroneous contact if they have parted for 1 ms or longer.
Screws	:	Tighten the screws at 80% of their respective standard torque values.

Results :

For S-N10 to N800 and TH-N12 to N600, they were not erroneous contact in the erroneous contact vibration testing and show no changes in the characteristics, parts damage, loose screws or similar defects in the constant vibration durability testing.

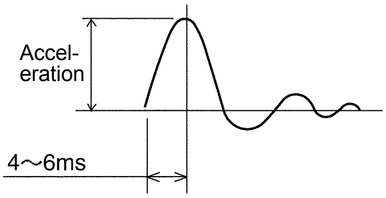
14. Resistance to Shock

Apply sinusoidal impulse to check for erroneous contact and parts damage.

Impulse waveform: See the figure on the right.

Number of impulse: 5 times in each direction (3 times with the operating coil off and 2 times with the operating coil on)

Criteria : Erroneous contact 49m/s^2 or over, parts damage 490m/s^2 or over

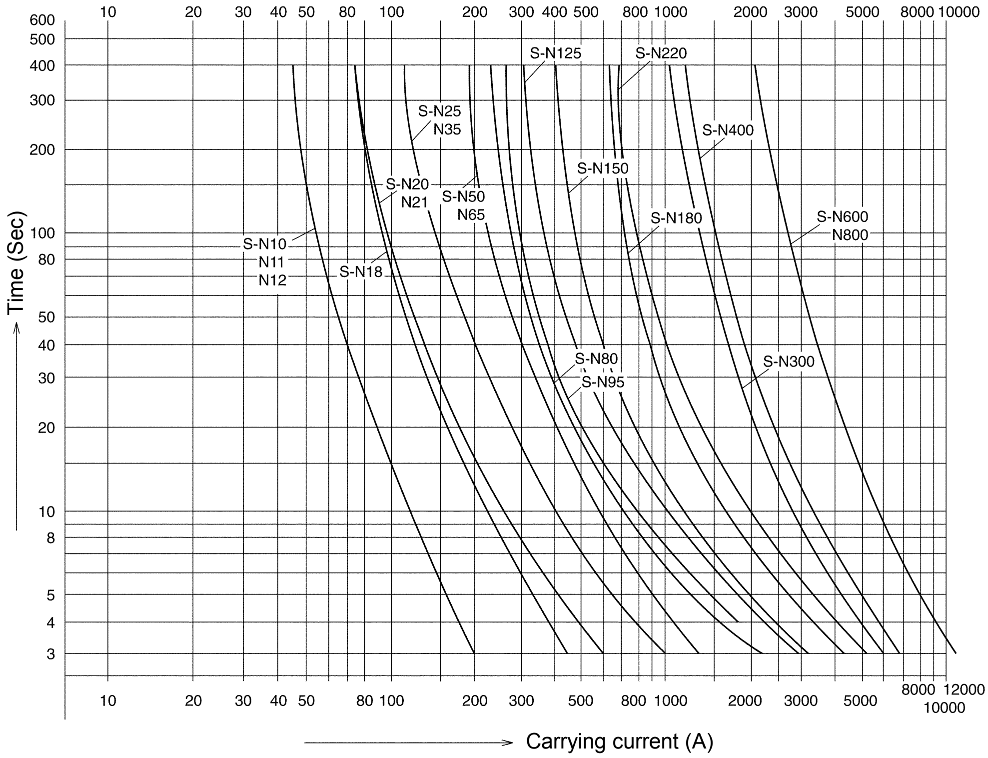


Impulse acceleration waveform

Model name	Test conditions				Test device	Results	
	Thermal overload relay		Operating coil				
	Nominal (A)	Carrying Current (A)	Voltage (V)	Frequency (Hz)		49m/s^2	490m/s^2
MSO-N10	9	7	170	60	Pendulum type	No erroneous contact	No damage
MSO-N11	9	7	170	60	Pendulum type	No erroneous contact	No damage
MSO-N12	9	7	170	60	Pendulum type	No erroneous contact	No damage
MSO-N18	15	12	170	60	Pendulum type	No erroneous contact	No damage
MSO-N20	15	12	170	60	Pendulum type	No erroneous contact	No damage
MSO-N21	15	12	170	60	Pendulum type	No erroneous contact	No damage
MSO-N25	22	18	170	60	Pendulum type	No erroneous contact	No damage
MSO-N35	35	30	170	60	Pendulum type	No erroneous contact	No damage
MSO-N50	42	34	170	60	Pendulum type	No erroneous contact	No damage
MSO-N65	54	43	170	60	Pendulum type	No erroneous contact	No damage
MSO-N80	67	54	170	60	Pendulum type	No erroneous contact	No damage
MSO-N95	82	65	170	60	Pendulum type	No erroneous contact	No damage
MSO-N125	105	85	170	60	Pendulum type	No erroneous contact	No damage
MSO-N150	125	100	170	60	Pendulum type	No erroneous contact	No damage
MSO-N180	150	120	170	60	Pendulum type	No erroneous contact	No damage
MSO-N220	180	140	170	60	Pendulum type	No erroneous contact	No damage
MSO-N300	250	200	170	60	Drop type	No erroneous contact	No damage
MSO-N400	330	270	170	60	Drop type	No erroneous contact	No damage
S-N600	–	–	170	60	Drop type	No erroneous contact	No damage
S-N800	–	–	170	60	Drop type	No erroneous contact	No damage

Note: Nominal rating of the coil: AC200V. The operating coils are turned on in one hour after starting applying the test voltage.

15. Short-time current withstand for contactors



Note: This diagram shows the relationships between the current and the duration where the temperatures of the contacts of the magnetic contactors reach their threshold temperatures that do not hinder continuous operation.

Type SD-N and SL(D)-N Magnetic Contactors

1. DC Operated Magnetic Contactors <Type SD-N>

Type SD-N DC operated magnetic contactors are the same as S-N type magnetic contactors except that the operating electromagnet is DC operated.

(1) Structure

Parts other than the iron core, operating coil and mount are the same as those of the AC operated type S-N.

Type SD-N11 to N65 magnetic contactors use one coil system while type SD-N80 to N400 use two-coil system.

The electromagnet used on type SD-N11 to N400 are given the total voltage directly. Since the coil resistance alone limits the current, it is free from a rush current, thus producing stable operation. To make compact the electromagnets used on type SD-N600 and N800, the saving resistor system with one coil is employed.

(2) Ratings

The contact ratings are the same as those of the AC operated type S-N.

(3) Temperature rise

Ambient temperature at 40°C

Model name	Temperature rise (°C [K])			Test conditions		
	Coil	Contact	Terminal	Coil voltage (VDC)	Main circuit current (A)	Connecting wire size (mm^2)
Standard values	100∗	∗∗	65	–	–	–
SD-N11	60	34	33	100	20	3.5
SD-N12	60	34	33	100	20	3.5
SD-N21	75	40	35	100	32	5.5
SD-N35	75	36	33	100	60	14
SD-N50	72	56	42	100	80	22
SD-N65	72	65	46	100	100	38
SD-N80	62	80	50	100	135	60
SD-N95	62	96	59	100	150	60
SD-N125	75	82	55	100	150	60
SD-N150	75	84	55	100	200	100
SD-N220	76	78	49	100	260	150
SD-N300	75	73	47	100	350	250
SD-N400	77	80	46	100	450	150 × 2
SD-N600	67 (170)	59	44	100	800	50 × 5 copper flat bar × 2
SD-N800	72 (175)	62	45	100	1000	60 × 5 copper flat bar × 2

Notes:
1. Nominal rating of the coil: DC100V.
2. ∗ Indicates IEC 60947-4-1 class E insulation.
3. ∗∗ Up to temperatures not harmful to items around (approximately 100°C [K])
4. The DC power supply is a three-phase full wave rectification without smoothing circuit.
5. The coil temperature rise values in the parentheses for the type SD-N600 and N800 indicate the temperature rise in the resistors.

(4) Operating characteristics

Model name	Coil designation DC(V)	Pick-up voltage (VDC)		Drop-out voltage (VDC)		Coil seiled current (mA)		Operating time 40°C cold (ms)		Coil time constant (ms)
		40°C cold	40°C hot	40°C cold	40°C hot	40°C cold	40°C hot	Pick-up	Drop-out	40°C cold
SD-N11	100	50~65	60~75	10~26	14~30	58~68	46~56	45	13	35
SD-N12	100	50~65	65~80	13~29	17~33	58~68	46~56	45	13	35
SD-N21	100	50~65	65~80	14~30	20~36	91~101	68~78	45	12	35
SD-N35	100	50~65	65~80	16~32	22~38	91~101	68~78	45	8	35
SD-N50 SD-N65	100	56~70	67~78	20~30	31~42	190~210	153~173	50	13	65
SD-N80 SD-N95	100	54~70	60~70	20~30	30~40	210~230	174~194	75	18	80
SD-N125	100	54~70	65~82	17~29	29~41	275~295	227~243	125	22	100
SD-N150	100	54~70	65~80	18~31	29~42	275~295	227~243	135	37	100
SD-N220	100	56~70	67~79	13~27	19~40	432~452	375~393	145	40	125
SD-N300 SD-N400	100	57~70	68~80	13~27	19~40	584~604	510~527	175	55	220
SD-N600 SD-N800	100	58~75	65~79	23~42	27~51	680~752	614~677	105	80	50

Notes:
1. At the coil ratings other than those for DC100V, calculate the pick-up voltages and drop-out voltage approximately by multiplying the above values by the voltage ratio to DC100V.
2. The operating times and coil time constants for the coil ratings other than those of DC100V are approximately the same as the values in the table above.
3. The coil has no rush current. (Except the SD-N600 and N800)
4. Use a power supply free from pulsation to measure the pick-up voltages and the drop-out voltages.

(5) Mechanical endurance

Nominal rating of the coil: DC100V, 105VDC applied

Model Name	Switching frequency (operations/ hour)	Before test (VDC)		After 5,000,000 cycles (VDC)		After 10,000,000 cycles (VDC)		Test results
		Pick-up voltage	Drop-out voltage	Pick-up voltage	Drop-out voltage	Pick-up voltage	Drop-out voltage	
SD- N11 2 × N11	7200	50 ~ 55	14 ~ 20	52 ~ 58	10 ~ 18	52 ~ 58	10 ~ 18	OK
SD- N12	7200	53 ~ 58	17 ~ 23	55 ~ 60	12 ~ 21	55 ~ 60	12 ~ 21	OK
SD- N21 2 × N21	7200	52 ~ 57	17 ~ 23	54 ~ 60	12 ~ 21	54 ~ 60	12 ~ 21	OK
SD- N35 2 × N35	7200	52 ~ 57	20 ~ 26	54 ~ 60	14 ~ 23	54 ~ 60	14 ~ 23	OK
SD- N50 2 × N50	7200	54 ~ 67	20 ~ 30	56 ~ 70	27 ~ 30	–	–	OK
SD- N65 2 × N65	7200	54 ~ 67	20 ~ 30	56 ~ 70	27 ~ 30	–	–	OK
SD- N80 2 × N80	7200	55 ~ 67	19 ~ 24	57 ~ 70	27 ~ 37	–	–	OK
SD- N95 2 × N95	7200	55 ~ 67	19 ~ 24	57~ 70	27 ~ 37	–	–	OK
SD- N125 2 × N125	3600	50 ~ 65	16 ~ 28	52 ~ 68	25 ~ 35	–	–	OK
SD- N150 2 × N150	3600	50 ~ 65	17 ~ 30	52 ~ 68	27 ~ 35	–	–	OK
SD- N220 2 × N220	3600	52 ~ 65	12 ~ 25	53~ 68	30 ~ 38	–	–	OK
SD- N300 2 × N300	3600	53 ~ 65	12 ~ 25	55 ~ 68	31 ~ 42	–	–	OK
SD- N400 2 × N400	3600	53 ~ 65	12 ~ 25	55 ~ 68	29 ~ 43	–	–	OK
SD- N600 2 × N600	3600	55 ~ 66	28 ~ 37	53 ~ 69	24 ~ 32	–	–	OK
SD- N800 2 × N800	3600	55 ~ 66	28 ~ 37	54 ~ 69	22 ~ 31	–	–	OK

2. Mechanically Latched Magnetic Contactors <Type SL-N and SLD-N>

Type SL-N and SLD-N mechanically latched magnetic contactors are the same as type S-N magnetic contactors with a latch mechanism and are equipped with a closing coil and a tripping coil. To close the contacts, the closing coil is magnetized to hold the closed state mechanically. To release the contacts, the tripping coil is magnetized to disengage the latch.

(1) Application

- Used in a memory circuit where the contactors keep the circuit closed during power outage, momentary power outage or voltage drop.
- Used in the power distributor circuit for a facility such as in hospitals and office buildings that should be free from noise.
- Used in a circuit such as street lamps that are electrically live for a long time.
- To save usual coil power consumption in a circuit where switching frequency is low.

(2) Ratings and specifications

<table>
<tr><th rowspan="2">Model Name</th><th colspan="3">Rated operational current 3-ph, category AC-3 (A)</th><th rowspan="2">Rated con-tinuous current Ith (A)</th><th rowspan="2">Standard free aux. contacts</th><th rowspan="2">Making and breaking current</th><th rowspan="2">Switching frequency</th><th colspan="2">Endurance</th></tr>
<tr><th>200-220V</th><th>380-440V</th><th>500-550V</th><th>Mechanical</th><th>Electrical</th></tr>
<tr><td>SL
SLD -N21</td><td>20</td><td>20</td><td>17</td><td>32</td><td rowspan="4">2NO+2NC</td><td rowspan="13">10 times the rated opera-tional current</td><td rowspan="13">1,200 opera-tions/hour</td><td rowspan="2">500,000 operations</td><td rowspan="2">500,000 operations</td></tr>
<tr><td>SL
SLD -N35</td><td>35</td><td>32</td><td>26</td><td>60</td></tr>
<tr><td>SL
SLD -N50</td><td>50</td><td>48</td><td>38</td><td>80</td><td rowspan="9">250,000 operations</td><td rowspan="9">250,000 operaions</td></tr>
<tr><td>SL
SLD -N65</td><td>65</td><td>65</td><td>45</td><td>100</td></tr>
<tr><td>SL
SLD -N80</td><td>80</td><td>80</td><td>75</td><td>135</td><td rowspan="9">1NO+2NC</td></tr>
<tr><td>SL
SLD -N95</td><td>100</td><td>93</td><td>75</td><td>150</td></tr>
<tr><td>SL
SLD -N125</td><td>125</td><td>120</td><td>90</td><td>150</td></tr>
<tr><td>SL
SLD -N150</td><td>150</td><td>150</td><td>140</td><td>200</td></tr>
<tr><td>SL
SLD -N220</td><td>220</td><td>220</td><td>200</td><td>260</td></tr>
<tr><td>SL
SLD -N300</td><td>300</td><td>300</td><td>250</td><td>350</td></tr>
<tr><td>SL
SLD -N400</td><td>400</td><td>400</td><td>350</td><td>450</td></tr>
<tr><td>SL
SLD -N600</td><td>630</td><td>630</td><td>500</td><td>660</td><td rowspan="2">100,000 operations</td><td rowspan="2">100,000 operaitions</td></tr>
<tr><td>SL
SLD -N800</td><td>800</td><td>800</td><td>720</td><td>800</td></tr>
</table>

Notes: 1. Vibration strength: 10 to 55 Hz, 19.6 m/s^2 , Impact strength: 49 m/s^2
2. The contact ratings are the same as those of type S-N.

(3) Mechanical endurance

Model name	Test conditions				Closing voltage (V)		Tripping voltage (V)		Test results
	Voltage applied to coil (V)	Fre-quency (Hz)	Switching frequency (operations/ hour)	Operations (x10^6)	Before testing	After testing	Before testing	After testing	
SL- N21	134	50	1800	0.5	66	66	48	50	OK
SL- N35	134	50	1800	0.5	66	66	55	55	OK
SL- N50 N65	134	50	1800	0.25	65	65	45	48	OK
SL- N80 N95	134	50	1200	0.25	65	65	50	52	OK
SL- N125	134	50	1200	0.25	65	63	45	43	OK
SL- N150	134	50	1200	0.25	70	68	45	43	OK
SL- N220	134	50	1200	0.25	65	63	50	46	OK
SL- N300 N400	134	50	1200	0.25	72	70	60	56	OK
SL- N600 N800	134	50	1200	0.1	70	74	65	73	OK
SLD- N21	116	DC	1800	0.5	61	60	54	56	OK
SLD- N35	116	DC	1800	0.5	61	60	60	61	OK
SLD- N50 N65	116	DC	1800	0.25	60	60	40	45	OK
SLD- N80 N95	116	DC	1200	0.25	60	62	47	50	OK
SLD- N125	116	DC	1200	0.25	60	60	43	45	OK
SLD- N150	116	DC	1200	0.25	65	67	45	45	OK
SLD- N220	116	DC	1200	0.25	60	62	50	50	OK
SLD- N300 N400	116	DC	1200	0.25	65	67	55	53	OK
SLD- N600 N800	116	DC	1200	0.1	70	72	65	70	OK

Notes: 1. The designation of the closing and tripping coils for the type SL-N21 to N800 are those of AC100V.
2. The designation of the closing and tripping coils for the type SLD-N21 to N800 are those of DC100V.

Performance for Environmental Conditions

1. Normal Service Conditions

Magnetic motor starters are used in a variety of environmental conditions. Since some of the conditions greatly affect the performance of the magnetic motor starters, the environmental conditions where they are used need to be specified.
Since manufacturers conduct performance testing in the standard working conditions, the performance is guaranteed in the standard working conditions. The standard working conditions are described below. Use of the magnetic motor starters in conditions other than below may cause failure.

a. Ambient temperature : Standard 20°C, range of working ambient temperature −10°C to +40°C (maximum one-day average air temperature at 35°C, maximum year average temperature at 25°C)
b. Maximum temperature in control panel : 55°C.
The ambient temperature for type MS with enclosure is 40°C.
It should be noted that the operating characteristics of magnetic contactors and the thermal relays vary depending on the ambient temperatures. Though operated normally, the insulation keeps deteriorating. The life of insulation reduces particularly if the ambient temperatures rise. It is said generally that the insulation life reduces to half every time the ambient temperature rises by 6°C to 10°C (Arrhenius' law).
c. Relative humidity : 45 to 85% RH. No condensation or freezing is allowed.
d. Altitude : 2,000m or lower
e. Vibration resistance : 10 to 55 Hz, 19.6m/s^2
f. Impact resistance : 49m/s^2
g. Ambient : Steam, oil mist, dust, smoke, corrosive gases, flammable gases or salt are not included much. Using for a long period in a shielded condition may cause the contacts to fail.
h. Storage temperature : −30°C to +65°C. Neither condensation nor freezing is allowed.

The service temperature ranges for type MS-N are shown in table 1.

Table 1

Specifications \ Temperatures	Service temperature (°C)	Storage temperature (°C)
Type MS-N with enclosure	−30 to +40	−40 to +65
Type MSO-N and S-N without enclosure	−30 to +55	−40 to +65

Notes: 1. The storage temperatures is the temperature range during transport and storage. At the start of operation the temperature must be in the service temperature range.
2. No condensation or freezing from rapid temperature changes are made conditions.

2. Application in Special Environments

2.1 High temperature

When magnetic starters are to be used at high ambient temperature, the temperature is decided mainly by the insulation endurance of the operating coil (continuous energization endurance) and the secular variation of the molded parts.

The temperature rise of the operating coil is specified in the standard, including the ambient temperature, as max. 125°C for class A insulation, and max. 140°C for class E insulation, but for series MSO-N and S-N, class E insulation is used for long time use at a temperature of 55°C in the panel, and the temperature rise is held to below class A.

In order to investigate the secular variation of molded parts, accelerated tests are executed at 120°C, providing a margin over the temperature of 105°C, which is obtained by adding the ambient temperature of 40°C to the standard value of 65°C for the temperature rise of the terminal part. As the secular variation of the molded arts saturates at about 300 hours, a test time of 300 hours was selected.

The results of the heating test for 300 hours at 120°C are shown in table 2. The results show that the type MS-N series has an excellent stability in regard to aging change from temperature.

Table 2 Type MSO-N heating test results

Hours	Characteristics \ Model name	MSO-N10	MSO-N11	MSO-N12	MSO-N21	MSO-N35	MSO-N50	MSO-N80	MSO-N125	MSO-N150	MSO-N220	MSO-N400	MSO-N800
0	Pick-up voltage (V 60 Hz)	137	139	143	151	153	120	121	118	119	113	121	125
	Drop-out voltage (V 60 Hz)	84	82	92	85	97	65	75	85	83	86	88	92
	Drop-out time (ms)	8.5	8.5	7	10	8.5	48	74	85	82	98	130	85
300	Pick-up voltage (V 60 Hz)	140	141	145	153	155	123	124	120	121	115	123	127
	Drop-out voltage (V 60 Hz)	83	81	90	83	95	63	72	83	82	85	86	90
	Drop-out time (ms)	8	8	6	9	8	45	70	82	80	99	128	83

Note: Nominal rating of the coil: AC200V.

2.2 Low temperature

The magnetic motor starters and magnetic contactors in panels may be transported to cold climate areas or used in severely cold conditions such as in cold climate areas or chilling units. For these special applications, products to cold temperature specifications are available. Storage and working temperatures for the standard products and low temperature specification are different as shown below.

- Storage temperature ..... –40°C or above

  No damage has occurred to any portion when tested by leaving the products at -50°C for one month. The products are considered to well withstand storage at –40°C or higher temperatures. Panels transported to cold climate areas are usually packaged waterproof and moisture-proof. Products packaged in warm climate areas may cause condensation and freezing in cold climate areas, possibly damaging the products. The packages therefore should be dehumidified thoroughly. It is suggested that approximately 3 kg of silica gel be placed every 1 m^3 of package as a desiccant.

- Service temperature ..... –30°C or above

  A mechanical life test is conducted under the following conditions.

Temperature	:	–30°C
Voltage and frequency applied to coil	:	220V 60 Hz to 200VAC coil
Switching frequency	:	120 cycles/hour
Duty cycle	:	0.66 % (to suppress temperature rise below 10°C)
Number of operating cycles	:	3 months (250,000 cycles)

  Since neither damage to parts nor any particular problems occur as a result of the test, the products can be used at cold temperatures of –30°C or above. However, the humidity must be thoroughly controlled because if moisture is attached, it freezes to cause damage. Although the thermal relay may need a larger operating current, no compensation is necessary as long as the motor and ambient temperatures are approximately the same.

2.3 High temperature, high humidity

Neither the magnetic motor starters nor the magnetic contactors are designed in principle to operate in high temperature, high humidity conditions. If used in such conditions, it is possible that the dielectric strengths and electrical characteristics deteriorate, the life reduces and ferrous parts (electromagnets and iron cores in particular) get rusted. The products should favorably be placed in damp-proof casings.
Various tests are conducted, considering these conditions as abnormal. Note that the Lloyd specifications also call for tests in high temperature, high humidity conditions.

- Conditions

Ambient temperature	:	40°C
Relative humidity	:	90 to 95%RH
Switching frequency	:	3,600 cycles/hour
Total switching	:	5,000,000 cycles
Test duration	:	3 months
Voltage applied to coil	:	210V 50Hz (200VAC coil)

600VAC is applied between the poles of the main circuit auxiliary contact circuit to see if insulation breakdown occurs.

- Test results

Measurement item		Model name	MSO-N11	MSO-N12	MSO-N21	MSO-N35	MSO-N50	MSO-N80	MSO-N125	MSO-N150	MSO-N220	MSO-N400	S-N800
Before the test	Pick-up voltage 50 Hz (V)		123	118	135	137	120	122	118	119	113	121	123
	Insulation resistance	Between poles	1,000 MΩ or more	1,000 MΩ or more	1,000 MΩ or more	1,000 MΩ or more	1,000 MΩ or more	1,000 MΩ or more	1,000 MΩ or more	1,000 MΩ or more	1,000 MΩ or more	1,000 MΩ or more	1,000 MΩ or more
		Between live parts and earth											
	Dielectric withstand voltage	Between poles	2500V 1 min. good	2500V 1 min. good	2500V 1 min. good	2500V 1 min. good	2500V 1 min. good	2500V 1 min. good	2500V 1 min. good	2500V 1 min. good	2500V 1 min. good	2500V 1 min. good	2500V 1 min. good
		Between live parts and earth											
After the test	Pick-up voltage 50 Hz (V)		120	112	135	135	117	120	116	117	110	117	119
	Insulation resistance	Between poles	1,000 MΩ or more	700~ 1000 MΩ	700~ 1000 MΩ	700~ 1000 MΩ	890~ 1000 MΩ	800~ 1000 MΩ	600~ 1000 MΩ	650~ 1000 MΩ	700~ 1000 MΩ	800~ 1000 MΩ	800~ 1000 MΩ
		Between live parts and earth	1,000 MΩ or more	1,000 MΩ or more	1,000 MΩ or more	1,000 MΩ or more	1,000 MΩ or more	600~ 800 MΩ	600~ 700 MΩ	400~ 600 MΩ	600~ 800 MΩ	1,000 MΩ or more	1,000 MΩ or more
	Dielectric withstand voltage	Between poles	2500V 1 min. good	2500V 1 min. good	2500V 1 min. good	2500V 1 min. good	2500V 1 min. good	2500V 1 min. good	2500V 1 min. good	2500V 1 min. good	2500V 1 min. good	2500V 1 min. good	2500V 1 min. good
		Between live parts and earth											

Notes: 1. Measurement at the room temperature. Taken out to the room temperature for measurement.
2. The insulation resistance is measured by a 1,000V insulation resistance tester.
3. No insulation breakdown between the poles occurs at 600VAC during switching.
4. The operating coil ratings are those of 200VAC.

3. Voltage Drop Characteristics

The guaranteed range of operating voltage for magnetic motor starters and magnetic contactors are 85% to 110% of the rated voltage of the operating coils. However, voltage drop due to the motor starting current reduces the attractive force of the electromagnet after the closed contacts meet. If the attractive force is lower than the reaction force, the contacts float. The process of opening, voltage recovery, closing again, voltage drop and contact floating is repeated at a high frequency, possibly causing the contact to weld or melt.
The MS-N series are designed to balance the attraction and reaction forces, suppress contact chattering and increase contact weld capacity.

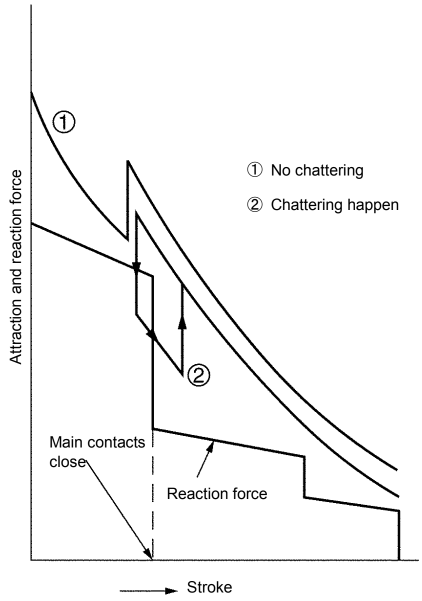
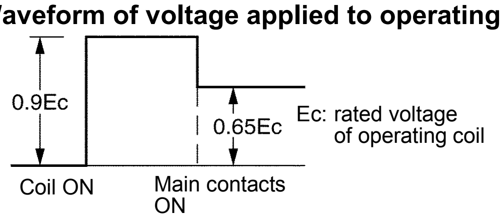


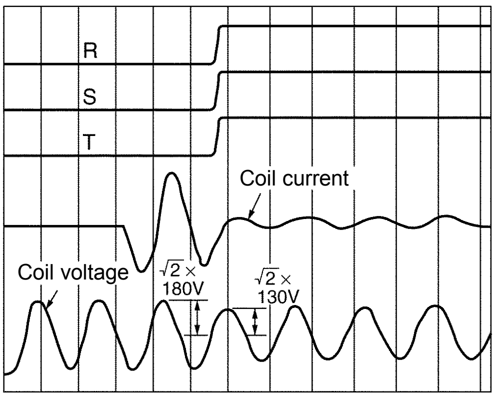
Fig. 4 Characteristics of electromagnet attraction force under voltage drop due to motor starting

(1) Voltage drop test conditions

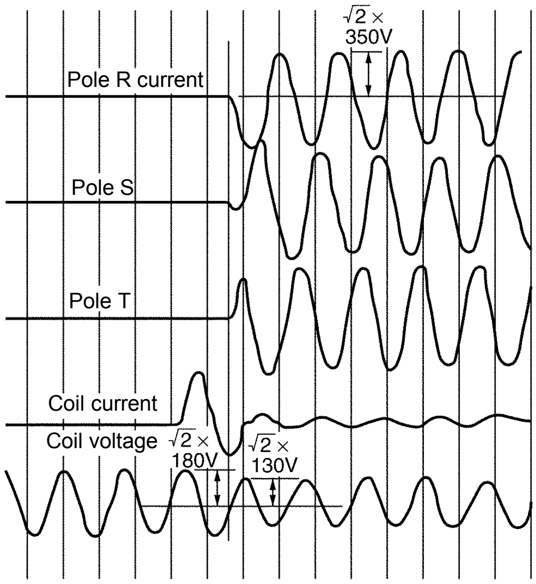
- Making current : 10Ie
  (Ie: rated working current)
- Making operation: 50 times

Waveform of voltage applied to operating coil:





Example of oscillogram of voltage waveform applied to operating coil



Type S-N35 oscillogram for voltage drop making test
(3ø 242V350A Pf 0.37
E1 : 180V60Hz → E2 : 130V60Hz)

(2) Criteria

No contact weld.

(3) Test results

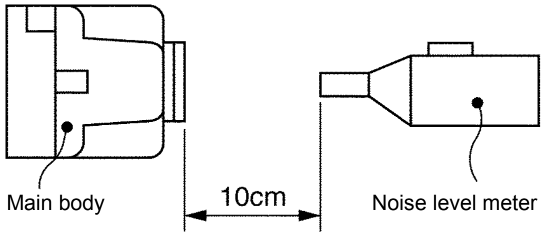
Model name	Test conditions				Test results
	Contact voltage (3øV)	Making current (A)	Operating coil voltage before closing (60Hz V)	Operating coil voltage when closed contact (60Hz V)	
S-N10	484	125	180	130	No welding
S-N11	484	140	180	130	No welding
S-N12	484	140	180	130	No welding
S-N18	484	220	180	130	No welding
S-N20	484	286	180	130	No welding
S-N21	484	286	180	130	No welding
S-N25	484	312	180	130	No welding
S-N35	484	416	180	130	No welding
S-N50	484	550	180	130	No welding
S-N65	484	660	180	130	No welding
S-N80	484	850	180	130	No welding
S-N95	484	1050	180	130	No welding
S-N125	484	1270	180	130	No welding
S-N150	484	1520	180	130	No welding
S-N180	484	1850	180	130	No welding
S-N220	484	2500	180	130	No welding
S-N300	484	3250	180	130	No welding
S-N400	484	4400	180	130	No welding
S-N600	484	6400	180	130	No welding
S-N800	484	8300	180	130	No welding

Note: Nominal rating of the coil: AC200V

4. Noise Characteristics

As a measure to suppress iron core beating, type S-N10 to N35 magnetic contactors use an optimized design and vibration insulation for the electromagnets and type S-N50 to N800 magnetic contactors use DC electromagnet with AC operation. These are referred to as "silent series".

4.1 Noise with contacts closed



Test conditions :
Nominal rating of the coil: AC200V
Soundproof chamber …..background noise 30 dB
Measured 30 times each with "characteristics A Fast"
Devices tested ….. 10 units each

Table 3 Noise with contact closed (dB A Fast)

Type \ Voltage applied to coil	170V 60Hz	200V 60Hz	220V 60Hz
	Average	Average	Average
S-N10 to N18	32	31	31
S-N20/N21	31	31	30
S-N25/N35	31	31	30
S-N50/N65	30	30	30

Note:
Indicates average for 10 units.

4.2 Noise when switching

Table 4 shows the results of measuring switching noise at 220V 60Hz at a 10 cm distance with other conditions same as those in section 4.1.

Table 4 Noise when switching

	N20/N21	N25/N35	N50/N65	N80/N95
Closing	90	90	98	98
Opening	84	86	98	98

(Test specimen)
4 units each
(dB characteristics A Fast)

4.4 Summary

It is concluded that the frames of S-N50 or larger using a DC electromagnet with AC-operation has no problem with iron core beating. The performance of type S-N20 to N35 are significantly improved against iron core beating due to pole gaps or unfavorable environments. They are characterized as stable models without unforeseen beating.
The switching noise data may appear great as it is measured at a 10 cm distance. Actually, however, the noise levels of type N20 to N35 are the same or lower and of type N50 or larger are significantly reduced compared with the existing Mitsubishi models.

5. Switching Impact

When switching a magnetic motor starter or a magnetic contactor installed in a control panel, the kinetic energy is converted into impact energy at the stop of the movable mechanism. This causes vibration as shown in Fig. 5. The vibration may be transmitted to other control devices in the control panel, possibly causing them to function incorrectly. Since the magnitude (acceleration and frequency) of the vibration depends on the switching magnitude of the magnetic contactor and the control panel specifications (rigidity, number and locations of devices installed, etc.), it is difficult to judge the malfunction possibility without measuring vibration in each case. For the MS-N series, impact accelerations and observation of relay contact malfunction are tested on the standard panel as shown in Fig. 6.

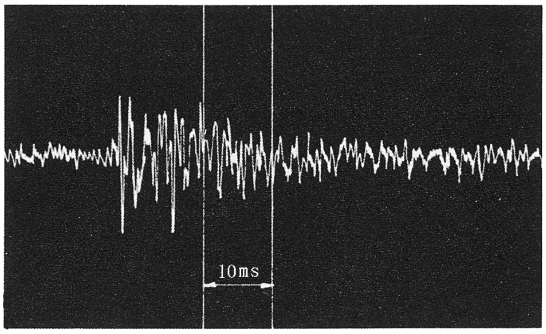


Fig. 5 Vibration waveform of control panel due to switching impact

Switching impact values

(Acceleration m/s^2 at frequencies ranging from 0 to 2,000 Hz)

Model name	200V 50Hz	220V 60Hz
S-N20, N21	14.7~19.6	9.8~14.7
S-N25, N35	14.7~19.6	9.8~14.7
S-N50, N65	14.7~19.6	14.7~24.5
S-N80, N95	19.6~29.4	24.5~39.2
S-N125	29.4~49.0	29.4~58.8
S-N150	29.4~49.0	29.4~58.8
S-N180, N220	49.0~78.4	58.8~88.2
S-N300, N400	49.0~78.4	58.8~88.2
S-N600, N800	118~137	176~206

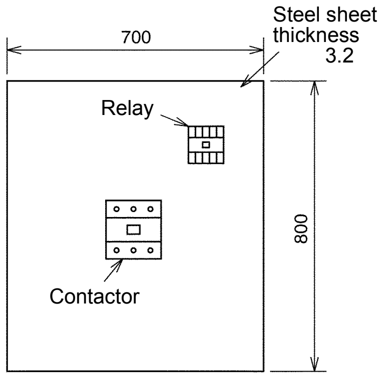


Fig. 6 Standard panel for switching impact test

Contact malfunction of other devices due to transmitted switching impact

Impact source		S-N20 to N800 (with 220V 60Hz applied to AC200V coil)
Subject of impact	**SR relay**	SR-N8 4NO + 4NC
	TH thermal overload relay	TH-N12 to N120 Applied with 100% of set current, temperature saturated.
Results	**SR relay**	No NC contact malfunction
	TH thermal overload relay	TH-N12: No NC contact malfunction on S-N20 to N220. TH-N20 to N120: No NC contact malfunction on S-N20 to N400.

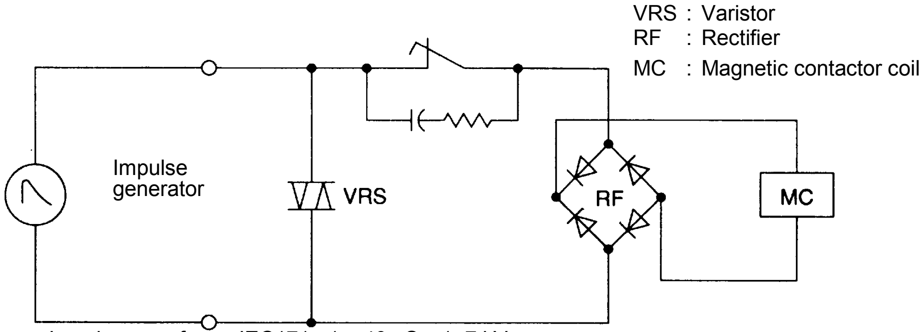
6. Protective Characteristics of DC Electromagnet with AC-operation on type S-N50 to N800 Magnetic Contactors Against External Surge

A surge protective characteristics test is conducted on a silicon rectifier equipped with a surge protection varistor. The results are summarized below.

6.1 Test specimen

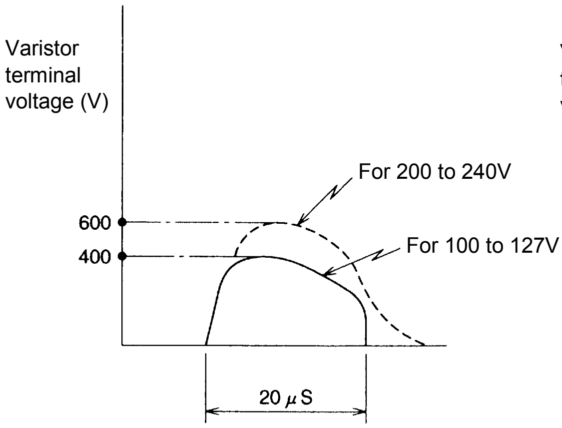
Circuit voltage	Silicon rectifier	Varistor	Applicable type
100 - 127VAC	1A silicon rectifying device V RRM = 600V	NV 270D14 (made by NEC) Varistor voltage : 270V	S-N50 to N95
	3A silicon rectifying device V RRM = 600V		S-N125 to N400
200 - 240VAC	1A silicon rectifying device V RRM = 800V	NV 470D14 (made by NEC) Varistor voltage : 470V	S-N50 to N400

6.2 Test circuit

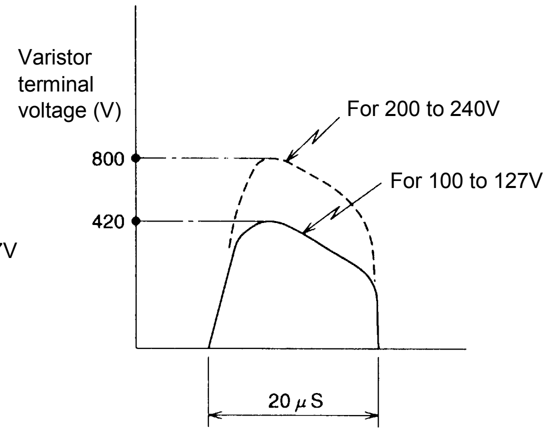


Impulse waveform: JEC171 ±1 × 40 µS 1~7 kV

6.3 Results



Impulse generator adjusted to 1 kV

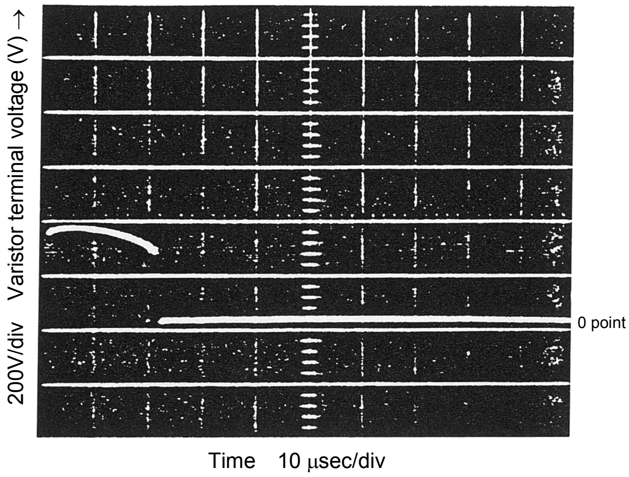


Impulse generator adjusted to 7 kV

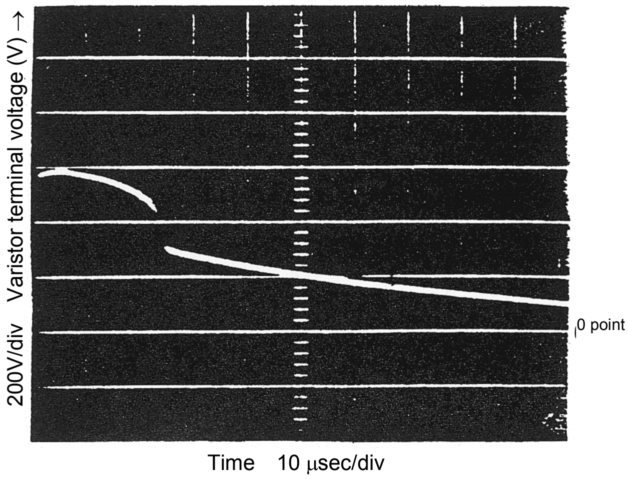
Both devices for 100 to 127V and 200 to 240V application are protected without problem against impulse of 1 to 7 kV. The waveform of the varistor terminal voltage after surge absorption is shown on page 43.

(1) Impulse generator output 1kV

For 100 to 127V

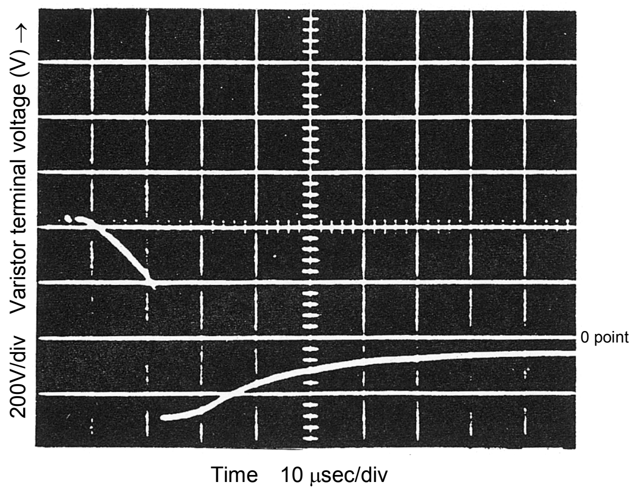


For 200 to 240V

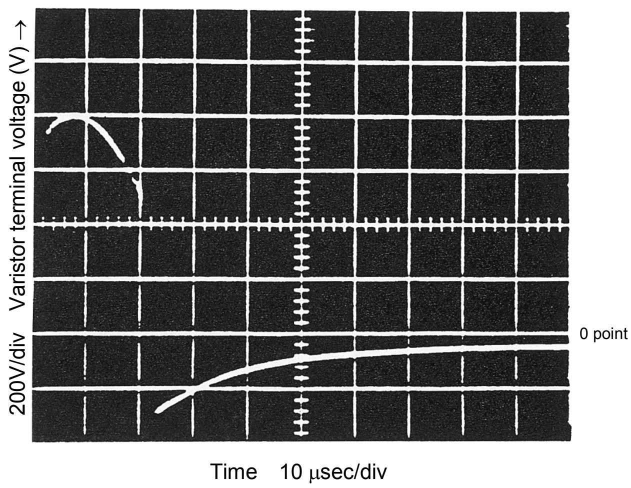


(2) Impulse generator output 7kV

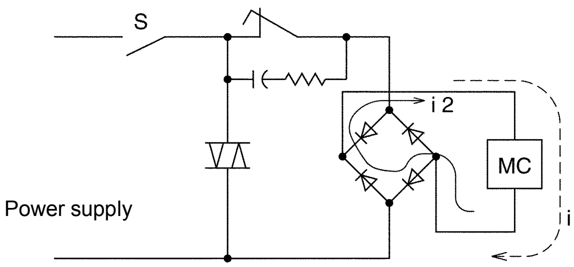
For 100 to 127V



For 200 to 240V



6.4 Surge generation due to switching coil



When breaking the exciting current of a coil (MC), the surge generated in the coil (MC) is a forward current with respect to the rectifier in the direction of i2 shown in the left figure. No surge is therefore generated on the power supply side.

Selection

1. Application for 3 phase Squirrel-cage Motor

1.1 Application for full voltage starting method of 3 phase squirrel-cage motor

(1) Selection of frame size of magnetic starter or contactor

Full voltage starting method is the most general, economical starting method of squirrel-cage motor. In JEM, JIS, IEC utilization category are prescribed AC-3 for starting and switching off motors during running, and AC-4 for starting, plugging, jogging..
For the frame selection for magnetic starters and contactors from the rated output of squirrel-cage motors, it is necessary to know.

- Utilization category
- Intermittent duty
- Required endurance
- Value of the starting current

However, as the type MS-N has a category AC-3 rated capacity, an intermittent duty of 1800 to 1200 operations/hour, and an electrical life of 1,000,000 to 500,000 times, it represents the highest class in the standard, and for standard duty in most cases the frame can be selected as [rated motor output] = [rated magnetic starter, contactor capacity]. In case of jogging duty or plugging, an inrush current of several times of the full load curent of the motor is switched, and the electrical endurance is reduced considerably, so that it is necessary to use a large frame to obtain the rewuired endurance. The current (capacity)/endurance curves for standard duty only and for jogging duty only are shown in Fig. 1. For standard duty with a slight amount of jogging, the contact wear amount is roughly proportional to the square of the breaking current, so that the endurance can be obtained as follows:

$$N = \frac{Nr}{1 + \frac{\alpha}{100}\left(\frac{Nr}{N_1} - 1\right)} \quad \cdots\cdots\cdots\cdots \quad (1)$$

with
N : Endurance with α% of jogging operation
Nr : Endurance with category AC-3 rating,
N_1 : Endurance with 100% jogging operation
α : Rate of jogging =(Number of jogging operations $\times$ 100)/(number of standard operations+ number of jogging operations) (%)

From this, the contactor frame size [rated capacity Po (kW)] for a motor of P (kW) with a ratio of α (%) of jogging operation and a required kife of N (times) can be obtained by the following equation. However, the starting current of the motor of P (kW) shall be β times of the total load current.

$$Po = P\sqrt{\frac{Nr}{N_1}\left\{1 + \frac{\alpha}{100}(\beta^2 - 1)\right\}} \quad \cdots\cdots\cdots\cdots \quad (2)$$

Example: Select the contactor frame for 500,000 switching cycles with operation including 30% inching for 220V, 7.5kW (full load current 28A, starting current 168A).

According to equation (2): P = 7.5 (kW), β = 168/28 = 6, α = 30 (%), Nr = 1,000,000 times, N = 500,000 times.

$$Po = 7.5\sqrt{\frac{50}{100}\left\{1 + \frac{30}{100}(6^2 - 1)\right\}} = 18 \text{ (kW)}$$

so that a frame of 220 to 240V, 18kW, e.g. MSO-N80 or S-N80 should be selected.

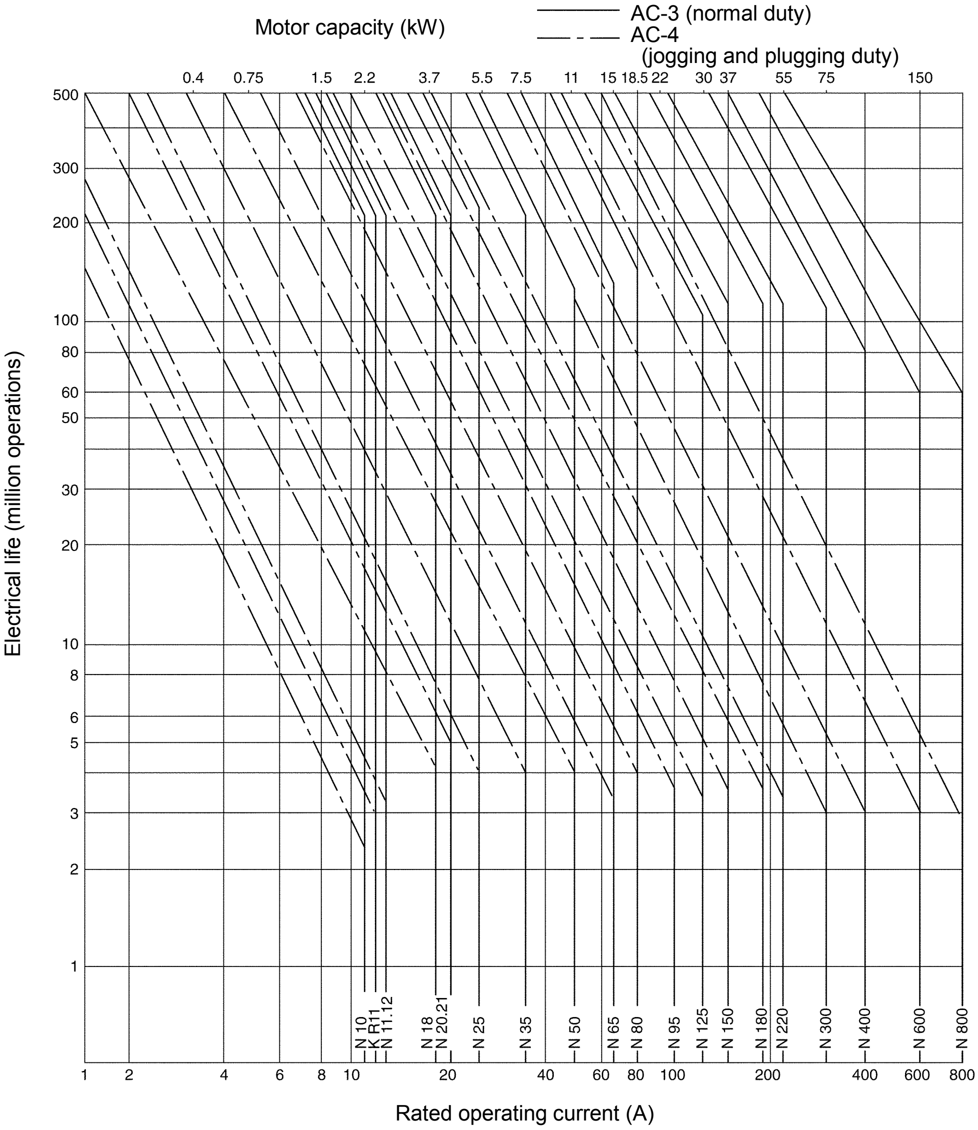


Fig. 1 Full load current (rated operational current) (A)
3-phase, 220V (for β=6)

(2) Motor reversing or plugging

Reversing type magnetic starters and contactors are used for motor reversing or plugging; and for changing between forward and reverse operation it is required that arcs are completely extinguished before the contacts of the opposite side contactor are closed. The time between the extinguishing of this arc and closing of the contacts is called deenergized margin time, and for reversing type it is necessary to pay attention to this time. For the MS/MSO/S-2xN series up to 440V, this deenergized margin time is sufficiently long, and phase short-circuits at the time of change-over do not occur. For circuit voltages of 500V or more, the margin time is short, and change-over should be executed via type SR contactor relays. (Refer to the connection diagram of Fig. 2)

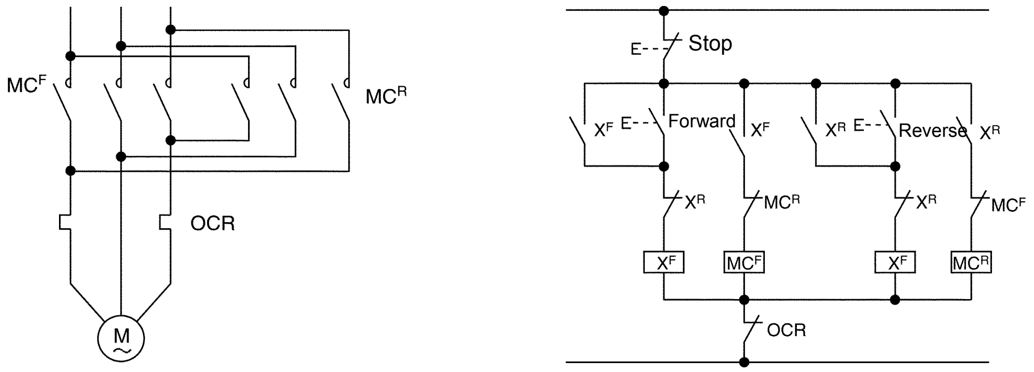
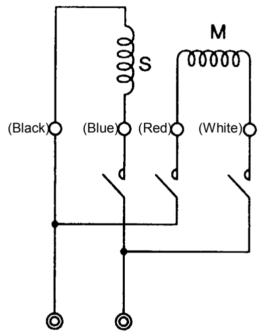


Fig. 2 Application circuit over 500V

1.2 Reversing for single-phase motors

A single-phase motor can be made reverse driving by reversing magnetic contactors, by changing connection of either the main coil or the starting (auxiliary) coil.



M: Main coil
S: Starting coil (auxiliary coil)

Fig. 3 Forward connection

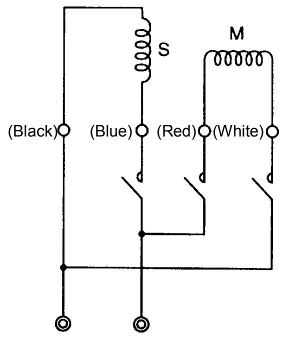
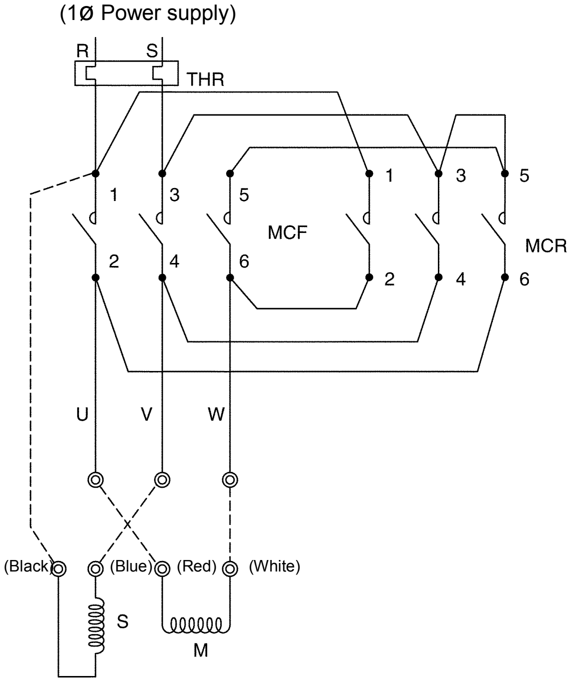


Fig. 4 Reverse connection



THR : Thermal overload relay
MCF : Magnetic contactor for forward driving
MCR : Magnetic contactor for reverse driving

Fig. 5 Connection diagram of reverse driving for single-phase motor by reversing magnetic contactors

1.3 Application to direct current motors

As the performance required for magnetic contactors in controlling DC motors, IEC standards define the making capacity, breaking capacity and electrical endurance as shown in the table below.

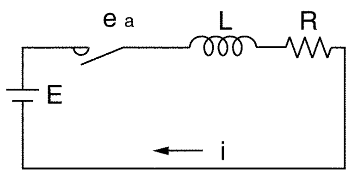
Table 1

Application	Utilization category	Making/breaking capacity		Electrical endurance	
		Making	Breaking	Making	Breaking
Shunt-wound motors: starting, plugging, reversing, inching, dynamic breaking	DC-3	4Ie, 1.1Ee, L/R 2.5ms	4Ie, 1.1Ee, L/R 2.5ms	2.5Ie, Ee, L/R 2ms	2.5Ie, Ee, L/R 7.5ms
Series-wound motors: starting, plugging, reversing, inching, dynamic breaking	DC-5	4Ie, 1.1Ee, L/R 15ms	4Ie, 1.1Ee, L/R 15ms	2.5Ie, Ee, L/R 7.5ms	2.5Ie, Ee, L/R 7.5ms

Note: Ie: Rated operational current, Ee: rated operational voltage, L/R: time constant

In general, alternating current magnetic contactors are designed for driving the three-phase induction motors. Therefore most magnetic contactors have three-pole configuration. Despite this construction, the AC magnetic contactors can be used as the magnetic contactors for direct current motors. An AC circuit is opened when the current passes through the zero point. However, since no zero-current point exists in the DC circuit, it is necessary to reduce the current by the arc voltage generated between the contacts to open the circuit.
When the contacts in the L-R circuit opens as shown on the right figure, the circuit equation is expressed as follows:

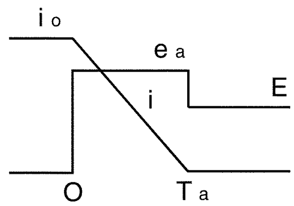
$$L \frac{di}{dt} + Ri + e_a = E$$



Assuming that arc voltage e_a is constant as shown in the figure:

$$i = i_o - \frac{e_a}{E} i_o (1 - \varepsilon^{-t/\tau})$$

Where, $i_o = E/R$, $\tau = L/R$



Arc time Ta is expressed as follows:

$$Ta = \frac{L}{R} \log \frac{e_a}{e_a - E}$$

As the arc voltage increases, the arc time reduces. As the time constant L/R increases, the arc time increases. For type S-N and SD-N, the arc voltage for one pole is 60 to 120V. Type S-N and SD-N can be applied to DC motors and used for the ratings shown in Table 2 if the contacts are connected 2- or 3-pole series.

Table 2 DC ratings

Model name	Rated voltage (VDC)	Operational current for category DC-3 and DC-5 (A)	
		2-pole series	3-pole series
S-N10	24	8	8
	48	4	6
	110	2.5	4
	220	0.8	2
S SD -N11, N12 S-N18	24	12	12
	48	6	10
	110	4	8
	220	1.2	4
S-N20 S SD -N21	24	20	20
	48	15	20
	110	8	15
	220	2	8
S-N25 (S SD -N35)	24	25 (35)	25 (35)
	48	20	25 (30)
	110	10	20
	220	3	10
S SD -N50, N65	24	45	50
	48	25	35
	110	15	30
	220	3.5	12
S SD -N80	24	65	80
	48	40	60
	110	20	50
	220	5	20
S SD -N95	24	93	93
	48	60	90
	110	40	80
	220	30	50
S SD -N125	24	120	120
	48	60	90
	110	40	80
	220	30	50
S SD -N150	24	150	150
	48	100	130
	110	80	120
	220	60	80
S-N180 (S SD -N220)	24	180 (220)	180 (220)
	48	150	180 (220)
	110	120	150
	220	80	100
S SD -N300 (N400)	24	300 (400)	300 (400)
	48	200	280
	110	150	200
	220	90	150
S SD -N600 (N800)	24	630 (800)	630 (800)
	48	630	630
	110	630	630
	220	630	630

Note: 1. Type SD does not have N10, N18, N20, N25 or N180.
2. Making/breaking capacity is 4 times the rated operational current.

1.4 Application for submergible motors

Water sealed types are presently the mainstream configuration for submergible motors. Water sealed type can be classified by insulation system into the watertight insulation wire system, resin molding type and the canned type, which currently accounts the most. Since the motor coil wires of the water sealed type are sealed so that they are not exposed to water, the over current capacity of the coil is generally smaller than that of the general purpose squirrel cage motors. For resin molding type in particular, the over current capacity of the motor is less than other type so that cracks in the resin due to abnormal temperature rise will not deteriorate the insulation.
Since the submergible motors are often used for civil engineering or treatment of sewage, overload or locked rotor accident are sometimes happened by penetration of mad and gravel. If failed in case of deep well pumps, it may take a lot of labor and time for repair or exchanging.
From these viewpoints, the surest means should be taken to protection for submergible motor. Type TH-N☐FS and TH-N☐KF thermal overload relays (which have simple structure with bimetal strips) have suitable characteristics of protection for submergible motors. (; overload, rocked rotor or phase failure.)
Their characteristics are as follows.

(a) They do not operate at 105% of the full load current of the motor and operates at 120% of the full load current, like general-purpose thermal overload relays. (ambient temperature 20°C).
(b) Operates within 5 seconds when 500% of the full load current of the motor is applied. (from cold state)
(c) Operates within one minute when 200% of the full load current of the motor is applied. (from hot state)
(d) With the ambient temperature compensation function. (the thermal overload relay characteristics are independent from the ambient temperature variation.)
(e) Type TH-N☐FS: Two heater type.
Type TH-N☐KF: Tree heater type with phase failure protection.
(f) Auxiliary contact: 1NO+1NC

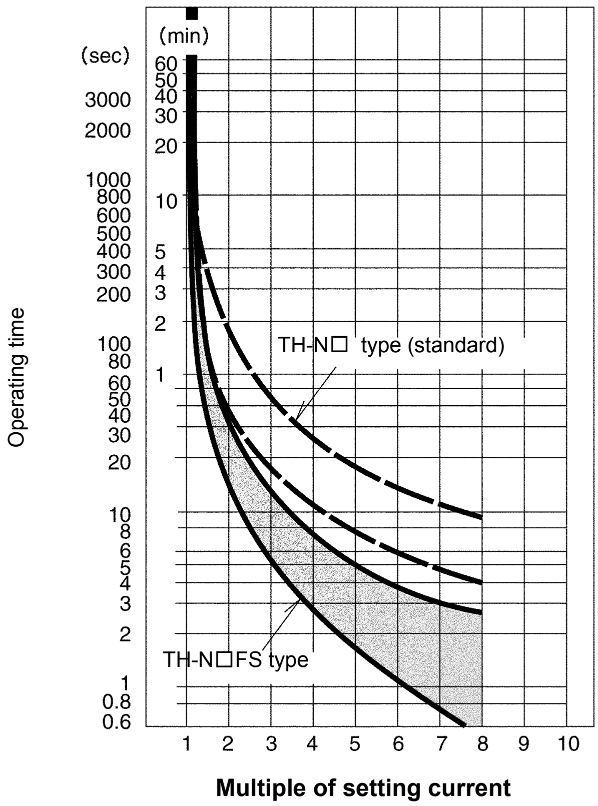


Table 3 Kind

Model name	Heater designation (heater setting range) (A)
TH-N12KF	2.1 (1.7~2.5), 3.6 (2.8~4.4), 5 (4~6), 6.6 (5.2~8), 9 (7~11), 11 (9~13)
TH-N20KS TH-N20KF	2.1 (1.7~2.5), 3.6 (2.8~4.4), 5 (4~6), 6.6 (5.2~8), 9 (7~11), 11 (9~13), 15 (12~18)
TH-N20TAFS TH-N20TAKF	22 (18~26), 29 (24~34), 35 (30~40)
TH-N60FS TH-N60KF	42 (34~50), 54 (43~65)
TH-N60TAKF	67 (54~80), 82 (65~93)

2. Application for Resistive Loads

In applying magnetic contactors to resistive loads such as electric heaters and resistors, the specifications define the duties as follows:

Table 4

Application	Utilization category	Making/breaking capacity		Electrical endurance	
		Making	Breaking	Making	Breaking
Switching AC resistive load	AC-1	1.51Ie, 1.1Ee, cosø 0.95	1.51Ie, 1.1Ee, cosø 0.95	Ie, Ee, cosø 0.95	Ie, Ee, cosø 0.95
Switching DC resistive load	DC-1	1.1Ie, 1.1Ee, L/R 1ms	1.1Ie, 1.1Ee, L/R 1ms	Ie, Ee, L/R 1ms	Ie, Ee, L/R 1ms

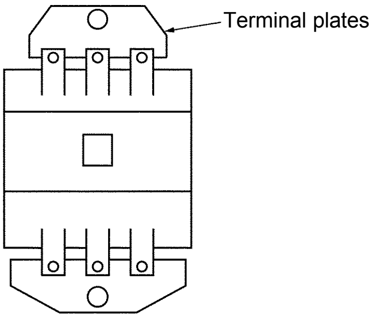
Note: Ie: Rated operational current, Ee: Rated operational voltage, cosø: Power factor, L/R: Time constant

Table 5 shows the ratings of the S-N series when applied to resistive loads.

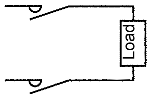
Table 5

Application / Model name	Rated operational current for AC-1 (A)		Rated capacity for AC-1 3-phase resistance (kW)		Rated operational current for AC-1 3-pole parallel (A)	Rated operational current for DC-1, 3-pole series (2-pole series) (A)		
	220~220V	400~440V	200~220V	400~440V	100 ~ 220V	48V	110V	220V
S-N10	20	11	6.5	8	40	10 (10)	8 (6)	8 (3)
S-KR11	20	11	6.5	8	40	10 (10)	8 (6)	8 (3)
S SD -N11, N12	20	13	6.5	10	40	12 (12)	12 (10)	12 (7)
S-N18	25	20	9	14	50	18 (18)	18 (13)	18(8)
S-N20 S SD -N21	32	32	11	22	65	20 (20)	20 (15)	20(10)
S-N25	50	50	17	34	100	25 (25)	25 (25)	22 (12)
S SD -N35	60	60	20	40	120	35 (35)	35 (25)	30 (12)
S SD -N50	80	80	27	55	160	50 (40)	50 (35)	40 (15)
S SD -N65	100	100	34	68	200	65 (40)	65 (35)	50 (15)
S SD -N80	135	135	46	92	270	80 (65)	80 (50)	60 (20)
S SD -N95	150	150	50	100	300	93 (93)	93 (80)	70 (50)
S SD -N125	150	150	50	100	330	120 (100)	100 (80)	80 (50)
S SD -N150	200	200	65	130	400	150 (120)	150 (100)	150 (100)
S-N180	260	260	90	180	520	180 (180)	180 (150)	180 (150)
S SD -N220	260	260	90	180	520	220 (180)	220 (150)	220 (150)
S SD -N300	350	350	120	240	700	300 (240)	300 (200)	300 (200)
S SD -N400	450	450	155	310	800	400 (240)	400 (200)	400 (200)
S SD -N600	660	660	220	440	1200	630 (630)	630 (630)	630 (630)
S SD -N800	800	800	270	540	1600	800 (800)	800 (630)	800 (630)

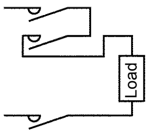
For three-pole parallel, use the following terminal plates to have uniform temperature rise among the poles.



Use the following connection for two- and three-pole series for DC application.



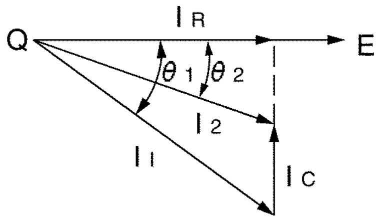
2-pole series



3-pole series

3. Application for Capacitor Loads

Where magnetic contactors are applied to capacitor loads, it is mainly for switching capacitor circuits for phase advance (power factor improvement). The capacitor capacity necessary for improving the load power factor from cos θ_1 to cos θ_2 is calculated as follows.



E : Voltage
I_1 : Current before phase advance
I_2 : Current after phase advance
I_c : Current for phase advance
I_R : Active component of load current
cos θ_1 : Power factor before phase advance
cos θ_2 : Power factor after phase advance
Q : Required capacitor capacity

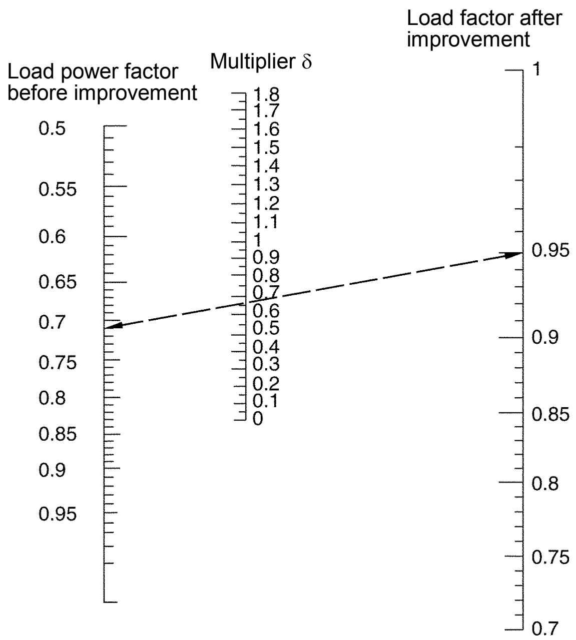
$$Q = EI_c = EI_R\,(\tan\theta_1 - \tan\theta_2) = EI_R\left(\sqrt{\frac{1}{\cos^2\theta_1} - 1} - \sqrt{\frac{1}{\cos^2\theta_2} - 1}\right) \quad \text{............ (1)}$$

(Calculation example)

Given the load of load power factor cos θ_1 = 0.7 and capacity EI_R=100 kW, capacity Q (kvar) of the capacitor to improve the power factor to cos θ_2 = 0.95 is calculated as follows.

$$Q = 100\left(\sqrt{\frac{1}{0.7^2} - 1} - \sqrt{\frac{1}{0.95^2} - 1}\right) = 100 \times 0.69 = 69 \text{ (kvar)}$$

Equation (1) is expressed in the diagram below.



Use example:

To improve the load power factor 0.7 of capacity 100 kW to power factor 0.95, first determine the multiplier δ =0.69 according to this diagram.
Required capacitor capacity Q (kvar)
= (load kW) × δ, Q = 100 × 0.69 = 69 kvar

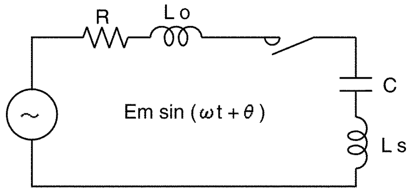
Use of a condensive capacitor causes strain in the voltage and current waveforms. Since the strain increases noise in equipment such as motors and transformers, a series reactor of 6% of capacitor reactance is installed to suppress voltage and current strain by 5th high harmonics. Since the series reactor not only improves the waveforms but restrain the rush current during closing, it should be used in all capacitor circuits.
The following paragraphs discuss the phenomenon related to switching capacitors by magnetic contactors.

(1) Making capacitors

If the capacitor is not with a series reactor, the rush current dependent on the line impedance will be several times to ten-fold, being too hard for the magnetic contactors.
Ignoring R in the circuit shown in the figure, the maximum rush current will be expressed as follows.

$$\mathrm{imax} = \left(\frac{1}{\omega \sqrt{(\mathrm{Lo} + \mathrm{Ls})\,C}} + 1 \right) \mathrm{Im}$$

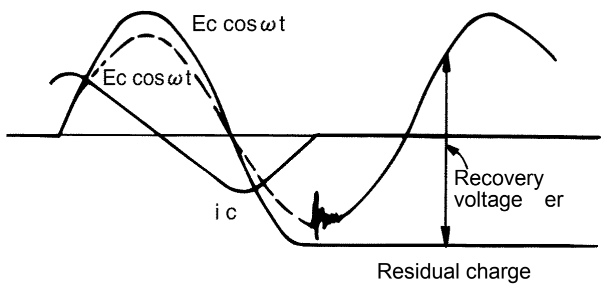
$$\mathrm{Im} = \frac{\mathrm{Em}}{\sqrt{R^2 + \omega^2 L^2 + \frac{1}{\omega^2 C^2}}} \fallingdotseq \frac{\mathrm{Em}}{\sqrt{\omega^2 \mathrm{Ls}^2 + \frac{1}{\omega^2 C^2}}}$$



If a series reactor is provided, Lo<L and ω^2LC=0.06, the maximum rush current is approximately 5 times the steady state current.

(2) Breaking capacitors

When breaking the capacitor circuit, the arc is extinguished easily because the voltage between the contacts of the magnetic contactor is low due to residual electric charge in the capacitor. However, if the insulation recovery between the contacts cannot follow the sudden recovery of the voltage that appears later, re-striking occurs.
See the figure on the right. When breaking, electric charge having the wave height of the voltage remains in the capacitor terminals. The recovery voltage appearing between the contacts after breaking is defined as the difference between the capacitor residual charge and the power supply voltage. The voltage between the contacts is small at the time of breaking. It will reach approximately 2 times the power supply voltage in 0.5 cycle after breaking.



If the insulation recovery characteristics between the contacts are below this level, arc re-striking occurs. The re-striking causes the capacitor overvoltage to reach approximately 3 times the steady state voltage and the re-striking current to reach several tens of times of the steady state current, adversely affecting the system. If a series reactor (6%) is provided, the re-striking current is suppressed to approximately 9 times or less.
From the discussion above, in introducing a condensive capacitor, use a series reactor or make sure that the maximum rush current is below the category AC-3 making current carrying capacity of the magnetic contactors. Table 6 shows the ratings where the type S-N magnetic contactors are used for switching capacitors.

Decreasing the size of the series reactor to be installed causes the rush current to increase, requiring magnetic contactors with higher ratings. Fig. 6 shows the rate of increase of the magnetic contactor rated current in relation to reduction in the reactor capacity from 6%. (Example: Assume that a frame of AC-3 rated current 100A is selected for a series reactor 6%. If the series reactor is reduced to 4%, the upper frame of 125A capacity is selected - 100 × 1.2 = 120A.

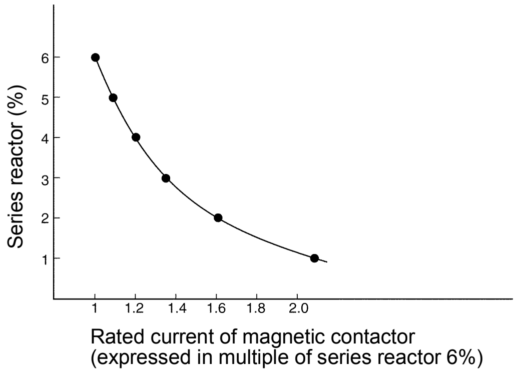


Fig. 6

(3) Standard for installing low voltage power capacitors

Table 6 200V three-phase motor (one motor configuration)

Motor capacity (kW)		0.2	0.4	0.75	1.5	2.2	3.7	5.5	7.5	11	15	18.5	22	30	37	45	55
Installation capacity μF(kvar)	50Hz	15 (0.19)	20 (0.25)	30 (0.38)	40 (0.50)	50 (0.63)	75 (0.95)	100 (1.3)	150 (1.9)	200 (2.5)	250 (3.2)	300 (3.8)	400 (5.0)	500 (6.3)	600 (7.6)	750 (9.5)	900 (11.3)
	60Hz	10 (0.15)	15 (0.23)	20 (0.30)	30 (0.45)	40 (0.60)	50 (0.76)	75 (1.2)	100 (1.5)	150 (2.3)	200 (3.0)	250 (3.9)	300 (4.5)	400 (6.0)	500 (7.6)	600 (9)	750 (11.3)

Notes:
1. Capacitors used are according to JIS C 4901 "Low-Voltage Power Capacitors".
2. The installation capacities (μF) indicate the full capacitance of capacitors.
3. The installation capacities (kvar) indicate the rated capacities of capacitors calculated by the following equation.

   $\text{kvar} = 2\pi fcE^2 \times 10^{-9}$

   f : Rated frequency .... (Hz)
   c: Full capacitance
   (Rated capacitance).... (μF)
   E: Rated voltage .... (V)

4. The rated current (condensive current) is calculated as follows.

   Rated current (A) = . $\frac{2\pi}{\sqrt{3}} fcE \times 10^{-6}$ for three-phase capacitors

Table 7 200VAC arch welding machines

Maximum input (kvar)	3 or greater	5 or greater	7.5 or greater	10 or greater	15 or greater	20 or greater	25 or greater	30 or greater	35 or greater	40 or greater	45 or more and less than 50
Installation capacity μF (kvar)	100 (1.5)	150 (2.3)	200 (3.0)	250 (3.9)	300 (4.5)	400 (6.0)	500 (7.6)	600 (9)	700 (10.6)	800 (12.1)	900 (13.6)

Notes:
1. Capacitors used are according to JIS C 4901 "Low-Voltage Power Capacitors".
2. The installation capacities (μ F) indicate the full capacitance of capacitors.
3. The installation capacities (kvar) indicate the rated capacities of capacitors calculated by the following equation. (For 60 Hz)

   $\text{kvar} = 2\pi fcE^2 \times 10^{-9}$

   f : Rated frequency .... (Hz)
   c: Full capacitance
   (Rated capacitance).... (μF)
   E: Rated voltage .... (V)

4. The rated current (cendensive current) is calculated as follows.

   Rated current (A) = $2\pi fcE \times 10^{-6}$ for single-phase capacitors

(4) Application of magnetic contactors (magnetic motor starters) for motor loads including capacitors

For circuits containing low-voltage power capacitors to improve the power factors of loads (motors), selection of magnetic motor starters and contactors is summarized as follows.

① Installation of low-voltage power capacitors

a. Installation capacity standard
See Table 6 above.

b. Cautions on installation
1) The capacitor capacity is not to be larger than the reactive component of the load.
2) The capacitor is to be installed between the local switch or the equivalent device and the load.
3) Use of a capacitor equipped with a discharge resistor.

② Selection of magnetic contactors
To suppress rush current at the time of closing the circuit, it is favorable for the capacitor to be equipped with a series reactor. It is generally not the case for small capacity motors. Absence of a series reactor causes a large rush current to flow across the contacts of the contactor when closing the circuit, possibly reducing the contact life. Selection of magnetic contactors should consider such an event.

③ Location of capacitor and setting current of thermal overload relay
The positions to connect the capacitor for power factor improvement are as shown in Fig. 7 (a), (b) and (c).

a. For Fig. 7 (a) and (b)
The current flowing through the thermal overload relay becomes equal to the motor current. Therefore, set the thermal overload relay to the value equal to the full load current of the motor.

b. Fig. 7 (c)
Since current I_{TH} running through the thermal overload relay is smaller than current I_M running through the motor, set it as follows.
Assuming that capacitor current is Ic, motor power factor $\cos\theta_1$ and circuit power factor $\cos\theta_2$ after installing a condensive capacitor, as shown in Fig. 7 (d), the following equation is given.

$I_{TH} = I_M \times (\cos \theta_1 / \cos \theta_2)$

Therefore, set the thermal overload relay as follows.

Thermal overload relay setting current = motor full load current × ($\cos\theta_1 / \cos\theta_2$)

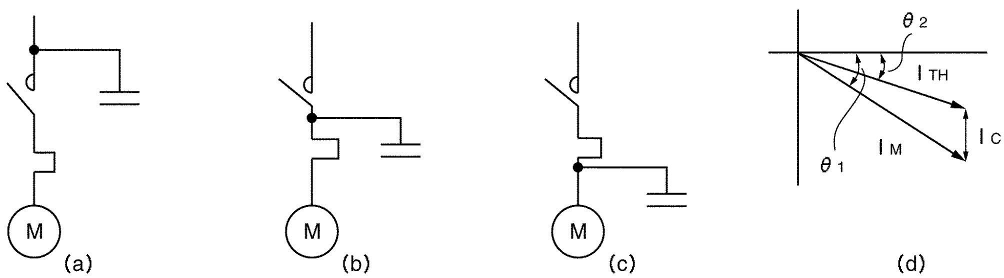


Fig. 7 Location of capacitors

(5) Application of magnetic contactors to capacitor loads (with rush current equal to or less than 20 times)

Table 8

Model name	Application capacity to 3-phase capacitor circuit kvar (A)				Application capacity to single-phase capacitor circuit kvar (A)			
					Single-pole use		3-pole series use	
	200~220V	400~440V	500V	600V	200~220V	400~440V	500V	600V
S-N11, N12	3 (9)	4 (6)	–	–	1.8 (9)	2.4 (6)	–	–
S-N18	4 (12)	6 (9)	–	–	2.4 (12)	3.6 (9)	–	–
S-N20, N21	5 (15)	10 (15)	–	–	3 (15)	6 (15)	–	–
S-N25	8.5 (25)	16 (24)	–	–	5 (25)	9.6 (24)	–	–
S-N35	11 (32)	20 (30)	–	–	6.4 (32)	12 (30)	–	–
S-N50	15 (45)	27 (40)	30 (35)	30 (30)	9 (45)	16 (40)	25 (50)	30 (50)
S-N65	17 (50)	34 (50)	35 (40)	35 (35)	10 (50)	20 (50)	27 (55)	33 (55)
S-N80	20 (65)	40 (60)	50 (55)	50 (50)	13 (65)	24 (60)	35 (70)	42 (70)
S-N95	30 (90)	60 (90)	60 (70)	60 (60)	18 (90)	36 (90)	40 (80)	48 (80)
S-N125	34 (100)	69 (100)	65 (75)	65 (65)	20 (100)	40(100)	42 (85)	50 (85)
S-N150	45 (130)	90 (130)	80 (95)	80 (80)	26 (130)	52 (130)	55 (110)	60 (105)
S-N180/N220	60 (180)	120 (180)	150 (170)	150 (150)	36 (180)	72 (180)	100 (200)	120 (200)
S-N300	85 (250)	170 (250)	200 (230)	200 (200)	50 (250)	100 (250)	120 (250)	130 (220)
S-N400	100 (300)	200 (300)	250 (290)	200 (200)	60 (300)	120 (300)	150 (300)	140 (250)
S-N600	170 (500)	350 (500)	350 (400)	400 (400)	100 (500)	200 (500)	250 (500)	300 (500)
S-N800	170 (500)	350 (500)	350 (400)	400 (400)	100 (500)	200 (500)	250 (500)	300 (500)

Note: When switching the capacitors listed in the table above, the electrical switching durability is approximately 200,000 cycles.

(6) Self-excitation of induction motors

The power factors of induction motors are in the range of 75% to 85% in general. Since this creates a large lagging load, a capacitor is installed to improve the power factor. Where induction motors and capacitors are connected directly on the load side of the switch, the circuit voltage after opening the switch does not reach zero immediately but increases abnormally or the voltage takes too much time to subside. This phenomenon is called self-excitation.

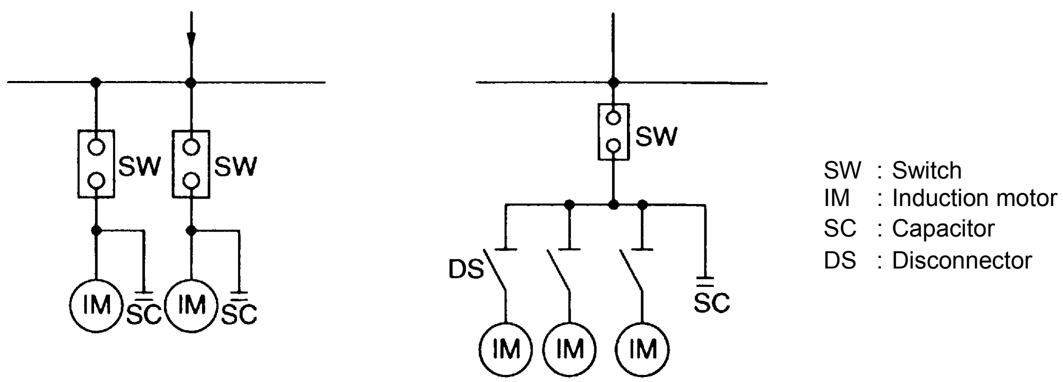
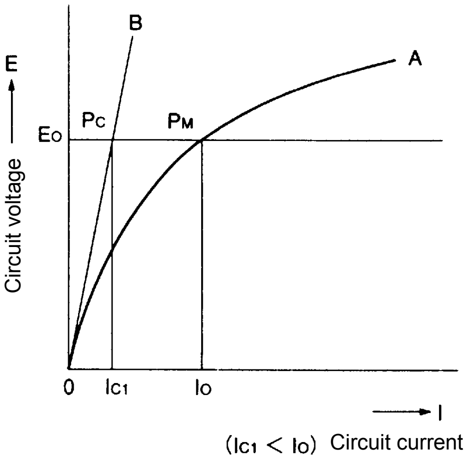


Fig. 8

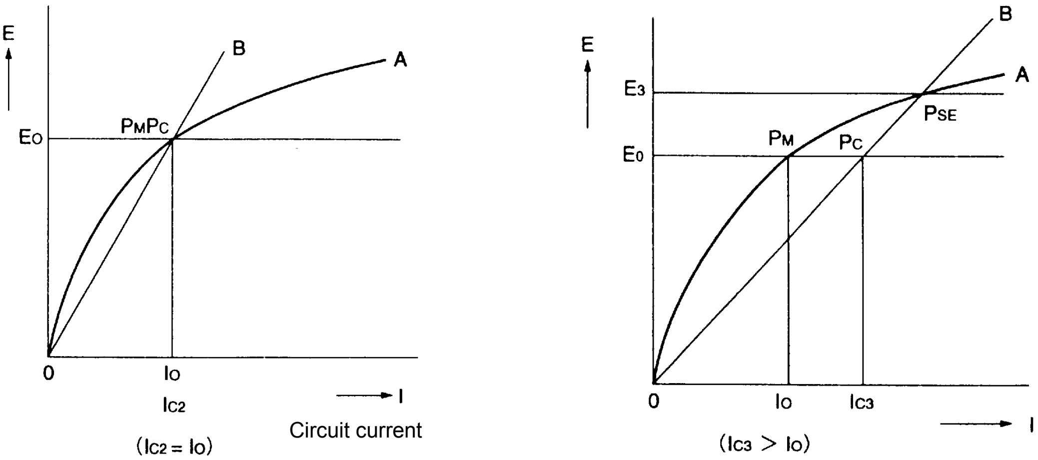
a) Causes

This section discusses the change in the bus line voltage when an induction motor and a capacitor being connected in parallel with the other are isolated from the power supply. Assuming that the capacitor currents immediately before the isolation are Ic_1 to Ic_3 and the induction motor excitation current is Io.

In cases ①, ② and ③ in Fig. 9, curve A and line B indicate the no-load saturation curve of the induction motor and the current-voltage characteristics of the capacitor, respectively. It is assumed that the induction motor and the capacitor operate at P_M and Pc respectively at rated voltage Eo.



① Without self-excitation



② At threshold of self-excitation **③ With self-excitation**

Fig. 9

① Without self-excitation (Ic_1<Io)
When the capacity of the capacitor is smaller than the no-load excitation capacity of the induction motor, the induction motor will not by excited by the power supply after it is isolated from the power supply. Instead, it is excited by the charge current in the capacitor circuit, operating as an induction generator.
In the beginning, the induction motor rotates at approximately the rated rotational speed due to inertia force. Since there is no power input, the rotational speed decreases gradually due to various losses. The voltage and rotational speed reduce toward the intersection of curve A and line B (where the voltage and current are zero).

② At threshold of self-excitation (Ic_2 = Io)
When the capacity of the capacitor is equal to the no-load excitation capacity of the induction motor (with the no-load power factor improved to 100%), the induction motor, after isolated from the power supply, keeps rotating at the intersection of curve A and line B (P_M and Pc) at the excitation voltage equal to the rated voltage. The voltage, however, reduces gradually as in the case of ① above.

③ With self-excitation (Ic_3 > Io)
When the capacity of the capacitor is larger than the no-load excitation capacity of the induction motor (with the full load power factor improved to 100%), the induction motor, after isolated from the power supply, keeps rotating at the intersection of curve A and line B (P_{SE}) at the excitation voltage higher than the rated voltage. This voltage also decreases gradually. However, it may rise to approximately 140% where the capacitor capacity is such that it makes the power factor 100% at the rated output.

The above phenomena are attenuated in a short time because there is no power input after isolating them from the power supply. However, too large an excitation voltage is not favorable to the devices. Although the excitation voltage is below the rated voltage, the induction motor may receive too high an electric torque when re-closing the circuit because the phases of the normal excitation voltage and power supply voltage do not match. This may damage the shaft and couplers.
This phenomenon is equivalent to turning on synchronous generators in parallel with the phases not in unison. For example, if the self-excitation voltage rises to approximately 140% of the rated value, the transient torque when turning on the circuit may reach as much as 20 times the rated value.

b) Countermeasures
As described above, this phenomenon occurs when capacitor rated current Ic is larger than no-load excitation current Io of the induction motor. Therefore, the capacitor connected directly to the induction motor must be selected so that Ic < Io.
Though the no-load excitation characteristics vary from one motor to another, the capacitor is selected according to the following guideline.

$$\text{Capacitor capacity} = \left(\frac{1}{2} \text{ to } \frac{1}{4}\right) \times \text{rated capacity of induction motor}$$

The following countermeasures are considered when a motor is switched frequently over a short time or when a relatively large capacitor must be connected.
1) Provide the capacitor with a dedicated switch so that the capacitor can be isolated before turning off the power supply.
2) Connect the capacitors collectively to a separate bus line.
3) Provide interlock to delay the re-closing until the self-excitation voltage goes below 50%.

c) Selecting capacitor capacities
Two points as follows need to be considered in selecting capacitor capacities.
① Survey on motor power factor (power factor before improvement)
······································ Ask the motor manufacturer.
↓
Determine the power factor after improvement (normally 0.9 to 0.95)
↓
Calculate the capacity of the power factor capacity.

② Satisfy the following relationship.
No load current ≥ capacitor current

Use the following equation to calculate the no-load current.

$$Io = I\sqrt{1-(\text{Cos}\theta)^2} \text{ (A)}$$

I : Rated current of motor (A)
Cos θ : Motor power factor (before improvement)

Use the following equation to calculate the capacitor current.

$$Ic = \frac{Q}{\sqrt{3} \times E} \text{ (A)}$$

Q : Capacity of condensive capacitor (var)
E : Power supply voltage (V)

[Basis]

When an induction motor connected in parallel with a capacitor is isolated from the power supply, the induction motor is excited by the charge current in the capacitor circuit. The induction motor then functions as an induction generator, generating voltage. If the capacitor having its condensive current smaller than the excitation current (no-load current) (that is, ② above is satisfied), the self-excitation voltage will not exceeds the rated voltage.
If ② above is not satisfied, an overvoltage exceeding the rated voltage is generated, possibly causing the induction motor to burn and the capacitor insulation to break (self-excitation of induction motors).
As a countermeasure to this problem, isolate the capacitor before turning off the motor, or use an overvoltage relay to isolate the capacitor.

4. Application for Primary Switching of Transformers

When a transformer is connected to a circuit, a transient rush current considerably larger than the steady state will run.

While depending on the closing phase of the excitation current, it is necessary to have magnetic flux two times as strong as the steady state magnitude flow in the iron core to generate a necessary inductive voltage. Since this reaches the saturated condition, the excitation current becomes considerably high in general.

Frame size	Single-phase transformer kVA (A)			3-phase transformer kVA (A)		
	220V	440V	550V	220V	440V	550V
N10	1.2 (5.5)	1.5 (3.5)	1.5 (3)	2 (5.5)	2.5 (3.5)	2.5 (3)
N11, 12	1.5 (6.5)	2 (4.5)	2 (3.5)	2.5 (6.5)	3.5 (4.5)	4 (4.5)
N18	2 (9)	3 (6.5)	2.8 (5)	3.5 (9)	5 (6.5)	6 (6.5)
N20, 21	2.2 (10)	3.3 (7.5)	3 (5.5)	4 (10)	7.5 (10)	8 (8.5)
N25	3 (13.5)	3.5 (8)	3.7 (6.5)	5.5 (15)	11 (15)	11 (12)
N35	3.7 (17)	4.5 (10)	4 (7.5)	6 (17)	13 (17)	13 (14)
N50	5.5 (25)	7.5 (17.5)	7.5 (14)	9.5 (25)	19 (25)	19 (20)
N65	7 (32)	13 (30)	11 (20)	12 (32)	24 (32)	21 (22)
N80	7.5 (35)	14 (32)	14.5 (27)	15 (40)	30 (40)	30 (32)
N95	10 (46)	18.5 (42)	19 (35)	19 (50)	38 (50)	38 (40)
N125	11 (50)	20 (45)	20 (37)	23.5 (62)	40 (62)	50 (52)
N150	13.5 (62)	24 (55)	27 (50)	28.5 (75)	57 (75)	65 (70)
N180, N220	22 (100)	45 (100)	50 (90)	42 (110)	84 (110)	95 (100)
N300	30 (135)	55 (120)	65 (115)	57 (150)	110 (150)	140 (150)
N400	35 (165)	65 (150)	80 (150)	76 (200)	150 (200)	190 (200)
N600	65 (300)	132 (300)	160 (300)	110 (300)	220 (300)	280 (300)
N800	88 (400)	180 (400)	215 (400)	150 (400)	300 (400)	380 (400)

Notes:
1. Applied when the rush current of the transformer is below 20 times the rated current.
2. When the rush current of the transformer exceeds 20 times the rated current, select a magnetic contactor in a manner that the current value is equal to or less than 10 times the AC-3 rated operational current. On the other hand, if the rush current is considerably smaller than 20 times the rated current, the capacity may be risen that those listed in the table above.
3. The electrical switching durability is 500,000 cycles.

5. List of Application for Driving Programmable Controllers (PC)

List of application of S-N series magnetic contactors for driving programmable controllers

Applicable models			Type MELSEC-A programmable controller											Type MELSEC-FX programmable controller					
Type	Model name	Nominal operating coil	Relay unit				Triac unit				Transistor unit			Relay unit		Triac unit		Transistor unit	
			A1SY10		A1SY18AEU		A1SY 22 Without varistor		A1SY 28EU Without varistor		A1SY60	A1SY50	A1SY40 A1SY41 A1SY42	FX-□R		FX-□S	* FX-□S-H with varistor	FX-□T	* FX-□T-H
			100V AC	200V AC	100V AC	200V AC	100 VAC	200 VAC	100 VAC	200 VAC	UN-SY□ Used 24VDC			100VAC 200VAC		100VAC 200VAC	*	UN-SY□ Used 24VDC	*
AC operated	SR-N4, N5, N8	AC 100V AC 200V	○2x10^6	○2x10^6	○2x10^6	○2x10^6	○	○	○	○	○			○1x10^6		○	○	○	○
	S-N10 to N18		○2x10^6	○2x10^6	○2x10^6	○2x10^6	○	○	○	○	○			○1x10^6		○	○	○	○
	S-N20/N21		○2x10^6	○2x10^6	○2x10^6	○2x10^6	○	○	○	○	○			○1x10^6		○	○	○	○
	S-N25/N35		○2x10^6	○2x10^6	○2x10^6	○2x10^6	○	○	○	○	○			○1x10^6		○	○	○	○
	S-N50/N65		○1.5x10^6	○2x10^6	○2x10^6	○2x10^6	○	○	○	×	○			○1x10^6		○	○	○	○
	S-N80/N95		○1x10^6	○1.5x10^6	○1.5x10^6	○2x10^6	○	×	○	×	○			○1x10^6		○	○	○	○
	S-N125/N150		○1x10^6	○1.5x10^6	○1.5x10^6	○2x10^6	○	×	○	×	○			○1x10^6		○	○	○	○
	S-N180/N220		○0.5x10^6	○1x10^6	○0.5x10^6	○1.5x10^6	○	×	○	×	○			○1x10^6		×	○	○	○
	S-N300/N400		○0.5x10^6	○0.5x10^6	○0.5x10^6	○1x10^6	○	×	○	×	○			○1x10^6		×	○	○	○
	S-N600/N800		×	○0.4x10^6	×	○0.5x10^6	×	×	○	×	×			○0.5x10^6		×	○	×	×
DC operated	SD-M□, MR□	DC 24V	○2x10^6		○2x10^6						○	○	○	○1x10^6				○	○
			24V DC	110V DC	24V DC	110V DC								24VDC 110VDC					
	SRD-N4, N5, N8	DC 24V DC 100V	○ 0.15x10^6	○ 0.4x10^6	○ 0.7x10^6	○ 1.5x10^6					○ 24VDC	○ 24VDC	×	○0.5x10^6				○ 24V DC	○ 24V DC
	SD-N11/N12		○ 0.15x10^6	○ 0.4x10^6	○ 0.7x10^6	○ 1.5x10^6					○ 24VDC	○ 24VDC	×	○0.5x10^6				○ 24V DC	○ 24V DC
	SD-N21		○ 0.1x10^6	○ 0.3x10^6	○ 0.5x10^6	○ 1x10^6					○ 24VDC	○ 24VDC	×	○0.1x10^6				○ 24V DC	○ 24V DC
	SD-N35		○ 0.1x10^6	○ 0.3x10^6	○ 0.5x10^6	○ 1x10^6					○ 24VDC	○ 24VDC	×	○0.1x10^6				○ 24V DC	○ 24V DC
	SD-N50/N65		×	×	×	×					○ 24VDC	○ 24VDC	×	×				×	×
	SD-N80/N95		×	×	×	×					○ 24VDC	×	×	×				×	×
	SD-N125, N150		×	×	×	×					○ 24VDC	×	×	×				×	×
	SD-N220		×	×	×	×					×	×	×	×				×	×
	SD-N300/N400		×	×	×	×					×	×	×	×				×	×
	SD-N600/N800		×	×	×	×					×	×	×	×				×	×
Mechanically latched type, AC operated			Close	Trip	Close	Trip	Close	Trip	Close	Trip				Close	Trip	Clo-se	Trip		
	SRL-N4	AC 100V AC 200V	○0.5x10^6	○0.5x10^6	○0.5x10^6	○0.5x10^6	○	○	○	○				○0.5x10^6	○0.5x10^6	○	○		
	SL-N21		○0.5x10^6	○0.5x10^6	○0.5x10^6	○0.5x10^6	○	○	○	○				○0.5x10^6	○0.5x10^6	○	○		
	SL-N35		○0.5x10^6	○0.5x10^6	○0.5x10^6	○0.5x10^6	○	○	○	○				○0.5x10^6	○0.5x10^6	○	○		
	SL-N50/N65		○0.5x10^6	○0.5x10^6	○0.5x10^6	○0.5x10^6	○	○	○	○				○0.5x10^6	○0.5x10^6	○	○		
	SL-N80/N95		○0.5x10^6	○0.5x10^6	○0.5x10^6	○0.5x10^6	○	○	○	○				○0.5x10^6	○0.5x10^6	○	○		
	SL-N125, N150		○0.5x10^6	○0.5x10^6	○0.5x10^6	○0.5x10^6	○	○	○	○				○0.5x10^6	○0.5x10^6	×	×		
	SL-N220		○0.5x10^6	○0.5x10^6	○0.5x10^6	○0.5x10^6	○	○	○	○				○0.5x10^6	○0.5x10^6	×	×		
	Sl-N300/N400		○0.5x10^6	×	○0.5x10^6	×	○	×	○	○				○0.5x10^6	○0.5x10^6	×	×		
	SL-N600/N800		×	×	×	×	×	○	○	○				○0.5x10^6	○0.5x10^6	×	×		

Notes:

1. ○ : Applicable, × : Not applicable (one operating coil for each one output pole)
2. The values of relay unit show the electrical endurance of the relay unit.
3. Mechanically latched, DC operated types (SRLD, SLD) are not applicable.
4. Type UN-SY□ is DC interface module (optional).
5. Type MELSEC-FX marked with "*" are high current additional block type.

1. Cautionary notes

1) Coil load rating
The output rating of a programmable controller is expressed by the resistance load in general. However, since this rating is not applicable, use the coil load rating (category AC-15) and operating coil VA when holding for selection. The DC-held systems of the S-N series are full wave-rectified, they are easy to switch by programmable controllers and can be driven directly up to high capacities.

2) High frequency switching
The list of application is organized according to approximately 1,200 cycles per hour of switching without jog operation. For a high frequency switching including jog operation, select the frames so that the coil VA at the time of closing is within the output rating of the programmable controller.

3) Breaking making current
The selection is such that the programmable controller output can break the making current due to failure or abnormal operation of a mechanical latch type magnetic contactor or to jog operation of a magnetic contactor. There is no possibility of accident due to inability of breaking.

4) Simultaneous drive
Driving two or more magnetic contactors at the same time is restricted by the total output current of the programmable controller or integrated fuse. Thus, limit the total coil current of the magnetic contactor within the limit of the programmable controller.

5) Isolation of input/output lines
Isolate the input line of a programmable controller from the output line to prevent programmable controller malfunction. Since type S-N50 to S-N800 have built-in surge absorbers to the standard specification, such isolation is generally unnecessary. Type S-N10 to N35 and SR-N4 to N8 are equipped with type UN-SA surge absorber optionally.

6) Category AC-15
AC-15 is for the contact capacities defined in JIS C 4531 "Contactor Relays" that are applicable to switching AC electromagnets.
It defines that "(closing VA) = 10 x (holding VA)". If the closing VA of the operating coil exceeds the specification, apply one tenth of the closing VA as the holding VA.

7) Triac output
In driving the AC operated type S-N50 to S-N800, turning off the triac causes a voltage of $2\sqrt{2}$ times the circuit voltage (622V peak for 220VAC) to be applied to the triac due to the capacitor integrated in the DC electromagnet with AC operation. This may cause the triac to break.
For systems with the circuit voltage of 200V, install a varistor (ϕ9 470V) in parallel with the triac.

Motor Protection and Thermal Overload Relay Selection

1. Protection Relays

Recently, the size of induction motors has been reduced by improved insulation technology. Insulation class E motors have come into general use, and even use of insulation class F motors has been begun, and in regard to the characteristics there is a tendency for reduction of the thermal margin. For these reasons it has become necessary that the motor protection relays also correspond to these thermal characteristics. On the other hand, the application methods for motors have branched out considerably, with general use and developments of automatic machine equipment and various use for intermittent operation, reverse running, and variable load operation. From this point of view also, the use of suitable protection relays is required for full development of the motor performance, as well as for safe and suitable operation of machines and equipment.

There are various types of protection methods and relays according to motor type and application, and the method used most generally is indirect detection of the winding coil temperature rise of the motor by the line current. There are cases, where this method is not necessarily sufficient, and it may be necessary to also use the method of embedded thermostats for direct detection of the winding coil temperature. In some cases it is also necessary to provide single phase running protection, protection from reverse running by reverse phase, etc., and it is necessary to select the suitable relay according to the motor protection conditions, etc..

Table 1 shows the tendency of the outline of the protection characteristics for the general thermal protection relay, type TH thermal overload relay, for protection from overload or locked rotor condition of the motor, for the type TH-KP thermal overload relay, with smaller single phase operation current by adding differential amplifier mechanism, for the type ET-N (over load, phase failure and reverse phase protection) relay with solid state method, for the thermal protective relay with direct detection of the winding coil temperature by PTC thermistors, etc. according to the protection objectives. For concrete applications it is necessary to study the possible protection range and to consider the possibility of occurrence of trouble, the required reliability, and the cost performance as explained in the following.

Fig. 1 shows a comparison of the operation characteristics of the various protection relays.

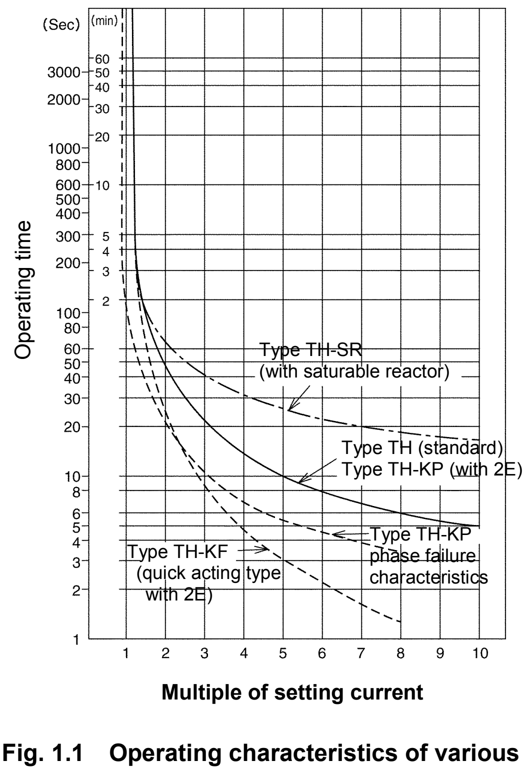


Fig. 1.1 Operating characteristics of various thermal relays

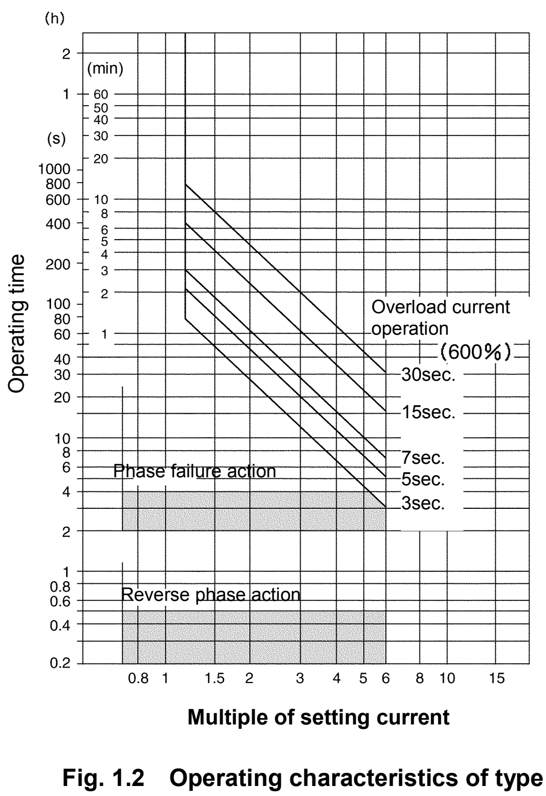


Fig. 1.2 Operating characteristics of type ET-N 3E relay

Fig. 1 Comparison of operating characteristics of various motor protective relays

Table 1 Subjects of protection for three-phase induction motors and applicable protective relays

Subjects of protection \ Protective relays			Type TH thermal overload relay		Type TH-SR (with saturable reactor) thermal overload relay	Type TH-KP (with 2E) thermal overload relay	Type TH-KF (quick acting type) thermal overload relay	Type ET 3E relay	PTC thermister type thermal protective relay
			With 2 heater elements	With 3 heater elements					
Overload	Standard duty	General squirrel cage motor	◎	◎	○	◎	△	◎	◎
		Wound-rotor type motor	○	○	○	○	○	○	○
		Submergible motor	△	△	×	△	◎	◎	○
	Intermittent operation	General squirrel cage motor	△	△	○	△	△	○	◎
		Wound-rotor type motor	△	△	△	△	○	○	△
		Submergible motor	△	△	△	△	△	△	○
Locking		General squirrel cage motor	◎	◎	○	◎	△	◎	○
		Wound-rotor type motor	△	△	△	△	○	◎	△
		Submergible motor	△	△	×	△	◎	◎	○
		Increased safety type explosion-proof motor	△	△	△	△	◎	◎	○
Wiring system abnormalities		Single phase running (prevention of burning)	△	△	△	○	△	◎	○
		3-phase unbalanced running	×	×	×	×	×	◎	○
		Short circuit	△	△	△	△	×	△	×
		Burning due to over/under voltage	○	○	○	○	○	○	○
		Earth leakage	×	×	×	×	×	×	×
		Ground fault	△	△	△	△	△	△	×
		Reverse phase	×	×	×	×	×	◎	×

Notes: 1. 2E : Overload and phase failure protection
3E : Overload, phase failure and reverse phase protection

2. ◎ : Certainly protectable
○ : Protectable excluding special cases
△ : Conditionally protectable
× : Not protectable

2. Type TH Thermal Overload Relays

2.1 Features of type TH thermal overload relays

Thermal overload relays of magnetic motor starters are used generally as protection devices for motors, especially for squirrel-cage motors. Their function is protection of the motor from burning by overcurrent and to separate the motor from the current in case of overload or locked rotor condition.
The thermal overload relays are less expensive with the operating characteristics being approximate to the current-to-time characteristics of the motor coils with respect to the allowable temperature. Because of the effective protective characteristics, the thermal overload relays are used most often for motor protection. To ensure safety, a relatively short time limit is used.
Type TH thermal overload relays are a general thermal operation system. It consists of bimetal strips as the thermal elements, a heater and a quick-breaking contact mechanism that are built in a mold casing.
The features of the type TH thermal overload relays are as follows.

(1) Having 1NO+1NC contacts. NC contact is for breaking the magnetic contactor. NO contact can be used for other voltage circuit for operation annunciation.
(2) For all the 2 heater elements types, the heater insertion phases are fixed to 1/L1-2/T1 and 5/L3-6/T3.
(3) Using the RC scale (indication by the motor full load current) that indicates current value.
(4) Adjusting the front knob with a flathead or a Phillips screwdriver, the relay can be adjusted to a setting of approximately ±20% of the nominal heater current.
(5) Easy to trip the relay manually from the front to facilitate wiring check.
(6) All types have 2 heater elements and manufacturing with 3 heater elements is also possible.
(7) Equipped with an ambient temperature compensation.
(8) Switching between manual and automatic resetting is possible.
(9) All types are of 3-pole structure, making wiring easy.
(10) Thermal overload relays with slow operation characteristics can be manufactured easily by adding saturable reactors.
(11) Thermal overload relays with 2E (for overload and phase failure protection) can be manufactured. (Type TH-N12KP to N600KP)
(12) Thermal relays quick acting characteristics suitable for submergible motors can be manufactured. (Type TH-N12KF to N60TAKF and TH-N20FS to N60TAFS)

2.2 Operating characteristics

The operating characteristics of the TH-N series thermal overload relays are according to IEC as shown in Table 1. Type TH-☐KP is according to the specifications for thermal overload relays with phase failure protective functions as shown in Table 2.

Table 1 Thermal overload relay specifications

		IEC 60947-4-1		
		Ambient temperature	**No-operation current**	**Operating characteristics (current : time)**
3-phase balanced		20°C 40°C –5°C	105% 100% 105%	120% : Within 2 hours (H) 120% : Within 2 hours (H) 130% : Within 2 hours (H)
Unbalanced (phase failure)	3 heater elements	20°C	105%	132% : Within 2 hours (H)
	2 heater elements	–	–	–

Notes:
1. Standard magnetic motor starters with enclosure [type MS-N☐(KP)] comply with the specifications.
2. The current values are in percentage with respect to the setting current.
3. In the operating characteristics column, (H) indicates action from the hot state (2 hours after carrying no-operation current).

Table 2 Specifications of thermal overload relays with phase failure protective function (2E type)

Specification	Ambient temperature	Conditions	Operation
IEC 60947-4-1	20°C	100% of set current flows through 2 poles. 90% of set current flows through another 1 pole.	No tripping for 2 hours from cold state
		115% of set current flows through 2 poles. No current flows through another 1 pole.	Tripping within 2 hours following the above.

2.3 Durability

Considering the operating characteristics, a thermal overload relay is durable enough if one can operate 1,000 cycles. The JEM standard also defines the 1,000 cycles of durability testing. Changes in the operating characteristics and contact wear are the keys for the thermal overload relay durability. Table 3 lists the results of the durability testing of the type TH thermal overload relays according to the JEM standard.

Table 3 Results of durability testing of type TH thermal overload relays

<table>
<tr><th colspan="2">Test specimen</th><th colspan="6">Test conditions</th><th colspan="4">Test results</th></tr>
<tr><th rowspan="3">Model name</th><th rowspan="3">Heater nominal</th><th rowspan="3">Setting current (A)</th><th colspan="4">Control circuit</th><th rowspan="3">Main circuit current (A)</th><th rowspan="3">Operation (cycle)</th><th rowspan="3">Minimum operating current (A)</th><th colspan="2">Operating time (second)</th></tr>
<tr><th colspan="2">Current (A), NO/NC contacts</th><th colspan="2">Power factor, NO/NC contacts</th><th rowspan="2">200% current application</th><th rowspan="2">600% current application</th></tr>
<tr><th>Closing</th><th>Breaking</th><th>Closing</th><th>Breaking</th></tr>
<tr><td>TH-N20</td><td>9A</td><td>11</td><td>5/10</td><td>0.5/1</td><td>0.65/
0.65</td><td>0.35/
0.34</td><td>66</td><td>0
1000
2000
3000</td><td>12.4
12.0
12.1
12.0</td><td>54.2
53.3
53.0
53.4</td><td>5.6
5.2
5.2
5.0</td></tr>
<tr><td>TH-N20KP</td><td>15A</td><td>18</td><td rowspan="3">30/50</td><td rowspan="3">3/5</td><td rowspan="3">0.65/
0.64</td><td rowspan="3">0.34/
0.33</td><td>108</td><td>0
1000
2000
3000</td><td>19.5
19.0
19.5
19.0</td><td>41.8
42.0
41.6
41.0</td><td>6.5
6.6
6.4
6.1</td></tr>
<tr><td>TH-N60KP</td><td>42A</td><td>50</td><td>300</td><td>0
1000
2000
3000</td><td>55.5
55.0
55.5
55.0</td><td>64.3
65.8
64.7
65.1</td><td>8.2
8.8
8.4
8.3</td></tr>
<tr><td>TH-N120KP</td><td>82A</td><td>100</td><td>600</td><td>0
1000
2000
3000</td><td>116
118
118
114</td><td>74.6
73.8
75.5
74.7</td><td>11.3
11.0
11.5
11.1</td></tr>
</table>

Notes:
1. All test specimens are conditioned to the automatic reset state.
2. The set currents are maximum within the respective ranges of adjustment.
3. The control circuit test voltage is 242VAC 60Hz.
4. 600% of the set current is applied to the main circuit until the contacts tripping. After the tripping, no current is applied until it resets automatically.
5. The tripping times in the test results column are from the cold state.
6. Test methods and conditions other than the above are according to JEM 1356 "Thermal overload relays for three-phase induction motors".

2.4 Overload withstand

Table 4 shows the results of testing where 10 times the setting current is applied to the main circuit to see changes in the characteristics.

Table 4 Changes in characteristics

Test specimen		Conditions		Test results					
				Before testing		After applying current 3 times			
Model name	Heater nominal	Setting current (A)	Current (A)	Minimum operating current (A)	200% operating time (sec)	Minimum operating current		200% operating time (sec)	
						(A)	Rate of change (%)	(Sec)	Rate of change (%)
TH-N12	9A	11	110	12.5	53.6	12.3	−1.0	52.4	−2.2
TH-N20KP	15A	18	180	20.2	41.8	20.0	−1.0	40.4	−3.3
TH-N20TAKP	29A	34	340	34.3	54.0	38.1	−0.5	53.6	−0.7
TH-N60KP	15A	18	180	20.0	54.0	19.5	−2.5	53.2	−1.5
TH-N60KP	42A	50	500	56.4	51.7	55.8	−1.1	50.4	−2.5
TH-N60TAKP	67A	80	800	89.5	52.2	87.2	−2.6	50.0	−4.2
TH-N120KP	82A	100	1000	111	62.0	113	1.8	64.2	3.5
TH-N120TAKP	125A	150	1500	168	54.1	169	0.6	54.6	0.9

Note: Test methods and conditions other than the above are according to JEM 1356.

The test results indicate no changes in the characteristics when 10 times the set current is applied. The thermal overload relays are practically without problems.
JEM 1356 specifies the thermal overload relay is no troubles with a test where eight times the setting current (maximum value) is applied until the thermal overload relay trips and such current application is repeated three times.
With the type TH-N series thermal overload relays supplied to 13 times the setting current (maximum value), no melting of electrically supplying parts before the contacts make.

2.5 Ambient temperatures and setting current

The TH-N series thermal overload relays are adjusted with enclosed in standard box as magnetic motor starters, and with a reference ambient temperature of 20°C.
These have an ambient temperature compensation device, so the fluctuation of operating characteristics in respect to the effect of the ambient temperature is low.
Fig. 2 shows the ultimate operating current characteristics based on the ambient temperature of 20°C. If the ambient temperature of where the magnetic motor starter is installed differs greatly from 20°C, use Fig. 2 to correct the set thermal overload relay setting current.
If the thermal overload relays are used in conditions different from the standard adjustment conditions, such as using the thermal overload relays alone, use Table 5 to correct the setting current.

Table 5 Correction factors based on mode of using thermal overload relays

Model name	With standard enclosure (type MS-□)	In control panel [∗2] (type MSO-□)	Open type (type MSO-□)	Thermal overload relay only, type TH-□
TH-N12 (CX) (TP, KP)	1.00	1.02	1.06	1.08
TH-N18 (CX) (KP)	–	1.02	1.06	–
TH-N20 (CX) (KP)	1.00	1.02	1.05	1.06
TH-N20 (CX) TA (KP)	1.00	1.02	1.05	–
TH-N60 (KP)	1.00	1.01	1.03	1.05
TH-N60TA (KP)	1.00	1.01	1.03	–
TH-N120 (KP)	1.00	1.02	1.06	1.08
TH-N120TA (KP)	1.00	1.02	1.06	–
TH-N220 (KP)	1.00	1.00	1.01	1.01
TH-N400 (KP)	1.00	1.00	1.01	1.01
TH-N600 (KP)	–	1.00 [∗3]	–	1.02

Notes:
1. Indicates correction factors at the ambient temperatures of 20°C.
2. The correction factors for those in control panels are calculated based on 15°C [K] from the temperature rise in the control panel.
3. Indicates correction factors when thermal overload relays alone are installed in control panel. (for independent mounting only)

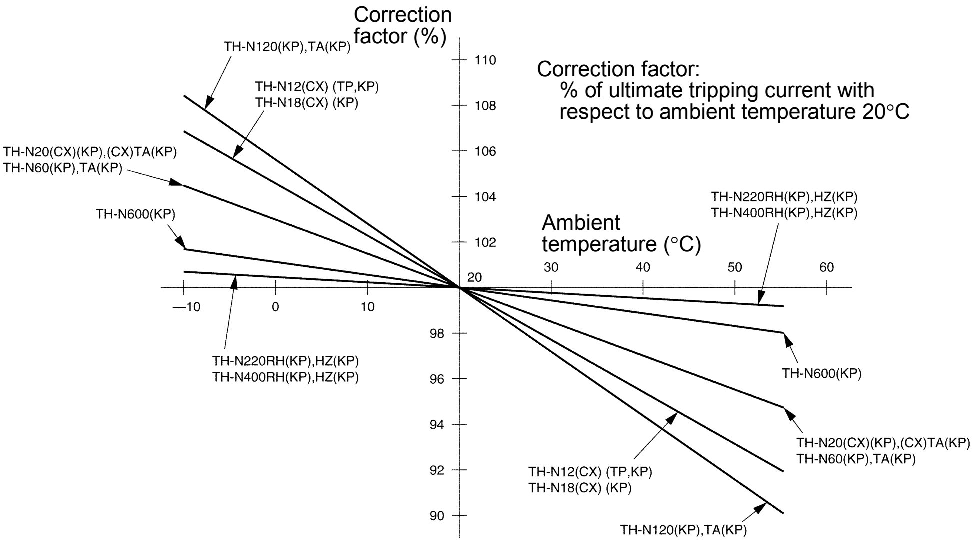


Fig. 2 Ambient temperature compensation curves for TH-N series thermal overload relays

<Correction of setting current>

Obtain the correction factor from the corresponding curve based on the working ambient temperature. Divide the full load current of the motor by the obtained correction factor to define the setting current.

2.6 Connection wire size

Because of different heat generation, wire size affect the thermal overload relay characteristics. The ultimate operating currents of type TH thermal overload relays are conditioned according to the standard wire sizes shown in Table 6. Use of smaller wires causes more heat to generate, making the ultimate operating currents small. Use of larger wires on the other hand makes the ultimate operating currents larger.

Strictly speaking, when using wire sizes other than the respective standard wire sizes, the set currents are to be corrected. For example, if the type TH-N20 thermal overload relay with the heater nominal and setting current 15A is connected to 5.5 mm^2 wires, adjust to division $15 \times \frac{1}{1.04} \fallingdotseq 14.4$ (A) based on the rate of change "1.04" in the ultimate operating current shown in Table 6.

Table 6 Connection wire sizes and ultimate operating currents for type TH thermal overload relays

Model name	Heater nominal (A)	Standard wire size (mm^2)	Connection wire size (mm^2)	Ultimate operating curent fluctuation rate average (%)
TH-N12 TH-N20	0.24~11	2	1.25 3.5	98 103
TH-N18 TH-N20	15	3.5	2 5.5	97 104
TH-N20TA	22, 29	5.5	3.5 8	97 104
	34	8	5.5 14	96 104
TH-N60	15	3.5	2 5.5	95 105
	22, 29	5.5	3.5 8	96 105
	35	8	5.5 14	95 105
	42	14	8 22	95 104
	54	22	14 30	96 104
TH-N60TA	67	22	14 30	97 103
TH-N120	42	14	8 22	95 104
	54, 67	22	14 30	96 104
	82	38	30 50	97 103
TH-N120TA	105	50	38 60	97 103
	125	60	50 80	98 103

2.7 Main circuit specifications of type TH thermal overload relays

Table 7 Main circuit specifications

Model name	Heater nominal (A)	Setting range (A)	Line-load resistance between terminals (mΩ)	Power consumption / pole (W)			Heater melting $I^2t(A^2S)$
				Minimum	Medium	Maximum	
TH-N12 TH-N12TP TH-N12KP	0.12	0.1 ~ 0.16	42600	0.43	0.62	1.1	0.03×10^3
	0.17	0.14 ~ 0.22	21400	0.42	0.62	1.1	0.05×10^3
	0.24	0.2 ~ 0.32	10500	0.42	0.61	1.1	0.06×10^3
	0.35	0.28 ~ 0.42	8750	0.69	1.1	1.6	0.18×10^3
	0.5	0.4 ~ 0.6	4320	0.70	1.1	1.6	0.36×10^3
	0.7	0.55 ~ 0.85	2450	0.75	1.2	1.8	0.74×10^3
	0.9	0.7 ~ 1.1	1340	0.66	1.1	1.7	1.1×10^3
	1.3	1 ~ 1.6	700	0.70	1.2	1.8	1.1×10^3
	1.7	1.4 ~ 2	366	0.72	1.1	1.5	3.1×10^3
	2.1	1.7 ~ 2.5	251	0.73	1.1	1.6	6.0×10^3
	2.5	2 ~ 3	186	0.75	1.2	1.7	6.0×10^3
	3.6	2.8 ~ 4.4	88	0.69	1.2	1.8	8.5×10^3
	5	4 ~ 6	46	0.74	1.2	1.7	17×10^3
	6.6	5.2 ~ 8	26	0.71	1.2	1.7	21×10^3
	9	7 ~ 11	15	0.74	1.2	1.8	46×10^3
	11	9 ~ 13	9.7	0.79	1.2	1.7	73×10^3
TH-N18 TH-N18KP	1.3	1 ~ 1.6	631	0.64	1.1	1.7	1.1×10^3
	1.7	1.4 ~ 2	366	0.72	1.1	1.5	3.1×10^3
	2.1	1.7 ~ 2.5	219	0.64	0.97	1.4	6.0×10^3
	2.5	2 ~ 3	162	0.65	1.0	1.5	6.0×10^3
	3.6	2.8 ~ 4.4	81	0.64	1.1	1.6	8.5×10^3
	5	4 ~ 6	45	0.72	1.2	1.7	17×10^3
	6.6	5.2 ~ 8	24	0.65	1.1	1.6	21×10^3
	9	7 ~ 11	16	0.75	1.3	2.0	46×10^3
	11	9 ~ 13	9.2	0.75	1.2	1.6	73×10^3
	15	12 ~ 18	6.1	0.88	1.4	2.0	160×10^3
TH-N20 TH-N20KP	0.24	0.2 ~ 0.32	10900	0.44	0.63	1.1	0.06×10^3
	0.35	0.28 ~ 0.42	9220	0.72	1.1	1.6	0.18×10^3
	0.5	0.4 ~ 0.6	4950	0.79	1.2	1.8	0.36×10^3
	0.7	0.55 ~ 0.85	2630	0.80	1.3	1.9	0.74×10^3
	0.9	0.7 ~ 1.1	1650	0.81	1.3	2.0	1.1×10^3
	1.3	1 ~ 1.6	819	0.82	1.4	2.1	1.1×10^3
	1.7	1.4 ~ 2	489	0.96	1.4	2.0	3.1×10^3
	2.1	1.7 ~ 2.5	282	0.81	1.2	1.8	6.0×10^3
	2.5	2 ~ 3	196	0.78	1.2	1.8	6.0×10^3
	3.6	2.8 ~ 4.4	96	0.75	1.2	1.9	8.5×10^3
	5	4 ~ 6	52	0.83	1.3	1.9	17×10^3
	6.6	5.2 ~ 8	30	0.81	1.3	1.9	21×10^3
	9	7 ~ 11	17	0.83	1.4	2.1	46×10^3
	11	9 ~ 13	12	0.97	1.5	2.0	73×10^3
	15	12 ~ 18	6.4	0.92	1.4	2.1	160×10^3
TH-N20TA TH-N20TAKP	22	18 ~ 26	4.5	1.5	2.2	3.0	370×10^3
	29	24 ~ 34	2.8	1.6	2.4	3.2	750×10^3
TH-N60 TH-N60KP	15	12 ~ 18	8.4	1.2	1.9	2.7	0.20×10^6
	22	18 ~ 26	5.4	1.7	2.6	3.7	0.58×10^6
	29	24 ~ 34	3.1	1.8	2.6	3.6	0.63×10^6
	35	30 ~ 40	2.0	1.8	2.5	3.2	1.0×10^6
	42	34 ~ 50	1.8	2.1	3.2	4.5	2.4×10^6
	54	43 ~ 65	1.3	2.4	3.8	5.5	1.3×10^6
TH-N60TA TH-N60TAKP	67	54 ~ 80	0.77	2.2	3.5	4.9	2.3×10^6
	82	65 ~ 100	0.60	2.5	4.0	6.0	2.7×10^6
TH-N120 TH-N120KP	42	34 ~ 50	2.2	2.5	3.9	5.5	1.3×10^6
	54	43 ~ 65	1.6	3.0	4.7	6.8	2.6×10^6
	67	54 ~ 80	0.87	2.5	3.9	5.6	5.0×10^6
	82	65 ~ 100	0.71	3.0	4.8	7.1	7.8×10^6
TH-N120TA TH-N120TAKP	105	85 ~ 125	0.44	3.2	4.9	6.9	8.4×10^6
	125	100 ~ 150	0.38	3.8	5.9	8.6	13×10^6

Notes:
1. The resistances between terminals are for one pole at the ambient temperature of 20°C at the cold state.
2. The minimum, medium and maximum power consumption values are when applying the minimum, medium (heater nominal) and maximum currents of the adjustable range of set current respectively.
3. The values of melting of live portion (I^2t) are when applying 10 to 13 times the maximum of the adjustable range of the set current. (The contacts of the TH-N series are designed to operate before the heater melts when applying 13 times the above current.)
4. Type TH-N220/N400 are used with the dedicated CTs. The power consumption is approximately as follows (for one pole).

   Applying minimum of set current : 2.5VA
   Applying medium of set current : 4VA
   Applying maximum of set current : 6VA

   With the typesTH-N220/N400 used with the dedicated CTs, the heater will not melt below 20 times the maximum setting current before the thermal overload relays operate.

2.8 Vibration and shock resistance

(1) Contact malfunction vibration

Check for parting of the contacts for 1ms or longer according to the following test procedure; Condition the thermal overload relay setting current to the minimum of the adjustable range, apply the setting current in the main circuit, with the temperature saturated, maintain the vibration acceleration at 19.6 m/s^2, vary the frequency evenly between 10Hz and 55Hz for a period of one minute and apply vibration in the three axes of vertical, left and right and fore and back.

Test results : No contact malfunction occurs for all the test specimens of type TH-N12 to N600.

(2) Constant vibration durability

Apply vibration at frequency 16.7Hz, reciprocating amplitude 4 mm, in three axes of vertical, left and right and front and rear for 2 hours in each axis. Check for changes in the characteristics, damage and loose screws before and after vibration application.

Test results : The rate of change in the 200% current tripping time is within ±5% (within the repeatability tolerance).

No parts damage or loose screws (tightened to 80% of the standard toque) is observed.

(3) Contact malfunction shock

Adjust the set current to the minimum of the adjustable range. Apply the main circuit with the setting current. After the temperature saturation, apply shock with the approximate waveform shown in Fig. 3 at the acceleration 49.0 m/s^2. Check for contact parting for 1ms or longer. Apply shock three times in each of the six directions of vertical, left and right and fore and aft for 3 times in each direction.

Test results : No contact malfunction is observed for all the type TH-N12 to N600 test specimens.

(4) Shock durability

Apply shock with the approximate waveform shown in Fig. 3 at the acceleration 490m/s^2. Check for changes in the characteristics and damage before and after shock application. Apply shock three times in each of the six directions of vertical, left and right and fore and aft.

Test results : The rate of change in the 200% current tripping time is within ±5% (within the repeatability tolerance) with no parts damage.

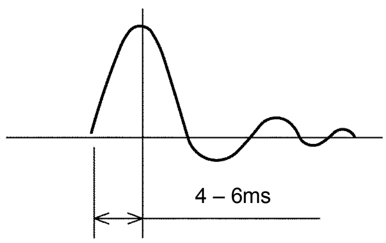


Fig. 3 Shock waveform.

2.9 Current transformers for type TH-N220/N400RH (HZ) thermal overload relays

The specifications and characteristics of the current transformers used for the type TH-N220/N400RH (type MSO-N220 to N400 magnetic motor starters) and type TH-N220/N400HZ (thermal overload relays used alone).

(1) Ratio of current transformation

Current ratio of the primary (main circuit side) to the secondary (thermal overload relay side) is 50:1.

(2) Rated load VA

Approximately 5VA (for one pole)
With a thermal overload relay connected, the load on the secondary circuit will be approximately 2VA when applying the maximum setting current.

3. Motors Overload and Locking Protection

The thermal overload relays protect the motors mainly against overload and locking of rotors in the intended circuit configuration. Adjusting the thermal overload relay set current to the motor full load current achieves such protections.

Fig. 4 shows an example of relationships between the current-to-time characteristics with respect to the coil temperature rise of a Mitsubishi motor (thermal characteristics) and the operating characteristics of the type TH thermal overload relay.

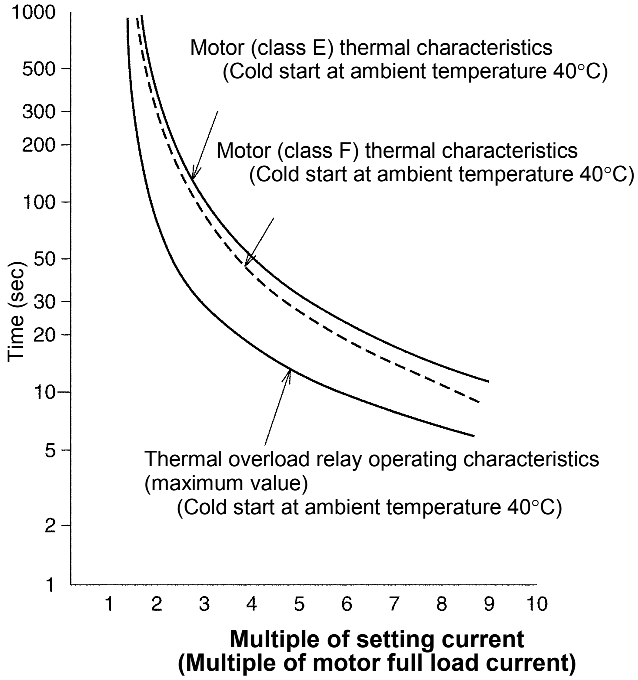


Fig. 4 Example of motor thermal characteristics and type TH thermal overload relay operating characteristics

4. Phase Failure Protection for 3-phase Motor

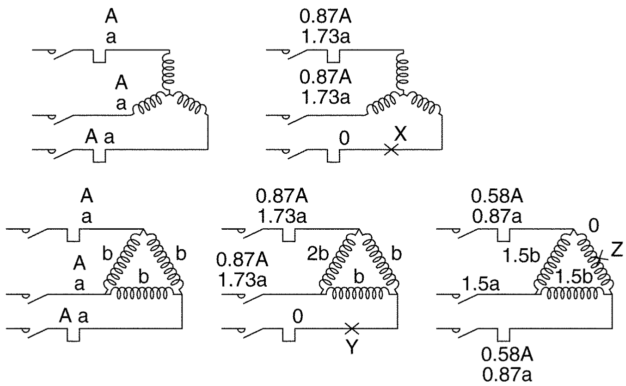
A three phase power source suffers open phase fault when the fuse in one of the phases melts. If attempting to start the motor with open phase fault in the circuit, single-phase locking current flows. This causes the thermal overload relay to trip, protecting the motor from burning. If open phase fault occurs, the motor either stalls to go into the state of single-phase locking or keeps running in single phase where the single-phase operation current depends on the load.
The thermal overload relay operates as follows.

- Motor stopped in single-phase lock condition
  Thermal overload relay to trip
- Motor continuing single-phase running (equal to or above the thermal overload relay tripping current)
  Thermal overload relay to trip
- Motor continuing single-phase running (below the thermal overload relay tripping current)
  Thermal overload relay not tripping → stop → restarting in locked condition → thermal overload relay tripping

Thus, the motor can be protected against most single-phase overload or single-phase locking. However, such protection does not occur in some cases that will be discussed as follows.

(1) Direct phase failure of motor input
(2) Internal phase failure for delta-connected motor
(3) Primary side phase failure of power transformer

In cases (1) and (2), it is assumed that the fault pattern is such that the circuit breaks at points X, Y and Z as shown in Fig. 5. The values in the figure are calculated assuming that the outputs are constant during the operation and the currents divert in proportion to the inverse ratio of the impedance.



A : Locking line current when 3-phase is normal.
a : Full load line current when 3-phase is normal.
B : Locking phase current when 3-phase is normal.
b : Full load phase current when 3-phase is normal.

Fig. 5 Currents in motor winding coils and protective relays in various phase failure of three phases

5. Protection of Motors with Long Starting Time

To protect a motor driving a load of high inertia therefore taking a long time to start, normal thermal overload relays may not provide proper protection as they trip during starting.

Mitsubishi has solved this problem by using less expensive thermal overload relays with saturable reactors. This type of relay is similar to the standard thermal overload relay except that a small reactor with a core is installed in parallel with the heaters. It produces similar operating characteristics to the standard ones up to approximately 200% of the set current. Above that current range, the reactor core is saturated to increase the current diverting to the reactor while limiting the current to the heaters, making the time limit longer.

In Fig. 6, when current I flowing through the main circuit is close to the full load current, the reactance component of the saturable reactor is several times larger than the heater resistance, making a small amount of the current divert to the reactor. When it becomes two to three times the full load current, the iron core is saturated, making the reactance smaller than the heater resistance while most of current I diverts into the reactor.

Fig. 7 "a" and "b" indicate the relationships between the terminal voltage and current of only the heaters alone and the relationships between the terminal voltage and current of only the saturation reactor alone. Fig. 7 "c" shows when connecting in parallel. With the current two to three times higher than the setting current, the voltage will not increase due to the iron core saturation. This means that even if current I increases, the terminal voltage will not increase, thus the current in the heaters will not increase either. This delays the operation and protects the heaters when short circuit occurs. Fig. 8 shows the operating characteristics.

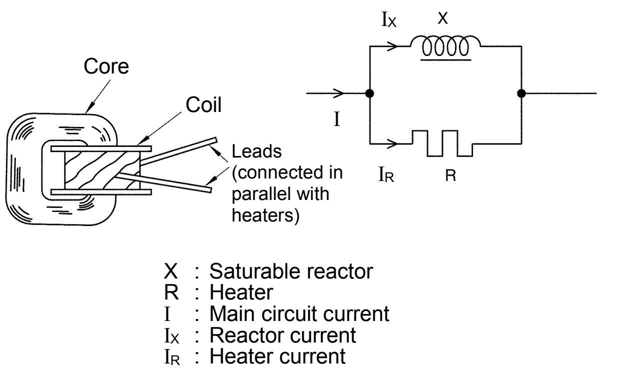


Fig. 6 Structure and principle of saturable reactor

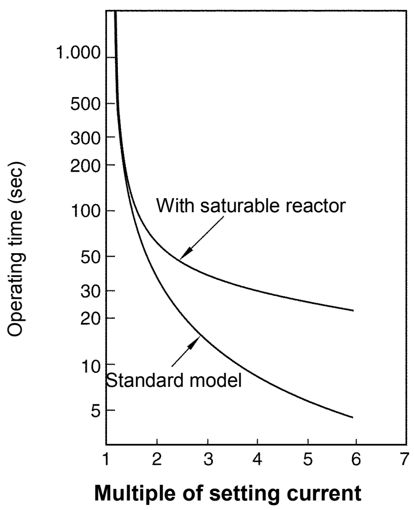


Fig. 8 Operating characteristics with saturable reactor (with and without saturable reactor)

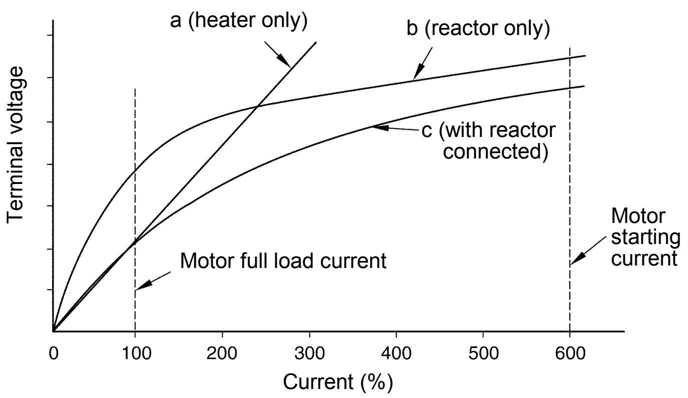


Fig. 7 Relationships between current and terminal voltage

Whether a thermal overload relay with a saturable reactor is necessary depends on the starting time of the motor. Generally, the time is safe if it is 15 seconds or shorter, inappropriate for standard motors if exceeding 15 seconds and dangerous if exceeding 30 seconds.
The following paragraphs sum up the cases where thermal overload relays with saturable reactors are applied.

(1) Protection of motor with long starting time

This function prevents incorrect operation when starting a motor that drives a load of high inertia. It must be noted that the starting time is shorter than the allowable locked rotor time of the motor.

(2) Protection of motor operating intermittently

When driving a motor intermittently (including jog operation and reverse braking) while desiring to produce the maximum short-time output optimally, a thermal overload relay with a large heater may be selected at the sacrifice of part of overload protection. However, use of a saturable reactor can achieve the same result while sacrificing little. An appropriate selection is available when the periodical intermittent operation takes place. See section 6 "Protection of motors operating intermittently".

(3) Protection coordination of motors with large starting current

Application of this function to a motor with a large starting current makes coordination of protection simple with molded case circuit breakers and fuse. When a circuit accident occurs, motor protection and short circuit protection can be coordinated. See Fig. 9.

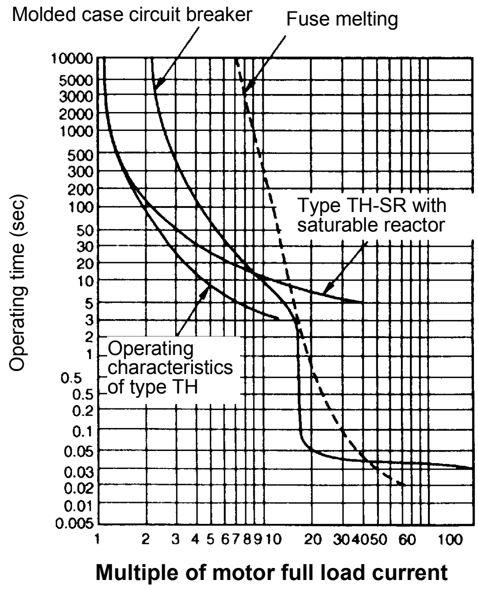


Fig. 9 Protection coordination of thermal overload relay and molded case circuit breaker or fuse

Available Starting Methods and Their Selection

1. Outline of Various Starting Methods

The systems for starting squirrel cage induction motors using magnetic contactors are generally classified as follows. Table 1 shows the comparison of various electromagnetic starting systems. Each system has advantages and shortcomings.

- Starting squirrel-cage motors
  - Full voltage starting (Direct-on-line starting)
  - Reduced voltage starting
    - Star-delta starter
    - Reactor starter
    - Autotransformer starter

(1) Purpose of reduced voltage starting

The full voltage starting is the least expensive. Since the motor is started with the large starting current (5 to 7 times the rated current) and the starting torque left uncontrolled, shock given to the power supply and mechanical system at the time of starting sometimes causes problems. To eliminate the problems, the reduced voltage starting is used. This starting method is of two types; one to mainly reduce the starting current, and the other to mainly control the starting torque. The star-delta and condolfer starting fall into the former group while the reactor and primary resistance starting fall into the latter group.

(2) Star-delta starters

The star-delta starting is the least expensive of all the reduced voltage starting methods and is applicable to motors of 5.5 kW or larger. Shortcomings are that the starting with the load applied is problematic because the starting current and torque are fixed and not adjustable, and that shock is great because the circuit is tentatively open (open transition system) when transiting from star to delta.
To improve these conditions, a resistor is used so that the circuit will remain closed (closed transition system) when transiting from star to delta. Since this system involves small rush current during transition, it is advantageous for applications such as one using an emergency generator as the power supply because the generator capacity can be made small. This system can be used as an alternative to the autotransformer starting.

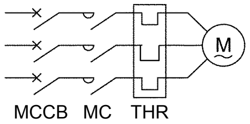
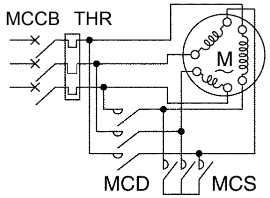
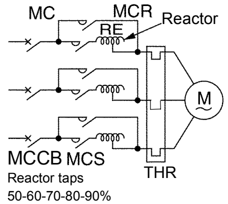
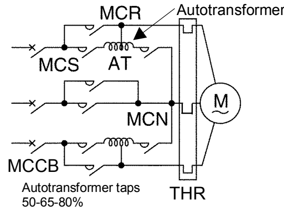
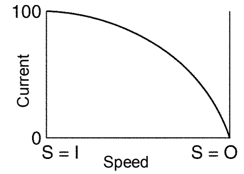
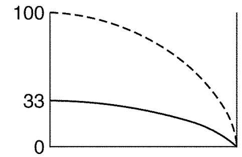
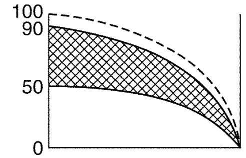
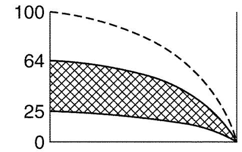
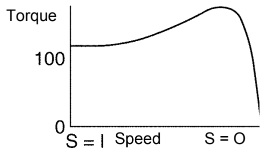
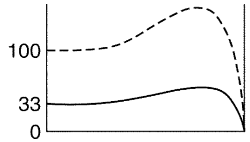
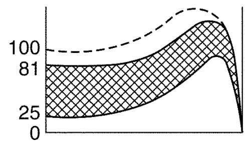
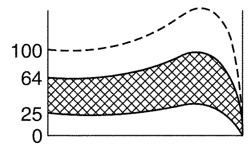
(3) Reactor starters

The reactor starting reduces the starting torque (proportional to the square of the applied voltage) while reducing the starting current moderately (proportional to the voltage applied). It is therefore used for gradual starting by adjusting the starting torque. When the rotational speed increases (the starting current to reduce), the voltage applied to the motor increases together with the torque. Since the reactor starting produces little shock during transition, it is optimum to applications where the load increases in proportion to the rotational speed or where the load should avoid shock during gradual starting or transition. It is typically used for bobbins of spinning machines.

(4) Autotransformer starters

The condolfer starting uses an automatic transformer having an 80-65-50% taps. With the coils in the automatic transformer functioning as a reactor, the circuit will not be open during transition (closed transition), making the transition shock small. Since the system is expensive, it is not fit to small capacity motors. It is however suitable for starting with a small capacity generator.

Table 1 Electromagnetic starting systems for squirrel-cage motors

Starting system	Full voltage starting	Reduced voltage starting Star-delta starter (Open transition)	Reactor starter	Autotransformer starter
Circuit configuration				
Current characteristics (line current)				
	Is : 100%	I_1 = Is × 1/3 : 33%	$I_2 = Is \times (\frac{V'}{V})$: 50-60-70-80-90%	$I_3 = Is \times (\frac{V'}{V})^2$: 64-42-25%
Torque characteristics				
	Ts : 100%	T_1 = Ts × 1/3 : 33%	$T_2 = Ts \times (\frac{V'}{V})^2$: 25-36-49-64-81%	$T_3 = Ts \times (\frac{V'}{V})^2$: 64-42-25%
Advantages	• Full motor accelerating torque is obtained and starting time is reduced. • Most economical	• Voltage drop due to starting current can be reduced. • Cheapest and simplest of all reduced voltage-starting methods.	• Starting current and torque can be step changed. • Accelerating torque can be rapidly increased as the motor speed increases. • Cushion start is possible.	• Starting current and torque can be step changed. • Shock is small because power supply is not disconnected during transition from starting to normal operation.
Disadvantages	• Large starting current causes abnormal voltage drop if power supply capacity is small.	• Because of small starting and accelerating torques, motor often cannot be started without disconnecting the load. • Electrical and mechnical shock occur due to interruption of power supply during transition from starting to normal operation.	• Most expensive method. • Loss of starting torque is large in terms of starting current.	• Most expensive method. • Accelerating torque is as small as in star-delta starting.
Mitsubishi type	MS-N	EYD-N (3 contactor system) EY-N (2 contactor system)	ERT-N	EG-N

Note: Symbols are as follows. V: Power supply voltage, V': Motor terminal voltage, Is: Full voltage starting current, Ts: Full voltage starting torque, $I_1 - I_3$ and $T_1 - T_3$: starting current and starting torque for full voltage starting

2. Selection of Magnetic Contactors in Various Motor Starters

Selection of magnetic contactors used in motor starters requires the following to be reviewed.

a. Closing and breaking capacities
b. Continuous current capacity or short-time over current capacity
c. Life (switching endurance)
d. No-current time margin during switching
e. Voltage drop

(1) Performance required for magnetic contactors in various applications

Table 2 shows the results of calculating necessary closing/breaking capacity and continuous current capacity of the magnetic contactors applied to various starters listed in Table 1.

Table 2 Necessary making/breaking capacity and continuous current capacity of magnetic contactors used in various starters

Starting method		Tap value (%)	Making current	Breaking current	Continuous current capacity		Applicable magnetic contactors (ratio to motor capacity kW)		
					Conti-nuous current	Conti-nuous current time	Selection based on making/breaking capacity (for category AC-3 magnetic contactors)	Selection based on continuous current capacity	Overall (category AC-3)
Direct-on-line starting	MC	–	6	1 (6)	1	Continuous	1	1	1
Star-delta starter (open transition)	MCS	–	2	0.8 (2)	2	Short time	0.33	0.33	0.33
	MCD	–	1.4 (3.5)	0.58 (3.5)	0.58	Continuous	0.58	0.58	0.58
	MCM	–	2	0.58 (3.5)	0.58	Continuous	0.58	0.58	0.58
Reactor starter	MCS	50	3	–	3	Short time	0.45	0.38 ~ 0.6	0.8
		65	3.9	–	3.9		0.58	0.5 ~ 0.8	
		80	4.8	–	4.8		0.72	0.6 ~ 0.9	
	MCR	50	1~1.2 (6)	1 (6)	1	Continuous	1	1	1
		65	1~1.2 (6)	1 (6)	1		1	1	
		80	1~1.2 (6)	1 (6)	1		1	1	
Auto-transformer starter	MCS	50	1.5	–	1.5	Short time	0.23	0.2 ~ 0.3	0.6
		65	2.6	–	2.6		0.39	0.33 ~ 0.5	
		80	3.9	–	3.9		0.58	0.5 ~ 0.8	
	MCN	50	–	0.6 (1.5)	1.5	Short time	0.29	0.2~ 0.3	0.3
		65	–	0.55 (1.4)	1.4		0.26	0.19 ~ 0.3	
		80	–	0.25 (1)	0.96		0.13	0.13 ~ 0.2	
	MCR	50	2.4 (6)	1 (6)	1	Continuous	1	1	1
		65	2.4 (6)	1 (6)	1		1	1	
		80	1.6 (6)	1 (6)	1		1	1	

Note: The figures in parentheses ( ) in the closing and breaking current columns show the maximum in abnormal conditions.

Table 2 is derived with the following assumptions.

a. The motor starting torque is 300%.
b. The load in the reduced voltage starting is 80% of the maximum torque. If it exceeds the rated torque, the rated torque is used.
c. The torque is proportional to the square of voltage.
d. The direct-on-line starting current of the motor is 6 times the full load current.

The figures in Table 2 are multiples of the rated current of the motors. The closing/breaking capacities in parentheses require attention. The multiples in steady state assumes that the starting process has been completed and the current has reduced before transiting from the starting to operation. If transition takes place before completing the starting process, the transition current immediately comes close to the values under abnormal conditions.
IEC292-2 recommends that the transition from starting to operation should take place when the motor has reached 80% of the rated speed or above. If transition takes place before the motor rotational speed is not high enough while the starting current has not reduced yet, the electrical endurance of the magnetic contactor will reduce considerably.
For reference, Fig. 1 and 2 show the current and torque characteristics curves in reduced voltage starting.

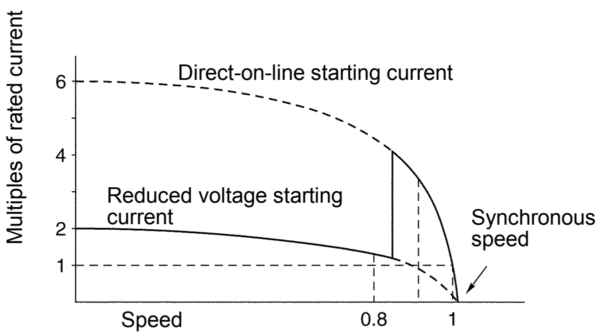


Fig. 1

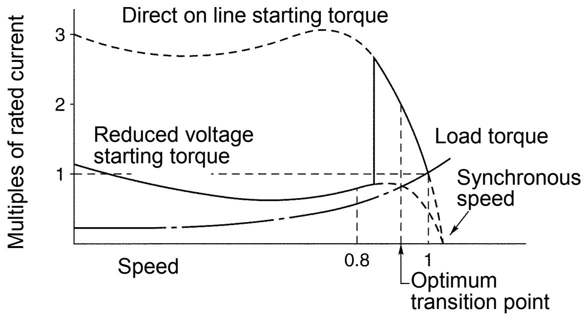


Fig. 2

(2) Selection of magnetic contactors based on closing and breaking capacities

Since general magnetic contactors assume full voltage starting of squirrel cage motors, they have performance of category AC-3 or AC-4. Class designation required for the full voltage starting magnetic contactors is AC-3. Since the class requires 10 times the closing and 8 times the breaking capacities be incorporated, they are with margin against the necessary closing and breaking capacities listed in Table 2. This is as a result of considering variations in the starting current due to voltage variation and other conditions. When selecting magnetic contactors based on the closing and breaking capacities, a similar margin needs to be provided.

(3) Selection of magnetic contactors based on continuous and short-time current capacity

For continuous operation, select magnetic contactors having required continuous current capacities based on the values shown in section (1). If the current time is short such as that for the contactors used only during starting, use of values shown in (1) may pick up magnetic contactors with too much margin. Since this is not economical, lower capacities should be selected based on the relationships among continuous current, current carrying time and the short-time current capacity of magnetic contactors.

In general conditions of use, the overall capacities are expressed as multiple of output kW of the motors as listed in Table 2.

(4) Electrical endurance of reduced voltage starters

If a starter is used several times a day, it can be selected based on the closing and breaking capacities and continuous current capacity. Switching durability does need to be considered particularly.

Based on the electrical switching durability of magnetic contactors used in full voltage starting, the electrical switching durability of the starter can be estimated to be inversely proportional to the square of the breaking current.

If switched in the middle of the starting process, the contactor breaking current may become the values in parentheses in Table 2 in section (1). This requires attention since it causes abnormal contact wear.

(5) No-current time margin for transition

Some magnetic contactors used in reduced voltage starters may cause short circuit if closed simultaneously. If an electrical interlock is provided, possibility of simultaneous closing is very low. If the time from breaking by the magnetic contactor of the starter to the closing by the running magnetic contactor (no-current time margin for transition) is too short, short circuit due to arc may occur.

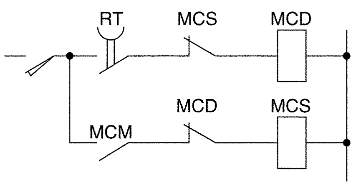
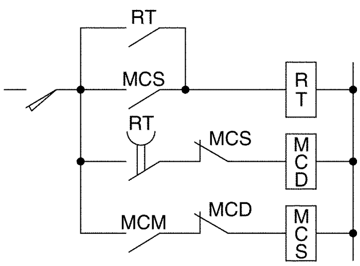
For high voltage circuit applications, a relay or a timer may be used during transition without changing the frame size of the magnetic contactor.

(6) Voltage drop

Since a reduced voltage starter is used for relatively small power supply, it may suffer voltage drop during starting. For an open transition star-delta starter in particular, when transiting from star to delta, the motor is momentarily isolated from the power supply. When closing for transition to delta, a large rush current flows due to the phases of the power supply and the residual voltage. Since this may cause the power supply voltage to drop considerably, a magnetic contactor having excellent anti-voltage drop characteristics should be used.

Type S-N magnetic contactors have the coil functions incorporated in the present low-voltage compensation type as part of the standard features.

3. Troubleshooting of Star-Delta Starter Failures

Phenomenon	Cause	Factor	Corrective action Action in ( ) applies to other than star-delta
Excessive contact wear, contact welding in some cases.	Contact chattering due to voltage drop	Insufficient power supply capacity 1) Voltage drop due to delta rush current 2) Voltage drop due to overload during delta operation 3) Voltage drop due to connection of other loads	1. (Review power supply capacity.) 2. Make delta contacts as follows. 1) Powerful against voltage drop 2) Equipped with mechanical latch 3) Delayed open type
	Contact chattering due to momentary power interruption	Momentary power interruption of power supply	Make delta contacts as follows: 1) Equipped with mechanical latch 2) Delayed open type
	Frequent, continuous, repeated starting	Star contactor short-time over current capacity is exceeded.	Increase contactor capacity.
	High star breaking and delta closing currents	1. Star starting time is too short. 2. Overload or locking during star operation 3. Rush current in delta wiring is high.	1. Make star starting time (timer setting) longer. 2. Review transition time from star connection to delta connection (if star-delta timer is used). 3. (Review load and motor torque.)
	Contact chattering due to operating contact chattering	1. Chattering of external command contacts 2. Chattering of timer contacts	1. Check for voltage drop. 2. Check timer and external command contacts.
	Contact chattering due to insufficient tightening of terminal screws	Repeated coil on/off due to insufficiently tightened coil or contacts terminal screws	Tighten terminal screws.
	Contactor unable to break.	Insufficient contactor capacity	Increase contactor capacity.
Phase-to-phase short circuit (Simultaneous closing of star and delta contacts) → Contact welding or melting	Simultaneous closing by external force (such as hand)	Only electrical interlock is available between star and delta contacts.	Provide mechanical interlock between star and delta contacts.
	Simultaneous closing due to shock	1. Only electrical interlock is available between star and delta contacts. 2. Installed where receiving shock easily.	1. Provide mechanical interlock between star and delta contacts. 2. (Review installation location.)
	Arc short circuit	1. Insufficient transition time from star to delta. 2. Arc time is long.	1. Provide mechanical interlock between star and delta contacts. 2. Use contactor with sufficient breaking capacity.
	Momentary power failure during delta operation	Where automatic contacts or residual type contacts are used, if power is restored with star and delta contacts open and main contacts closed, excitation of star and delta coils occurs simultaneously due to re-closing of time delay contact a (see circuit below). 	Change circuit. 1) Use timer to interlock star and delta. 2) If 1) above does not work, Use following circuit. 

Combination of Magnetic Motor Starters and Circuit Breakers

1. Protective Range of Magnetic Motor Starters

Magnetic motor starters are used mainly for remote control of motors, like start, stop, etc., and for motor burning protection from overload, locked rotor condition, etc., and the used current range is relatively small, and there is no braking and making capacity for the large currents at time of short circuit. The presently marked general magnetic motor starters mostly have the category AC-3, AC-4 breaking and making capacity specified in the IEC standard (IEC 60947-4-1) (8 to 10 times of the rated operational current), and the margin is about 10 to 15 times. For thermal overload relays also, except for special cases, there is the danger that the heater melts before tripping with flow of a current above a certain value.

The IEC standard (IEC 60947-4-1) considers this as 13 times of the rated operational current. The currents in excess of 13 times of the rated operational current are outside of the range of magnetic motor starters, and distribution line circuit breakers, fuses, or other automatic breakers must be used.

2. General Study of the Protection Coordination of Molded Case Circuit Breakers and Magnetic Motor Starters

(1) Necessary condition for protection coordination

The following items are to be considered for protection coordination of a branch circuit with motor load and molded case circuit breakers and magnetic motor starters.

(a) The magnetic motor starters must be able to make and break accurately the max. current which can occur in normal operation of the motor.

(b) The thermal overload relays must have tripping characteristics permitting accurate protection of the motor against overload and locked rotor condition.

(c) The molded case circuit breakers must have the breaking capacity to accurately break the short circuit current flowing at the time of short circuit. (including cascade breaking.)

(d) The wire size of the branch circuit must be so that no burning occurs from I^2t during the tripping time of the molded case circuit breaker, when a short circuit current flows.

(e) The wiring of the branch circuit must be protected correctly by thermal overload relays or molded case circuit breakers against overcurrent.

(f) There may be no erroneous tripping of the molded case circuit breaker from the inrush current of the motor. (Pay special attention to the inrush current at the half cycle at the time of making.)

(g) The tripping characteristics of thermal overload relay and molded case circuit breaker must have a point of intersection, protection tripping characteristic must be provided over the entire current range without interruptions, and the current below the intersection point must be below the characteristic of the thermal overload relay.

(h) The intersection point of the tripping characteristics must be at a current value below the breaking capacity of the magnetic motor starters.

(i) When short circuit current flows through the magnetic motor starters, the magnetic motor starters may not be damaged until the molded case circuit breaker breaks.

When all of the above conditions are fulfilled, the protection coordination for the branch circuit is perfect, but from the point of economy it cannot always be said that perfect equipment for all conditions is of advantage. The extent of the protection coordination for a branch circuit as a system, and this reliability of the system should be considered in several steps according to the degree of necessity and the economical connection.
Of the above conditions, (a) to (f) are definitely necessary, while (g) to (i) can be realized without troubles from the economical point of view, and investigation should be made according to the degree of necessity.

(2) Relationships of operating characteristics between circuit breakers and magnetic motor starters

The operating characteristics of a magnetic motor starter used for a class E motor needs to satisfy the following conditions to protect the motor and to avoid incorrect operation.

1) Not to operate at 100% of the rated motor current and to operate at 125%.
2) To operate between 3 and 30 seconds at the starting (rocked rotor) current of the motor.

Fig. 1 shows the operating characteristics of a thermal overload relay and the thermal characteristics and starting current of a motor. Above conditions 1) and 2) are satisfied if all curves are figured in a configuration shown in Fig. 1 (A).
For the present thermal overload relays (having RC divisions), these conditions are satisfied in general by selecting a thermal overload relay having its heater setting current equal to the rated current of the motor.
On the other hand, the capacity of accompanying circuit breakers is limited to 2.5 times the motor rated current (or the model immediate above) or lower according to the Japanese electrical-equipment-technical-standard clauses 185-5 and 186-6. While it is necessary to follow this restriction, if the selected rated current is too small, it may operate incorrectly due to the rush current during starting the motor as shown in Fig. 2.

A steady state starting current which is approximately 5 to 7 times the rated current flows in a squirrel cage motor. In the beginning or starting process (first half cycle in particular), since the DC is superimposed, a further greater transient rush current flows. Its multiplying factor depends on the power factor as shown in Fig. 3. Assuming that the motor starting power factor is -0.4, it will be approximately 1.3 times the steady state starting current. In addition, if instantaneous restarting (after the power turned off and before the motor stopping, the motor is restarted) takes place, it will be approximately twice more in the worst case, that is, the current can reach approximately 2.6 times the steady state starting current. Fig. 4 shows the measurement on an actual motor.

Since a circuit breaker trips instantaneously with approximately the half cycle minimum, selection should be such that the circuit breaker will not operate under this rush current. To avoid incorrect operation due to the rush current, it seems to be all right if the instantaneous trip current of the circuit breaker is approximately 14 times the rated current.

As described above, it is a key to have an intersection when selecting the characteristics of a magnetic motor starter and a circuit breaker. Fig. 1 (A) shows when condition 2 (1) (g) is satisfied while it is not satisfied in Fig. 1 (B). Since a point of discontinuity exists in the protective coordination in Fig, 1 (B), heaters of the thermal overload relays will melt when a current in this region flows. In Fig. 1 (A), if the intersection is above the breaking capacity of the magnetic motor starter, the magnetic motor starter may be unable to break current even if the thermal overload relay operates. This means that, even if there is an intersection between the two characteristics curves, condition 2 (1) (h) should be satisfied.

It is favorable to satisfy the conditions set out in this section from the viewpoint of protective coordination. However, since such a current region is relatively small and the possibility for such a current to generate is also marginal because the current in this region depends mainly on the grounding of the winding and the layer, such conditions are sometimes dismissed.

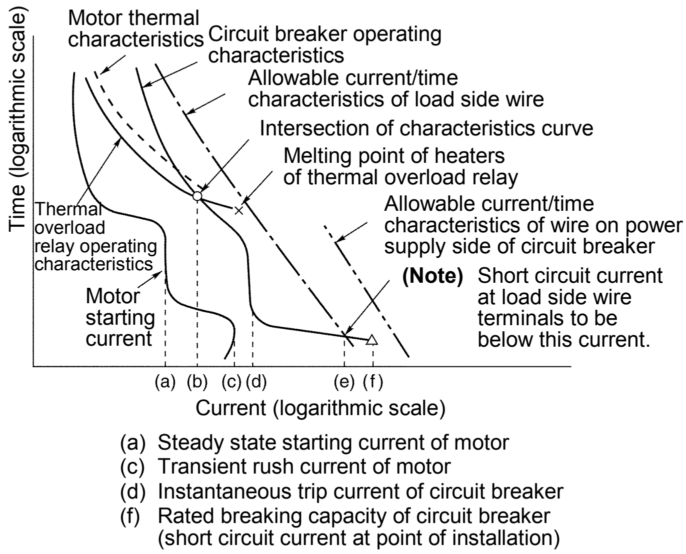


Fig. 1(A) Relationships between characterictics in protective coordination

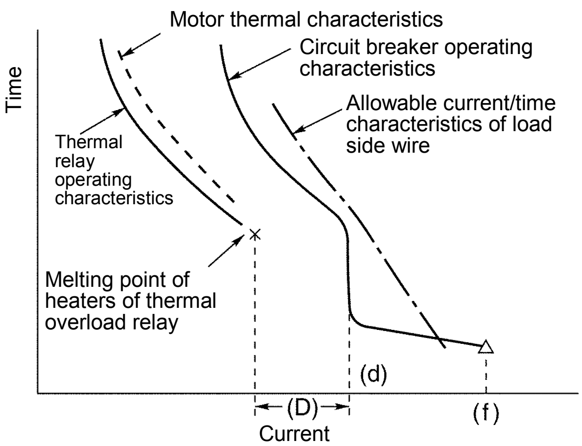


Fig. 1(B) Relationships between characteristics circuit in protective coordination

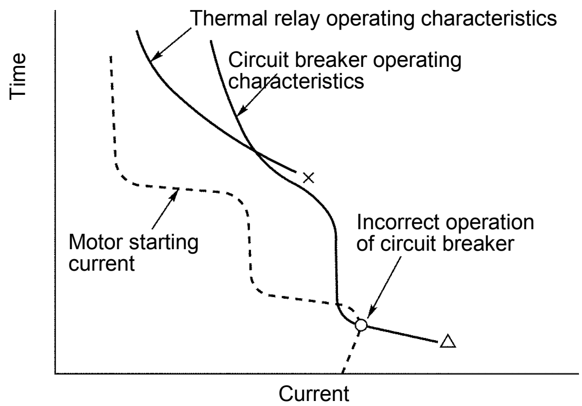


Fig. 2 Example of incorrect operation of breaker due to motor rush current

(3) Behavior of magnetic motor starter applied to short circuit current

When current flows through a magnetic motor starter, electromagnetic reaction force is generated across the contacts that is expressed approximately by Snowden's formula. Due to this electromagnetic reaction force, contact of the magnetic motor starter float and open if 20 to 40 times the rated working current flows. Therefore, if a short circuit current of not less than above value flows, the contacts float. This causes arc to generate between the contacts, possibly resulting in contact weld or short circuit between poles.

If a short circuit accident occurs, the circuit breaker breaks the short circuit current. The wave height and I^2t of the passing current expressed as the function of the prospective short circuit current increase when the short circuit current increase. Where a short circuit current exceeding a certain limit flows, to prevent damage to the magnetic motor starter by the circuit breaker, it is essential to either prevent arc generation between the contacts (to make the contacts not float) or to keep it very small. However, when the point of short circuit is far end of the load and small in magnitude, the magnetic motor starter may escape such damage as described in section 3(4).

(4) Degree of protective coordination

Various circuit breakers with different performance and characteristics are manufactured. Magnetic motor starters can be improved to some degree in terms of protective coordination. This allows to achieve various degrees of protective coordination with respect to the conditions discussed in sections 2(2) and (3).

The required degree of protective coordination should be determined based on its necessity and economy as described earlier.

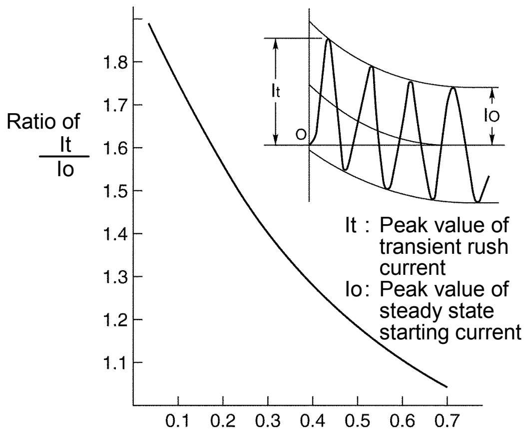


Fig. 3 Rush current when starting motor

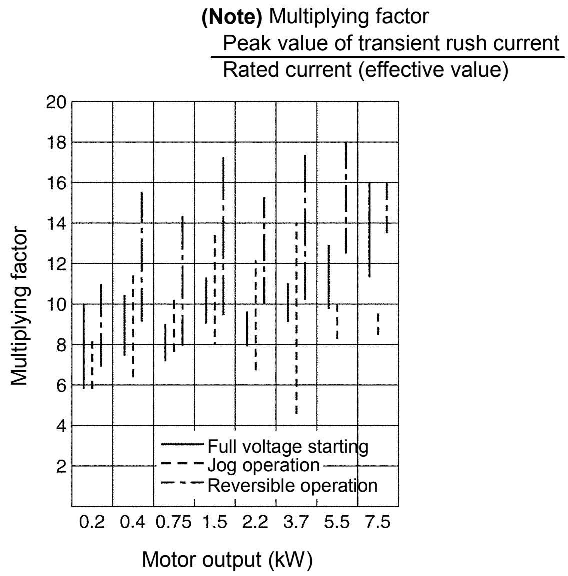


Fig. 4 Multiplying factors between motor rated current and transient rush current

In this regard, IEC Standard (IEC 60947-4-1 "Electromechanical contactors and motor starters") defines the following "types of coordination" depending on the degree of damage to magnetic motor starters under short circuit.

Type "1" In a short circuit state, the contactor or a starter does not cause any personal injuries or damage to equipment while it does not need to be operative further without parts repair or replacement.

Type "2" In a short circuit state, the contactor or a starter does not cause any personal injuries or damage to equipment while it must still be operative. If the manufacturer provides instruction to be taken with the equipment, the contacts may weld.

As examples of handling by some other codes and standards, the UL Standard (USA) No.508 and CSA Standard (Canada) C22-2 No.14 define that, when a magnetic motor starter combined with a fuse or a circuit breaker having the capacity of 3 to 4 times the rated working current carries a short circuit current of 5,000A, the magnetic motor starter is to exhibit no abnormalities (welding of the contacts is allowed).

3. Protection Coordination of Type MS-N Series Magnetic Motor Starters and Type NF Circuit Breakers

(1) Breaking capacity of type S-N magnetic contactor

The intersection of the operating characteristics of a circuit breaker and a thermal overload relay is not necessarily in the region of inverse time-delay operation of the circuit breaker as shown in Fig. 1 (A). It may be in the instantaneous trip region as shown in Fig. 5. In this region, if the breaking capacity of the magnetic contactor is without a sufficient margin, the intersection may exceeds the breaking capacity of the magnetic contactor. Considering this possibility, the type S-N magnetic contactors are designed to have a margin in the breaking capacity. As shown in Table 1, the breaking capacity is 13 times the rated working current or higher at 440V or below.
This allows to select magnetic contactors by a slight margin in the rated capacity with respect to the motor even if the intersection of the operating characteristics curves is such as shown in Fig. 5. The selection is economically advantageous when considering protective coordination.

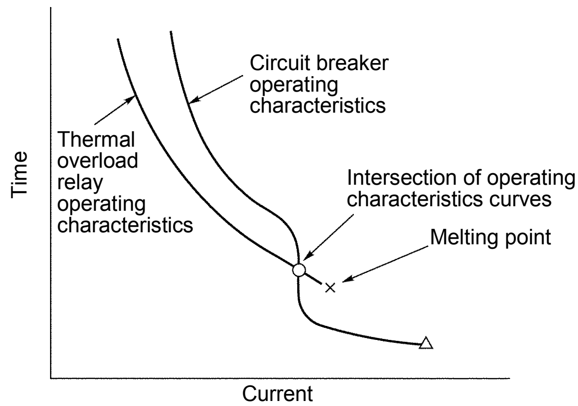


Fig. 5 Intersection of circuit breaker and thermal overload relay

Table 1 Maximum breaking capacity of type S-N magnetic contactors (number of breaking operations: 5)

Model Name	Rated current (A) AC-3 440VAC	Breaking capacity (A) 440VAC	Model name	Rated current (A) AC-3 440VAC	Breaking capacity (A) 440VAC
S-N10	7	100	S-N125	110	1800
S-N11, N12	9	150	S-N150	150	2300
S-N18	13	200	S-N180	180	2700
S-N20, N21	20	270	S-N220	220	3600
S-N25	24	400	S-N300	300	4800
S-N35	32	500	S-N400	400	7200
S-N50	46	700	S-N600	630	6400
S-N65	62	950	S-N800	800	8200
S-N80	75	1200			
S-N95	93	1200			

(2) Over current capacity of Type TH-N thermal overload relays

To locate the intersection of the operating characteristics curves in the inverse time-delay operation region of the circuit breaker as much as possible, the type TH-N thermal overload relays have slightly long operating times and heaters with larger over current capacities. These features indicate that the thermal relays are designed as a prerequisite to have protective coordination of the operating characteristics with the type NF circuit breakers.
The so-called "melting point" in particular where the heater melts before the thermal overload relay operates is 13 times the maximum heater current as shown in Fig. 6. This is for definite protective coordination with the type NF circuit breakers.

The melting of the heater of a thermal overload relay in a short circuit fault depends on the amount of I^2t that passes through the thermal overload relay. The amount of heater melting I^2t for the type TH-N is relatively large, facilitating to achieve better protective coordination.
Table 2 lists outline of the allowable I^2t and heater melting I^2t of the type TH-N thermal overload relays.

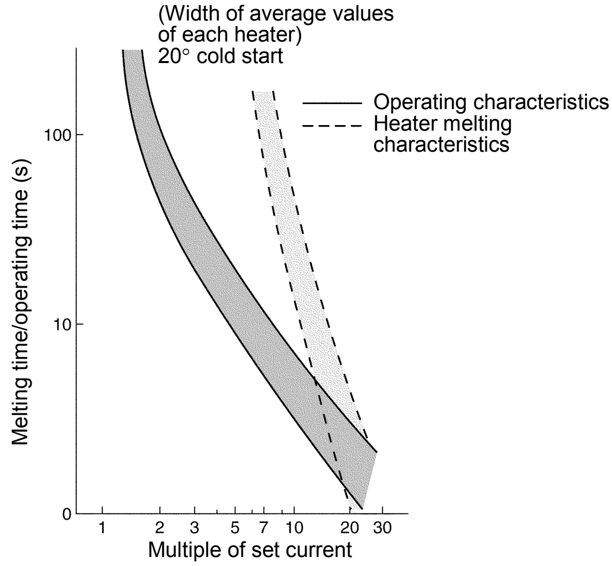


Fig. 6 Example of heater melting characteristics of heater of type TH thermal overload relay

Table 2 Allowable I^2t of type TH thermal overload relays with short circuit current passing

Type	Allowable I^2t still reusable (A^2s)	Heater melting I^2t (A^2s)	Heater melting I^2t with reactor (types TH-SR) (A^2s)
TH-N12/N18	150 ~ 500 I^2	250 ~ 1000 I^2	10000 I^2 or more
TH-N20	150 ~ 500 I^2	250 ~ 1000 I^2	10000 I^2 or more
TH-N60	250 ~ 600 I^2	400 ~ 1000 I^2	10000 I^2 or more
TH-N120	300 ~ 700 I^2	500 ~ 1200 I^2	10000 I^2 or more
TH-N220 TH-N400	Used with dedicated current transformer. Due to current transformer saturation in large current region, heater hardly melts.		
TH-N600	Though depending on characteristics of accompanying current transformer, possibility of heater to melt is low due to current transformer saturation.		

Note I : Heater nominal current (see page 74)

(3) Coordination of operating characteristics

Fig. 7 and 8 show examples of protective coordination characteristics between the type MSO-N magnetic motor starters and the type NF circuit breakers. Those figures show achievement of favorable coordination.
To prevent unnecessary incorrect operation, the instantaneous trip current is set slightly higher for the type NF circuit breakers. Therefore, the rated current of the type NF circuit breakers to be selected in appropriate protective coordination with the type MSO-N magnetic motor starters can be relatively small, which is approximately 1.5 times the set current of the thermal relay heaters. Tables 3.1 and 3.2 show examples of combination of the type NF circuit breakers and the type MSO-N magnetic motor starters while considering the operating characteristics coordination. These combinations actually exhibit favorable coordination characteristics as illustrated in the figures.
One of the issues related to arranging operating characteristics coordination occurs when, due to the breaking capacity, a circuit breaker of a relatively larger frame for the size of the type TH-N thermal relay heater needs to be selected. In such a case, because of the lower limit of the rated current of the circuit breaker, protective coordination is sometimes difficult to establish. As a solution to the problem, the type TH-N thermal relay equipped with a reactor is used because one with a reactor allows to set the heater melting point at 30 times the rated current or above. Fig. 9 and 10 show examples of protective coordination characteristics applicable to this case.

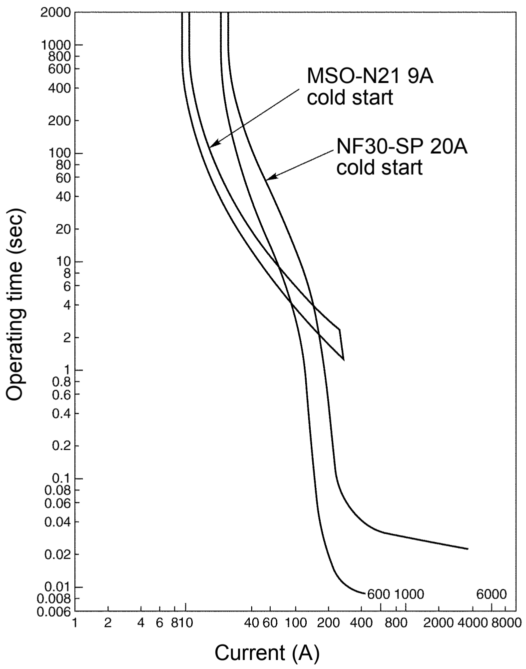


Fig. 7 Example of protective coordination between type NF30-SP circuit breaker and type MSO-N21 magnetic motor starter

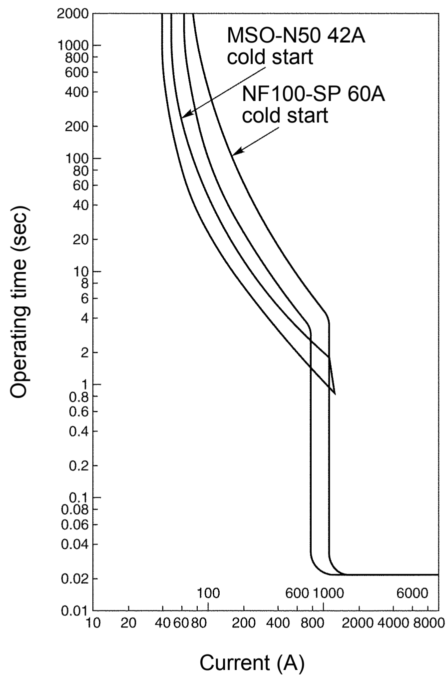


Fig. 8 Example of protective coordination between type NF100-SP circuit breaker and type MSO-N50 magnetic motor starter

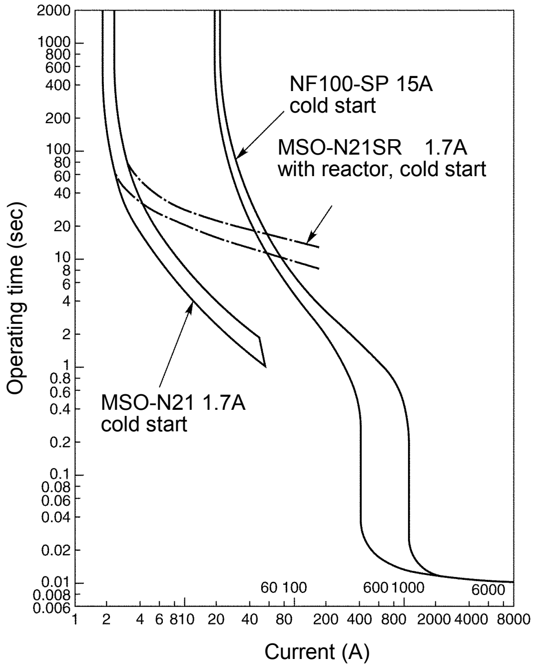


Fig. 9 Example of protective coordination between type NF100-SP circuit breaker and type MSO-N21SR magnetic motor starter (with reactor)

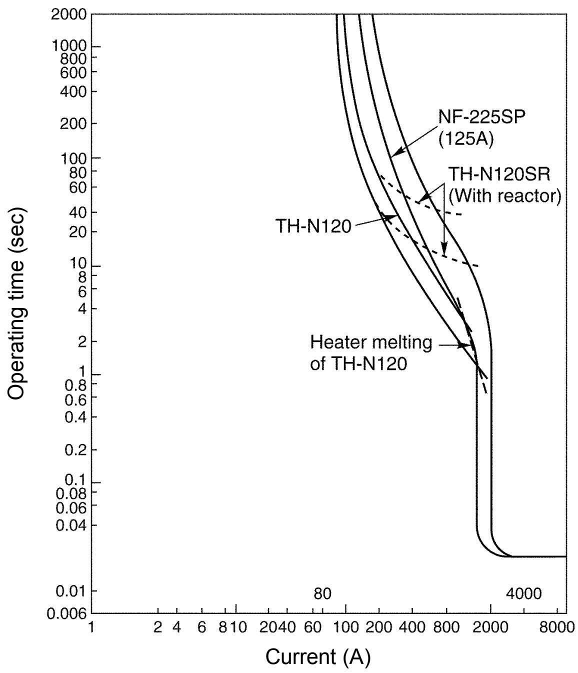


Fig. 10 Example of protective coordination between type NF225-SP circuit breaker and type MSO-N150SR magnetic motor starter (with reactor)

Table 3.2 For 400/440VAC three-phase induction motors

Starting	For 4-pole motor		Magnetic motor starter		Interrupting capacity (kA) 460VAC (sym)																							
					1.5		2.5		7.5		10		15		25		30		42		50		65		125		200	
	Capa-city kW	Full load current A	Flame size	Heater nominal A	Model name	Rating	Model name	Rating	Model name	Rating	Model name	Rating	Model name	Rating	Model name	Rating	Model name	Rating	Model name	Rating	Model name	Rating	Model name	Rating	Model name	Rating	Model name	Rating
Full voltage starting	0.2	0.6	N10~N21	0.7	NF30-CS	(3)	NF30-SP	(3)	NF50-SP	(10)	NF50-HP	10	NF225-CP		NF100-SP	(15)			NF50-HC	(3)	NF100-HP	(15)			NF100-RP	(15)	NF100-UP	(15)
Full voltage starting	0.4	1.1	N10~N21	1.3	NF30-CS	(3)	NF30-SP	(3)	NF50-SP	(10)	NF50-HP	10			NF100-SP	(15)			NF50-HC	(3)	NF100-HP	(15)			NF100-RP	(15)	NF100-UP	(15)
Full voltage starting	0.75	1.9	N10~N21	1.7	NF30-CS	5	NF30-SP	5	NF50-SP	(10)	NF50-HP	10			NF100-SP	(15)			NF50-HC	5	NF100-HP	(15)			NF100-RP	(15)	NF100-UP	(15)
Full voltage starting	1.5	3.2	N10~N21	3.6	NF30-CS	10	NF30-SP	10	NF50-SP	10	NF50-HP	10			NF100-SP	(15)	NF50-HC	8			NF100-HP	(15)			NF100-RP	(15)	NF100-UP	(15)
Full voltage starting	2.2	4.6	N10~N21	5	NF30-CS	10	NF30-SP	10	NF50-SP	10	NF50-HP	10			NF100-SP	(15)	NF50-HC	8			NF100-HP	(15)			NF100-RP	(15)	NF100-UP	(15)
Full voltage starting	3.7	7.5	N11~N35	6.6	NF30-CS	20	NF30-SP	20	NF50-SP	20	NF50-HP	20			NF100-SP	20	NF50-HRP	20			NF100-HP	20			NF100-RP	20	NF100-UP	20
Full voltage starting	5.5	11	N18~N35	11	NF30-CS	30	NF30-SP	30	NF50-SP	30	NF50-HP	30			NF100-SP	30	NF50-HRP	30			NF100-HP	30			NF100-RP	30	NF100-UP	30
Full voltage starting	7.5	15	N20~N35·N50	15	NF30-CS	30	NF30-SP	30	NF50-SP	30	NF50-HP	30			NF100-SP	30	NF50-HRP	30			NF100-HP	30			NF100-RP	30	NF100-UP	30
Full voltage starting	11	22	N25·N35·N50·N65	22			NF50-CP NF50-k	50	NF50-SP	50	NF50-HP	50			NF100-SP	50	NF50-HRP	50			NF100-HP	50			NF100-RP	50	NF100-UP	50
Full voltage starting	15	28	N35·N50~N80	28			NF60-CP	60	NF60-SP	60	NF60-HP	60			NF100-SP	60					NF100-HP	60			NF100-RP	60	NF100-UP	60
Full voltage starting	18.5	34	N50~N95	35					NF100-K	100	NF100-CP	60			NF100-SP	60					NF100-HP	60			NF100-RP	60	NF100-UP	60
Full voltage starting	22	42	N50~N95	42					NF100-K	100	NF100-CP	75			NF100-SP	75					NF100-HP	75			NF100-RP	85	NF100-UP	75
Full voltage starting	30	55	N65~N125	54					NF225-K	150	NF100-CP	100			NF100-SP	100					NF100-HP	100			NF100-RP	100	NF100-UP	100
Full voltage starting	37	65	N80~N150	67					NF225-K	200	NF100-CP	100			NF100-SP	100					NF100-HP	100			NF100-RP	100	NF100-UP	100
Full voltage starting	45	82	N95~N150	82					NF225-K	225			NF225-CP	125	NF225-CP	125					NF225-HP	125			NF225-RP	125	NF225-UP	125
Y-Δ starting	5.5	11	–	11			NF50-CP	30	NF50-SP	30	NF50-CP	30			NF100-SP	30	NF50-HRP	30			NF100-HP	30			NF100-RP	30	NF100-UP	30
Y-Δ starting	7.5	15	–	15			NF50-CP	40	NF50-SP	40	NF50-CP	40			NF100-SP	40	NF50-HRP	40			NF100-HP	40			NF100-RP	40	NF100-UP	40
Y-Δ starting	11	22	–	22			NF50-CP	50	NF50-SP	50	NF50-CP	50			NF100-SP	50	NF50-HRP	50			NF100-HP	50			NF100-RP	50	NF100-UP	50
Y-Δ starting	15	28	–	28					NF100-K	75	NF100-CP	60			NF100-SP	60					NF100-HP	60			NF100-RP	60	NF100-UP	60
Y-Δ starting	18.5	34	–	35					NF100-K	100	NF100-CP	60			NF100-SP	60					NF100-HP	60			NF100-RP	60	NF100-UP	60
Y-Δ starting	22	42	–	42					NF100-K	100	NF100-CP	75			NF100-SP	75					NF100-HP	75			NF100-RP	75	NF100-UP	75
Y-Δ starting	30	55	–	54					NF225-K	150	NF100-CP	100			NF100-SP	100					NF100-HP	100			NF100-RP	100	NF100-UP	100
Y-Δ starting	37	65	–	67					NF225-K	200	NF100-CP	100			NF100-SP	100					NF100-HP	100			NF100-RP	100	NF100-UP	100
Y-Δ starting	45	82	–	82					NF225-K	225			NF225-CP	150	NF225-CP	150					NF225-HP	150			NF225-RP	150	NF225-UP	150
Y-Δ starting / Full voltage starting	55	96	N125~N220	105									NF225-CP	175	NF225-CP	175					NF225-HP	175			NF225-RP	175	NF225-UP	175
Y-Δ starting / Full voltage starting	75	134	N150~N220	125									NF225-CP	225	NF225-CP	225					NF225-HP	225	NF400-HEP	225	NF225-RP	225	NF225-UP	225
Y-Δ starting / Full voltage starting	90	160	N180~N400	150											NF225-SEP	225					NF225-HEP	225	NF400-HEP	225	NF400-REP	225	NF400-UEP	225
Y-Δ starting / Full voltage starting	110	192	N180~N400	180																	NF400-SP	350	NF400-HEP	300	NF400-REP	300	NF400-UEP	300
Y-Δ starting / Full voltage starting	132	233	N220~N400	250																	NF400-SP	400	NF400-HEP	400	NF400-REP	400	NF400-UEP	400
Y-Δ starting / Full voltage starting	160	290	N300·N400·(N600)	250																	NF600-SP	500	NF600-HEP	500	NF600-REP	500	NF600-UEP	500
Y-Δ starting / Full voltage starting	200	360	N300·N400· (N600·N800)	330																	NF600-SP	600	NF600-HEP	600	NF600-REP	600	NF600-UEP	600
Y-Δ starting / Full voltage starting	220	389	N300·N400· (N600·N800)	–																	NF600-SP	600	NF600-HEP	600	NF600-REP	600	NF600-UEP	600
Y-Δ starting / Full voltage starting	250	430	(N600·N800)	500																	NF800-SEP	700	NF800-HEP	700	NF800-REP	700	NF800-UEP	700
Y-Δ starting / Full voltage starting	300	500	(N600·N800)	500																	NF800-SEP	700	NF800-HEP	700	NF800-REP	700	NF800-UEP	700

Notes:

1. Starting conditions equivalent to IEC 60947-4-1 AC-3 (full voltage starting, Y-Δ starting).
2. Protective coordination is decided at 40°C cold start.
3. The ratings shown in ( ) are for thermal relays equipped with reactors.
4. The rush current switching to Δ depends on the residual magnetic flux at the time of Y starting, Δ closing phase or power transformer capacity. They are approximately as shown in the table on the right.
5. The maximum starting current is the effective current (current after disappearance of the transient phenomenon) when the rotor is about to start rotating.
6. It is generally known that a large transient rush current flows in Y-Δ starting. The open transition system is assumed.

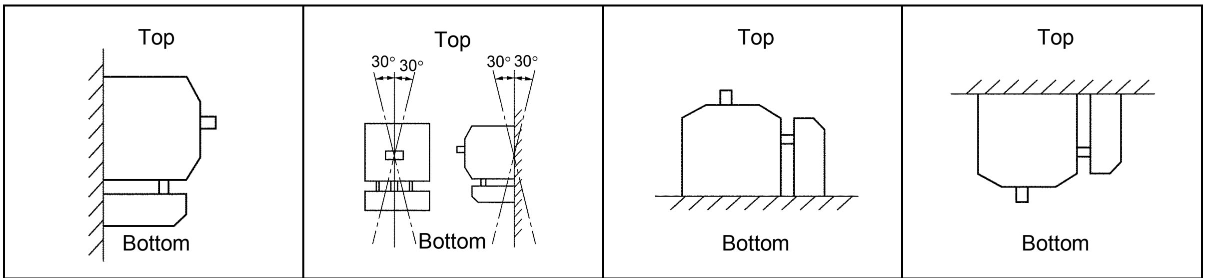
Starting conditions

Motor capacity (kW)	Full voltage starting time (600%) (sec.)	Maximum starting current of full voltage starting (multiple of full load current) (times)	Starting rush current (multiple of full load current)	
			Full voltage starting (times)	Y-Δ starting (times)
0.2 ~ 7.5	10	8	12	16
11 ~ 55	10	8	12	17
75 ~150	10	8	14	18

Installation and Connection

1. Direct Installation

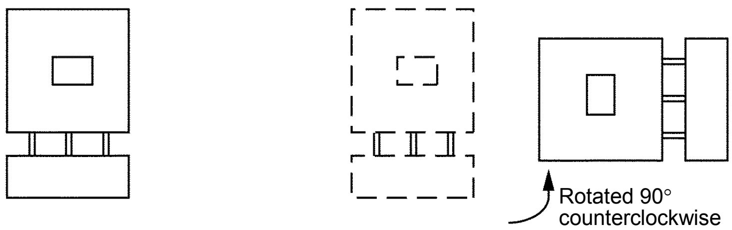
The magnetic motor starters are designed to be installed to one positional orientation due to their structure. The characteristics change if installed differently.
The magnetic motor starter is installed correctly if the terminals on the line terminal upwards and the load terminals downwards and if it is in parallel with the vertical planes such as the panel face, wall and column. Structurally, the balance of operation between the movable elements and the spring system is designed so that the movable elements move horizontally. The thermal overload relay characteristics are also defined when installed to the correct orientation. Fig. 1 shows the positional orientation of installation.
If installed face up, the weight of the contactor movable elements acts downward against the spring. This causes the closing time to quicken, the operating voltage to lower and breaking voltage to lower. The closing impact becomes high, adversely affecting the switching durability and circuit breaking.
If installed face down on the other hand, the operating voltage becomes high due to insufficient attractive force during closing. Therefore, it is unfavorable because poor contact closing may result depending on beat or voltage. Installation with one side up causes the motion of the sliding elements to change, adversely affecting the switching durability.
The allowable tilt is within ±30° both in left/right and fore/aft directions. It is favorable that the wall and panel are sturdy and do not transmit vibration or impact easily.



Regular	Tilted	Face up	Face down
◎	○	×	×

Fig. 1 Installation orientation

Because of wiring or device layout, the magnetic motor starter may have to be installed with one side up. It makes little difference in the characteristics compared with the correct installation. However, from the viewpoint of the operating reliability and mechanical switching durability, the MS-N series are to be installed as shown in Fig. 2. Note that the type S-N600 and N800 cannot be installed with one side up. Due to the mechanical interlock system, the reversible types cannot be installed with one side up either.



Regular installation **Horizontal installation**

Fig. 2 Horizontal installation direction

2. DIN Rail Installation

(1) Applicable types

Table 1 Typical types applicable to rail installation

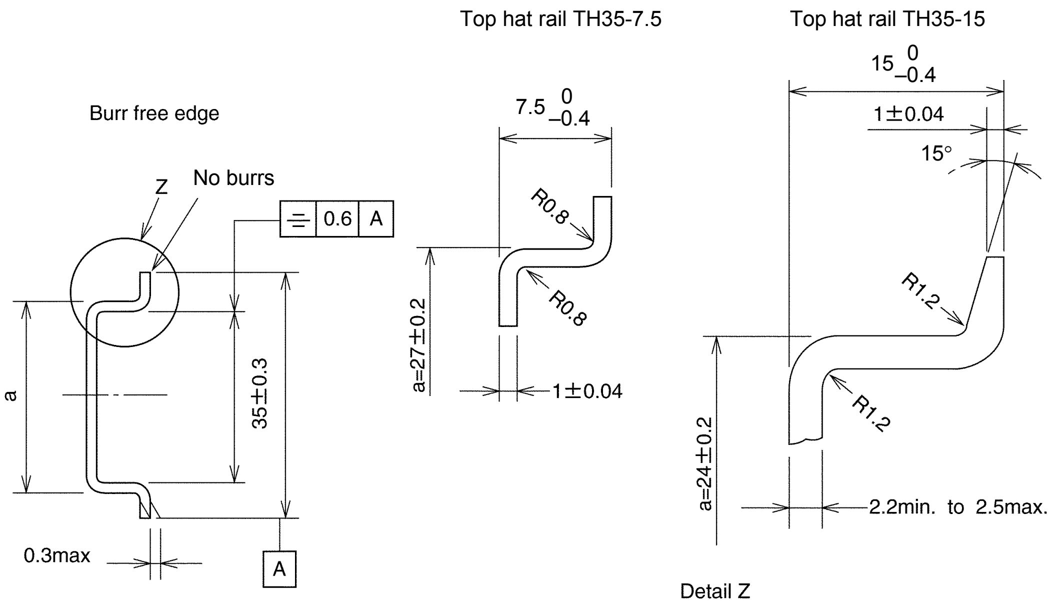
Magnetic motor starter	Magnetic contactor	Magnetic motor starter	Magnetic contactor	Thermal overload relay
MSO-N10	S-N10	MSOD-N11	SD-N11	TH-N12 + UN-HZ12
MSO-N11	S-N11	MSOD-N12	SD-N12	TH-N20 + UN-RM20
MSO-N12	S-N12	MSOD-N21	SD-N21	**Magnetic relay**
MSO-N18	S-N18	MSOD-N35	SD-N35	SR-N4
MSO-N20	S-N20		S-N28	SR-N5
MSO-N21	S-N21		S-N38	SR-N8
MSO-N25	S-N25		S-N48	SRD-N4
MSO-N35	S-N35		SL (D) - N21	SRD-N5
MSO-N50	S-N50		SL (D) - N35	SRD-N8
MSO-N65	S-N65		SL (D) - N50	SRL (D) - N4
			SL (D) - N65	

(2) Applicable rails

Two types of top hat rails available that comply with DIN, EN and IEC standards. The profiles and dimensions are defined as shown in the table below.

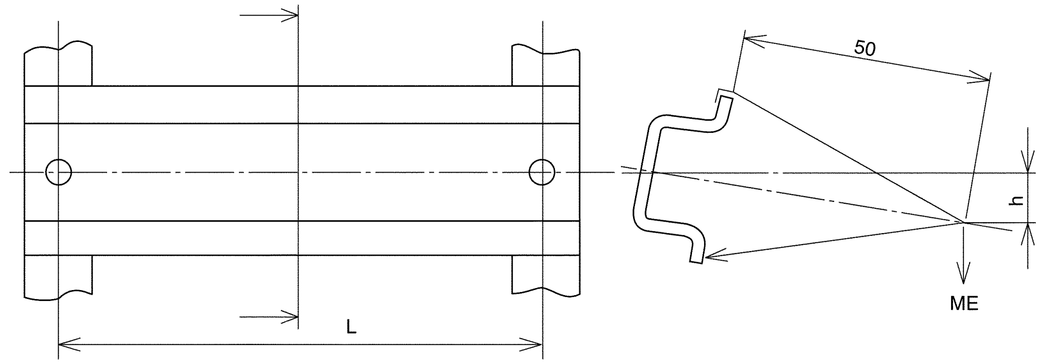
Table 2 Applicable rails

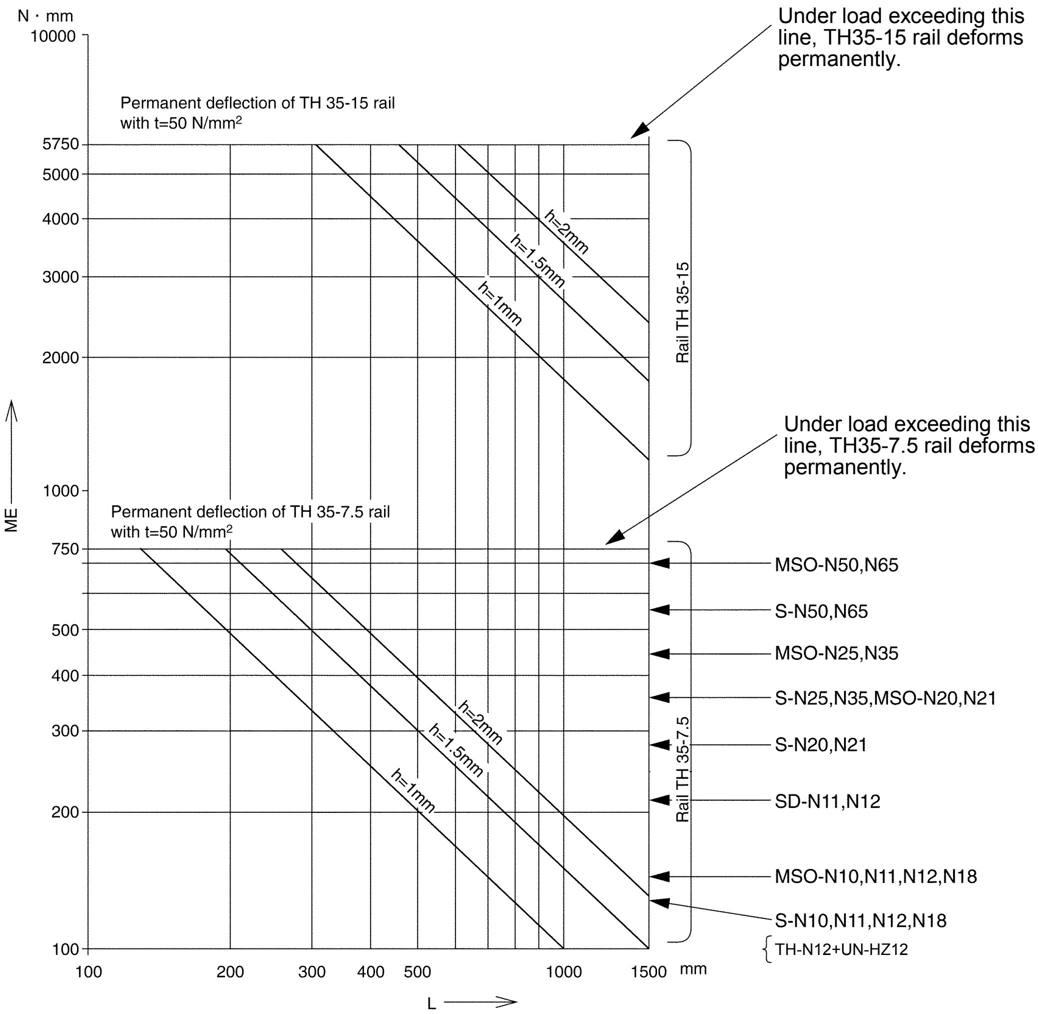
Rail		Rail specification
1	TH35-7.5	Rail width 35 mm, height 7.5 mm
2	TH35-15	Rail width 35 mm, height 15 mm



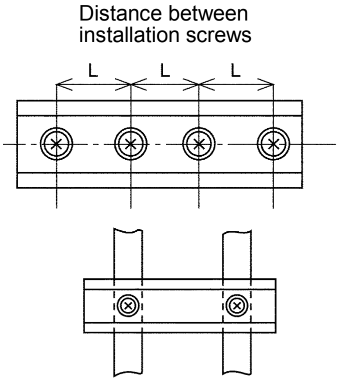
(3) Rail installation screw distance

The DIN rail strength depends on the deflection and permanent deformation due to torsion with the product installed. Obviously, this in turn depends on the magnitude of torsional moment with the product installed and the distance of the screws that secure the rail on the panel surface.
Deflection h of steel rails is as follows. (This can be applicable to aluminum as well.)





Due to the mechanical strength of the rails, the distance between the screws should be equal to or less than those shown in Table 3.



(a) Installed on channel

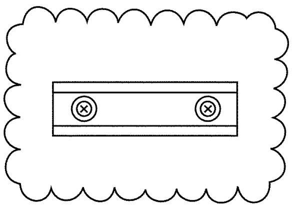

(b) Installed on panel surface

Table 3 Distance L between rail installation screws (mm)

Mode of installation \ Frame size		N10 N11 N12 TH-N12 + UN-HZ12	N18 N20 N21	N25 N35	N50 N65
Installation on channel	TH35-7.5	100	(100)	(100)	–
	TH35-15	500	500	500	500
Installation on panel surface	TH35-7.5	250	250	200	(150)
	TH35-15	500	500	500	500

Notes: 1. If several types are on one rail, selecting the minimum distance is favorable.
2. The distance in parentheses are not recommended to operation at high switching frequency.

(4) Clearance between products on rail

Considering the temperature rise and life of each product, the clearance between products on one rail should be equal to or greater than those shown in Table 4.

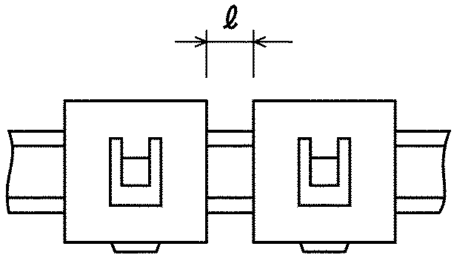


Table 4 Clearance ℓ between products installed on rail (mm)

Type \ Frame size	N10 N11 N12	N18 N20 N21	N25 N35	N50 N65
MSO type	5	5	5	10
S type	5	5	5	10
Installation with no clearance ∗	OK	OK	OK	OK

Note: ∗ When installing products that carry current continuously, operate at high switching frequency and heavy duty on one rail, installation with no clearance should be avoided as much as possible because temperature rise and impact may reduce the life.

As a means to provide clearances, it is recommended that commercially available spacers (thicknesses in multiple of 5 mm) be used.

(5) Installation strength of products on rail

As a guideline of the securing force and safety for products installed on a rail, the following table shows the test results.

1) Vibration resistance ..... Accelerated vertically, horizontally and fore and aft in the following conditions.

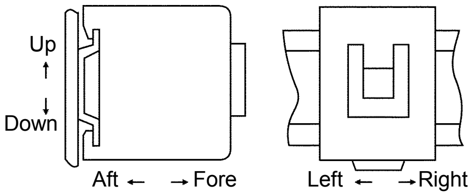


Table 5 Vibration resistance

Test item	Test details	Results
Resonance point	Vibrated at a constant acceleration of 19.6 m/s^2 at 10 to 100 Hz to check for resonance point.	All right without resonance point, damage and side slip.
Constant vibration durability	Vibrated at frequency 16.7 Hz and amplitude 4 mm in both directions for 1 hour.	

2) Impact resistance .... Tested on pendulum test equipment to check impact resistance.

Table 6 Impact resistance

Impact direction	Fore $\rightarrow$ aft	Up $\rightarrow$ down	Down $\rightarrow$ up	Left $\rightarrow$ right
Results	490m/s^2 OK	490m/s^2 OK	At 196 m/s^2 or above, claw breaks or falls.	At 196 m/s^2 or above, side slip occurs.

3) Drop impact .... Installed on the panel shown below to check acceleration at a point immediately below the product and its effect.

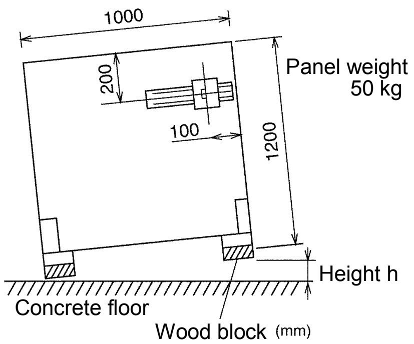


Table 7 Drop impact

	Acceleration (m/s^2)	Height h (mm)
Results	29.4 OK	(200mm)
	At 343 to 490, claw breaks or fall.	(250mm or higher)

(Note) Height h is a guideline and for reference.

4) Static strength.............. Loaded vertically and horizontally.

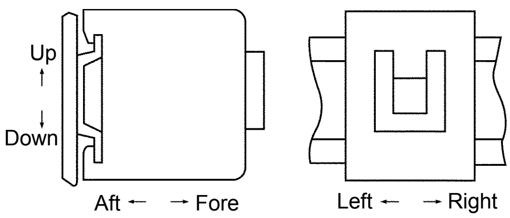


Table 8 Static strength

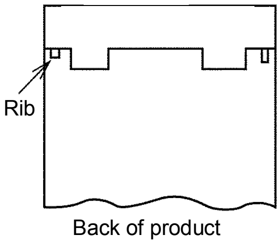
Direction of loading	Results
Up $\rightarrow$ down	588N OK At 1760N, rail deforms.
Left $\rightarrow$ right	At 196N or above, side slip occurs.

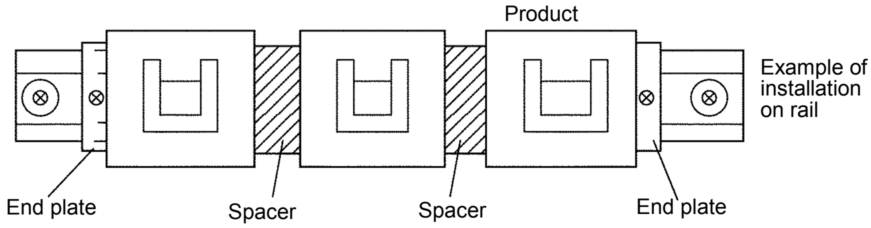
5) Displacement due to switching

No displacement occurs before and after 5,000,000 cycles of mechanical switching durability test.

(6) Cautions on application

1) Prevention of side slip . As a means to side slip prevention, break the ribs on the mount at the time of installation. This makes side slip least likely.
Side slip is possible if it is installed and removed frequently. In such a case, it is recommended that commercially available end plates be used on both ends of the product train.

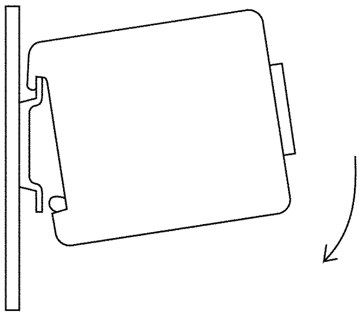




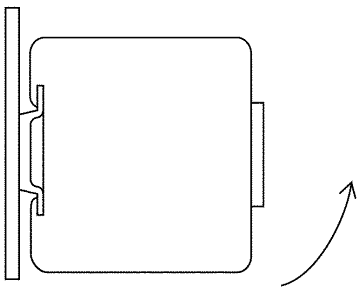
2) Operating environment.................................... Avoid installation on rails where subjected to constant vibration during operation. Also avoid using in an acid gas ambient because the claws may crack.

3) Check after transporting installation panel ...... If the panel is dropped unintentionally or given large shock (see section (5) 3)), check the claws for damage and dislodging from the rail.

(7) Method of installation on rails and condition of installation



To install a device on the rail, first engage the upper claws with the rail. While pressing it downward, push the device in the direction of the arrow. The lower claws are engaged automatically to complete installation on the rail.



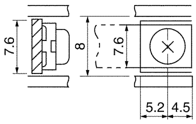
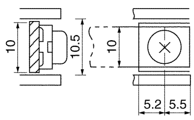
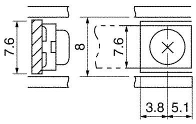
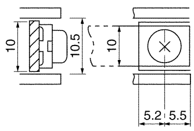
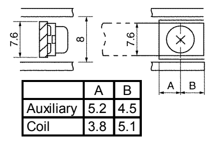
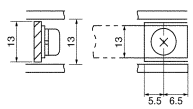
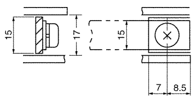
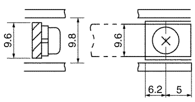
To check that the device has been installed correctly, push the device upward with approximately 29.4 N of force. It is all right if the device is not disengaged from the rail.
If it does, install the engaging claws and push it upwards.

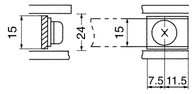
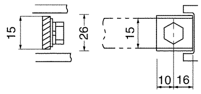
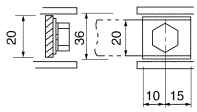
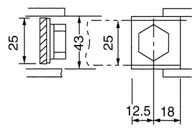
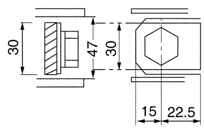
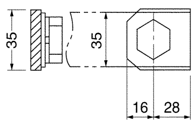
3. List of Terminal Size and Applicable Terminal Lag

⚠ Overheat or a fire may occur. Observe tightening torque and tighten further periodically.
Install and connect the wires accurately according to the connection diagram. Fasten the terminal screws correctly according to the torque ranges shown in the list below.
Insufficient fastening causes overheat or wire fallout. Excessive tightening may cause the terminal screws to break.
Do not let lock paint or thermo-label to contaminate the wire connections or contacts.
Or else, resulting insufficient electrical continuity causes dangerous heat buildup.

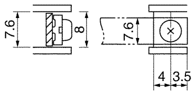
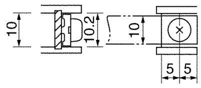
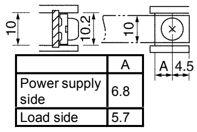
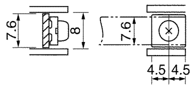
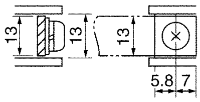
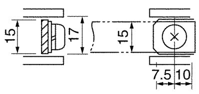
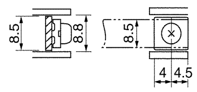
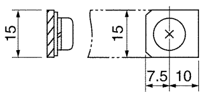
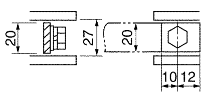
Either single wires, stranded wires or terminal lug can be used for the main circuit terminals of the N10 through N21, TH-N12 through TH-N20 types. Terminals with retainers ("self-lifting terminals") are used for the main circuit terminals of the N10 through N21 and TH-N12 through TH-N20 types and for the operation circuit terminals of all the types to facilitate connection.

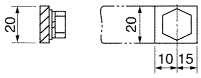
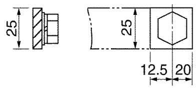
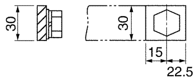
(1) List of dimensions around terminals, screw sizes, applicable wires and tightening torque for S-N type magnetic contactors.

Model name	Location	Dimensions around terminal	Terminal screw size [mm] and type	Applicable conductor size [ø mm, mm²]	Applicable terminal lug (Ring type) Max. width in ( )	Terminal screw tightening torque [N•m]
S-N10 S-N11 S-N12	Main Auxiliary Coil		M3.5 × 8 Self-lifting terminal screw	ø1.2 - ø1.6 1 - 2.5	1 – 2.5 (Width 7.8)	0.94 - 1.51
S-N18	Main		M4 × 10.5 Self-lifting terminal screw	ø1.6 - ø2.6 1 - 6	1 – 6 (Width 10)	1.18 – 1.86
	Coil		M3.5 × 8 Self-lifting terminal screw	ø1.2 - ø1.6 1 - 2.5	1 – 2.5 (Width 7.8)	0.94 – 1.51
S-N20 S-N21	Main		M4 × 10.5 Self-lifting terminal screw	ø1.6 - ø2.6 1 - 6	1 – 6 (Width 10)	1.18 – 1.86
	Auxiliary coil		M3.5 × 8 Self-lifting terminal screw	ø1.2 - ø1.6 1 - 2.5	1 – 2.5 (Width 7.8)	0.94 – 1.51
S-N25 S-N35 S-N38 S-N48	Main		M5 × 14 screw with SW-PW	(ø1.6 - ø3.6) (2 - 16) [∗1, ∗2]	1 – 16 (Width 13)	2.06 - 3.33
	Auxiliary coil	Same as S-N20 and N21	M3.5 × 8 Self-lifting terminal screw	ø1.2 - ø1.6 1 - 2.5	1 – 2.5 (Width 7.8)	0.94 - 1.51
S-N50 S-N65	Main		M6 × 12 screw with SW-PW	(2 - 25) [∗1]	2 – 25 (Width 16.5)	3.53 – 5.78
	Auxiliary coil		M4 × 10 Self-lifting terminal screw	ø1.2 - ø1.6 1 – 2.5	1 – 2.5 (Width 8.5)	1.18 – 1.86

Model name	Location	Dimensions around terminal	Terminal screw size [mm] and type	Applicable conductor size [ø mm, mm^2]	Applicable terminal lug (Ring type) Max. width in ( )	Terminal screw tightening torque [N•m]
S-N80 S-N95	Main		M6 × 12 screw with SW-PW	(2 – 38) [∗1]	2 - 60 (Width 22)	3.53 – 5.78
	Auxiliary coil	Same as S-N50 and N65	M4 × 10 Self-lifting terminal screw	ø1.2 - ø1.6 1 – 2.5	1 – 2.5 (Width 8.5)	1.18 – 1.86
S-N125	Main		M8 × 20 bolt with SW-PW	—	6 - 70 (Width 22)	6.28 – 10.29
	Auxiliary coil	Same as S-N50 and N65	M4 × 10 Self-lifting terminal screw	ø1.2 - ø1.6 1 - 2.5	1 – 2.5 (Width 8.5)	1.18 – 1.86
S-N150	Main		M8 × 20 bolt with SW-PW	—	6 - 95	6.28 – 10.29
	Auxiliary coil	Same as S-N50 and N65	M4 × 10 Self-lifting terminal screw	ø1.2 - ø1.6 1 - 2.5	1 – 2.5 (Width 8.5)	1.18 – 1.86
S-N180 S-N220	Main		M10 × 25 bolt with SW-PW	—	10 – 120	11.8 – 19.1
	Auxiliary coil	Same as S-N50 and N65	M4 × 10 Self-lifting terminal screw	ø1.2 - ø1.6 1 - 2.5	1 – 2.5 (Width 8.5)	1.18 – 1.86
S-N300 S-N400	Main		M12 × 30 bolt with SW-PW	—	25 - 240	19.6 – 31.3
	Auxiliary coil	Same as S-N50 and N65	M4 × 10 Self-lifting terminal screw	ø1.2 - ø1.6 1 - 2.5	1 – 2.5 (Width 8.5)	1.18 – 1.86
S-N600 S-N800	Main		M16 × 45 bolt with SW-PW	—	70 - 325	62.8 - 98
	Auxiliary coil	Same as S-N50 and N65	M4 × 10 Self-lifting terminal screw	ø1.2 - ø1.6 1 - 2.5	1 – 2.5 (Width 8.5)	1.18 – 1.86

(2) List of dimensions around terminals, screw sizes, applicable wires and fastening torque for type TH-N thermal overload relays

Model name	Location	Dimensions around terminal	Terminal screw size [mm] and type	Applicable conductor size [ø mm, mm²]	Applicable terminal lug (Ring type) Max. width in ( )	Terminal screw tightening torque [N•m]
TH-N12	Main Auxiliary		M3.5 × 8 Self-lifting terminal screw	ø1.2 - ø1.6 1 - 2.5	1 – 2.5 (Width 7.8)	0.94 – 1.51
TH-N18	Main		M4 × 10.5 Self-lifting terminal screw	ø1.6 - ø2.6 1 - 6	1 – 6 (Width 10)	1.18 – 1.86
	Auxiliary	Same as TH-N12	M3.5 × 8 Self-lifting terminal screw	ø1.2 - ø1.6 1 - 2.5	1 – 2.5 (Width 7.8)	0.94 – 1.51
TH-N20	Main		M4 × 10.5 Self-lifting terminal screw	ø1.6 - ø2.6 1 - 6	1 – 6 (Width 10)	1.18 – 1.86
	Auxiliary		M3.5 × 8 Self-lifting terminal screw	ø1.2 - ø1.6 1 - 2.5	1 – 2.5 (Width 7.8)	0.94 – 1.51
TH-N20TA	Main (Load side)	 Line side, same as TH-N20	M5 × 14 screw with SW-PW	(ø1.6 - ø3.6) (6 - 16) [∗1, ∗2]	6 – 16 (Width 13)	2.06 – 3.33
	Auxiliary	Same as TH-N20	M3.5 × 8 Self-lifting terminal screw	ø1.2 - ø1.6 1 - 2.5	1 – 2.5 (Width 7.8)	0.94 – 1.51
TH-N60	Main		M6 × 12 screw with SW-PW	(2 - 25) [∗1]	2 – 25 (Width 16.5)	3.53 – 5.78
	Auxiliary		M4 × 10 Self-lifting terminal screw	ø1.2 - ø1.6 1 - 2.5	1 – 2.5 (Width 8.5)	1.18 – 1.86
TH-N60TA	Main (Load side)	 Line side, same as TH-N60	M6 × 12 screw with SW-PW	(8 - 38) [∗1]	8 – 38	3.53 – 5.78
	Auxiliary	Same as TH-N60	M4 × 10 Self-lifting terminal screw	ø1.2 - ø1.6 1 - 2.5	1 – 2.5 (Width 8.5)	1.18 – 1.86
TH-N120	Main		M8 × 20 bolt with SW-PW	—	10 – 38 (Width 25)	6.28 – 10.29
	Auxiliary	Same as TH-N60	M4 × 10 Self-lifting terminal screw	ø1.2 - ø1.6 1 - 2.5	1 – 2.5 (Width 7.8)	1.18 – 1.86

Model name	Location	Dimensions around terminal	Terminal screw size [mm] and type	Applicable conductor size [ø mm, mm^2]	Applicable terminal lug (Ring type) Max. width in ( )	Terminal screw tightening torque [N•m]
TH-N120TA	Main (Load side)	 Line side, same as TH-N120	M8 × 20 bolt with SW-PW	—	10 – 60	6.28 – 10.29
	Auxiliary	Same as TH-N60	M4 × 10 Self-lifting terminal screw	ø1.2 - ø1.6 1 - 2.5	1 – 2.5 (Width 8.5)	1.18 – 1.86
TH-N220RH TH-N220HZ	Main		M10 × 25 bolt with SW-PW	—	10 – 150	11.8 – 19.1
	Auxiliary	Same as TH-N60	M4 × 10 Self-lifting terminal screw	ø1.2 - ø1.6 1 - 2.5	1 – 2.5 (Width 8.5)	1.18 – 1.86
TH-N400RH TH-N400HZ	Main		M12 × 30 bolt with SW-PW	—	25 – 240	19.6 – 31.3
	Auxiliary	Same as TH-N60	M4 × 10 Self-lifting terminal screw	ø1.2 - ø1.6 1 - 2.5	1 – 2.5 (Width 8.5)	1.18 – 1.86
TH-N600	Auxiliary	Same as TH-N60	M4 × 10 Self-lifting terminal screw	ø1.2 - ø1.6 1 - 2.5	1 – 2.5 (Width 8.5)	1.18 – 1.86

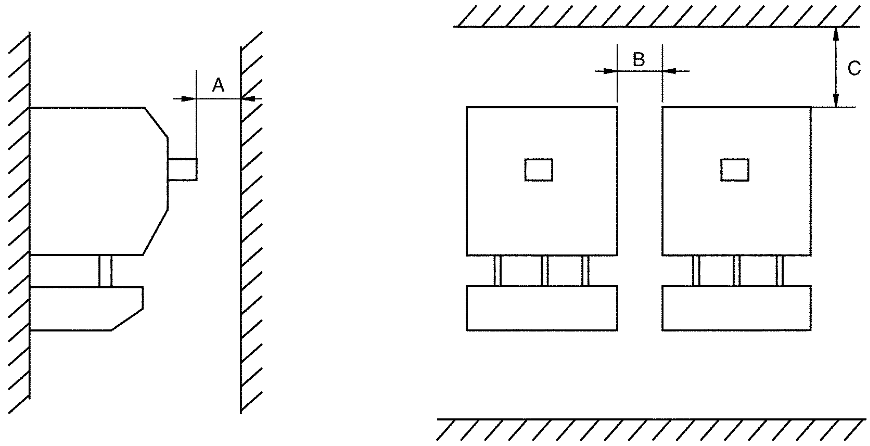
Notes 1. When connecting a wire with the insulation stripped to a terminal, use the attached wire clamper. In this case, the wire sizes in the parentheses can be used.

- Type S-N25, N35 and TH-N20TA are equipped with terminal screws (self-lifting plus/minus screws) for retaining main circuit wires. Type MS-N50 to N95 and TH-N60, N60TA are equipped with main circuit wire clampers.
- Type MS, MSO, S-N125 to N800 are exclusive to crimp terminal wiring.

2. Connect wires as follows when using type MSO, S-N25CX or N35CX or TH-N20TA.

- Do not connect wire of 8 mm^2 or larger with wire of 2 mm^2 together. Use ø1.6 wire instead of 2 mm^2.
- Only one wire of 16 mm^2 can be connected. In this case, divide the conductor to connect the wire on both sides of the screw.

4. Minimum Gaps for Installation of Type MSO-N Magnetic Motor Starters



Minimum gaps

mm

Model name	A	B	C
MSO-N10	5	5	15
MSO-N11, N12	5	5	15
MSO-N18	5	5	15
MSO-N20, N21	5	5	15
MSO-N25, N35	5	5	15
MSO-N50, N65	5	10	25
MSO-N80, N95	10	10	25
MSO-N125	10	12	25
MSO-N150	10	12	30
MSO-N180, N220	10	12	50
MSO-N300, N400	10	12	90
S-N600, N800 **(Note)**	10	15	90

Note: Indicates gaps for magnetic contactors. Magnetic motor starters are not in the scope of manufacturer.

Approved Standards

1. MS-N Series Magnetic Motor Starters conformed with Overseas and Marine Vessel Standards

As shown in the table below, the MS-N series magnetic motor starters are conformed with the overseas and marine vessel standards.

Standard	Nation	Standard No.	Year	Title	MS-N series compliance
Domestic standards	Japan	JEM1038 JIS C8325	1990 1983	Magnetic contactors AC magnetic motor starters	Conformed with JEM and JIS.
Overseas safety standards	U.S.A.	UL508	1993	Industrial Control Equipment	Approved UL standard.
	Canada	CSA C22.2 No.14-95	1995	Industrial Control Equipment Industrial Products	Approved to Canada CSA standard.
	Europe	Low voltage directives (CE mark) 73/23/EEC 93/68/EEC/Article13 Product standard EN60947-4-1	 1973 1993 1992	 Low Voltage Directive Amending Directive 73/23/EEC Specification for Low-voltage switchgear and controlgear Part4 contactors and motor-starters Section 1. Electromechanical contactors and motor-starters	CE marking on the products. As products can be exported direct to Europe. Since conformed with EN standard and certified TÜV, the MS-N series can be installed on machine tools, control equipment, etc. to Europe.
	Miscel-laneous	IEC60947-4-1	1990	Low-voltage switchgear and controlgear Part 4: Contactors and motor-starters Section One-Electromechanical contactors and motor-starters	Though applicable standards differ from one country to another, their standards are principally based on IEC standard. Basically applicable as the MS-N series are conformed with IEC standards. Need to be conformed with each individual standard, as necessary.
Marine vessel standards	NK (Japan)		1997	Steel Vessel Code, Division H	Approved NK for applications to steel vessels.
	KR (Korea)		1995	KR Rule Part6	Approved KR for applications to steel vessels.
	BV (France)		1996	BV Rule Part Ⅲ	Approved BV for applications to steel vessels.
	LR (U.K.)		1996	LR Type Approval System, Test Specification No.1	Approved LR for applications to steel vessels.

2. MS-N Series Conformity to International Standards

Type	Model name	Europe: CE Mark	Europe: TÜV (TÜV Rheinland)	North America / UL: Listing (c UL us) U.S.A.	North America / UL: Listing (c UL us) Canada	North America / UL: Recognition (c RU us) U.S.A.	North America / UL: Recognition (c RU us) Canada	Marine: Japan (Nippon Kaiji Kyokai)	Marine: U.K. (Lloy's Register of Shipping)	Marine: France (Bureau Veritas)	Marine: Korea (Korean Register of Shipping)
AC operated magnetic contactor	S-N10 (CX) S-N11 (CX)/N12 (CX) S-N18 (CX) S-N20 (CX)/N21 (CX) S-N25 (CX) S-N35 (CX)	◎	● [*2]	◎	◎	◎ (UL mark)	◎ (cUL mark)	◎	○	○	○
	S-N28 (CX)	◎	● [*2]	◎	◎	◎ (UL mark)	◎ (cUL mark)	–	○	○	–
	S-N38 (CX) S-N48 (CX)	◎	● [*2]	◎	◎	◎ (UL mark)	◎ (cUL mark)	◎	–	–	–
	S-N50 S-N65 S-N80 S-N95 S-N125 S-N150 S-N180 S-N220 S-N300 S-N400 S-N600	◎	●	☆		◎		◎	○	○	○
	S-N800	◎	–	☆		☆		◎	○	○	–
Thermal overload relay	TH-N12 (CX) KP TH-N18 (CX) KP TH-20 (TA) (CX) KP	◎	○ [*2]	☆	☆	◎	◎	–	○	○	–
	TH-N60 (TA) KP TH-N120 (TA) KP TH-N220RHKP/HZKP TH-N400RHKP/HZKP	◎	○	☆	☆	◎	◎	–	○	○	–
DC operated magnetic contactor	SD-N11 (CX)/N12 (CX) SD-N21 (CX) SD-N35 (CX)	◎	● [*2]	◎	◎	◎ (UL mark)	◎ (cUL mark)	◎	○	○	–
	SD-N50 SD-N65 SD-N80 SD-N95 SD-N125 SD-N150 SD-N220 SD-N300 SD-N400	◎	●	☆		◎		◎	○	○	–
	SD-N600 SD-N800	◎	–	–	–	–	–	◎	○	○	–
AC operated contactor relay	SR-N4 (CX) SR-N5 (CX) SR-N8 (CX)	◎	● [*2]	◎	◎	◎ (UL mark)	◎ (cUL mark)	–	○	○	–
DC operated contactor relay	SRD-N4 (CX) SRD-N5 (CX) SRD-N8 (CX)	◎	● [*2]	◎	◎	◎ (UL mark)	◎ (cUL mark)	–	○	○	–
Additional auxiliary contact block	UN-AX2 (CX) UN-AX4 (CX) UN-AX11 (CX)	◎	○ [*2]	◎	◎	◎ (UL mark)	◎ (cUL mark)	–	○	○	–
	UN-AX80 UN-AX150	◎	○	–	–	○	–	–	○	○	–

Notes: 1. ◎ : CE Mark (Manufacturer's Deceleration) = Standard model is applicable, marking on the product.
UL= Standard model is applicable, marking on the product.
NK= Standard model is applicable, certificate No. on the product.

● : Standard model is applicable, no marking on the product. If marking required, order model name followed by suffix "DZ"

○ : Standard model is applicable, no marking on the product.

☆ : Special model is applicable, marking on the product. Order model name followed by suffix "UL"

– : Not applicable to the standard or not approved.

2. Finger protection type is certified according to DIN VDE 0106 part 100.
For finger protection type, order model name followed by suffix "CX"

3. For each certificate conditions, see next twelve pages.

3. MS-N Series Magnetic Motor Starters Approved UL and CSA Standards

- **UL standard**

The UL is a U.S.A. organization that establishes the safety standard called "UL" and conducts certified tests on safety according to the UL standards. The organization issues products that have passed the certified tests and allows them to marking the certification marks.
The UL certification marks are widely recognized and accepted in U.S.A. Some states and cities even make it an obligation to be qualified to the UL standard. Thus, the UL qualification is necessary to devices, control panels, equipment and other similar products exported to U.S.A.
The MS-N series have obtained the UL parts certification (recognition) or the UL product certification (listing) according to control device UL standard (UL508). They can be installed for use in control panels, equipment and other similar products exported to U.S.A.

: UL parts certification (recognition)

This is called "recognition" and is applicable to products that are intended to be installed in other devices or equipment. The products approved "recognition" can be installed in control panels, machine tools, control equipment and other similar products.

: UL product certification (listing)

This is called "listing" and is applicable to products that can be sold directly to end users for their use. These products can also be installed in control panels, machine tools, control equipment and other similar products.

- **CSA standard**

The CSA standard is the product safety standard established by the CSA (Canadian Standard Association). In Canada, state laws define the safety for electrical products. Some state laws obligate to be approved to the CSA standard. Thus, CSA certification is necessary to devices, control panels, equipment and other similar products exported to Canada.
Since the MS-N series are approved to the CSA standard (control device standard CSA C22.2 NO.14) conducted by the testing organization UL, they can be installed for use in control panels, equipment and similar products exported to Canada. The UL is recognized by SCC (Standard Council of Canada) as a registered organization for testing, certification and quality audit. Furthermore, products approved to the CSA standard by the UL are recognized by the safety rules in all the Canadian states.

: Recognition on products for Canada
Parts certification to the CSA standard conducted by the testing organization UL.

: Listing on products for Canada

Product certification to the UL / CSA standards conducted by the testing organization UL.

- **The following certification marks are allowed to products approved to both UL and CSA standards.** (Marks respective to U.S.A. and Canada are recognized as practiced presently.)

: Recognition for parts to both U.S.A. and Canada
Parts certification to the UL/CSA standards by the testing organization UL.

: Listing for products to both U.S.A. and Canada
Product certification to the UL/CSA standards by testing organization UL.

The following table lists the MS-N series models approved to the UL/CSA standards.

MS-N series models approved to the UL/CSA standards

3.1 AC operated magnetic motor starters, magnetic contactor and terminal overload relay

(1) Parts certification

File No. E58968			File No. E58968			File No. E58969		
Magnetic contactor			Magnetic motor starter			Thermal overload relays to be coupled		
Mark	Model name	Appli-cability	Mark	Model name	Appli-cability	Mark	Model name	Appli-cability
c UL us (∗1)	S-N10 (CX)	◎	c RU us (∗2)	MSO-N10(CX)KP	○	c RU us (∗2)	TH-N12(CX)KP	○
	S-N11 (CX)	◎		MSO-N11(CX)KP	○			
	S-N12 (CX)	◎		MSO-N12(CX)KP	○			
	S-N20 (CX)	◎		MSO-N20(CX)KP	○		TH-N20(CX)KP	○
	S-N21 (CX)	◎		MSO-N21(CX)KP	○			
	S-N25 (CX)	◎		MSO-N25(CX)KP	○		TH-N20(TA)(CX) KP	○
	S-N35 (CX)	◎		MSO-N35(CX)KP	○			
c RU us	S-N50	○	c RU us	MSO-N50KP	○	c RU us	TH-N60KP	○
	S-N65	○		MSO-N65KP	○			
	S-N80	○		MSO-N80KP	○		TH-N60(TA)KP	○
	S-N95	○		MSO-N95KP	○			
	S-N125	○		MSO-N125KP	○		TH-N120(TA)KP	○
	S-N150	○		MSO-N150KP	○			
	S-N180	○		MSO-N180KP	○		TH-N220RHKP	○
	S-N220	○		MSO-N220KP	○			
	S-N300	○		MSO-N300KP	○		TH-N400RHKP	○
	S-N400	○		MSO-N400KP	○			

○ : Standard model is applicable

◎ : Standard model is applicable Listing for products. Also applicable Recognition for parts.

Notes: **1.** Marked on the product is UL and cUL.

2. Marked on the product is RU and cRU.

(2) Product certification

File No. E58968			File No. E58968			File No. E58969		
Magnetic contactor			Magnetic motor starter			Thermal relay to be coupled		
Mark	Model name	Appli-cability	Mark	Model name	Appli-cability	Mark	Model name	Appli-cability
c UL us (∗1)	S-N10 (CX)	○	c UL us (∗1)	MSO-N10(CX)KPUL	☆	c UL us (∗1)	TH-N12(CX)KPUL	☆
	S-N11 (CX)	○		MSO-N11(CX)KPUL	☆			
	S-N12 (CX)	○		MSO-N12(CX)KPUL	☆			
	S-N20 (CX)	○		MSO-N20(CX)KPUL	☆		TH-N20(CX)KPUL	☆
	S-N21 (CX)	○		MSO-N21(CX)KPUL	☆			
	S-N25 (CX)	○		MSO-N25(CX)KPUL	☆		TH-N20(TA)(CX) KPUL	☆
	S-N35 (CX)	○		MSO-N35(CX)KPUL	☆			
c UL us	S-N50UL	☆	c UL us	MSO-N50KPUL	☆	c UL us	TH-N60KPUL	☆
	S-N65UL	☆		MSO-N65KPUL	☆			
	S-N80UL	☆		MSO-N80KPUL	☆		TH-N60(TA)KPUL	☆
	S-N95UL	☆		MSO-N95KPUL	☆			
	S-N125UL	☆		MSO-N125KPUL	☆		TH-N120(TA)KPUL	☆
	S-N150UL	☆		MSO-N150KPUL	☆			
	S-N180UL	☆		MSO-N180KPUL	☆		TH-N220RHKPUL	☆
	S-N220UL	☆		MSO-N220KPUL	☆			
	S-N300UL	☆		MSO-N300KPUL	☆		TH-N400RHKPUL	☆
	S-N400UL	☆		MSO-N400KPUL	☆			

○ : Standard model is applicable. ☆ : Special model is applicable (N50 to N400: main circuit with solderless terminal)

Note: **1.** Marked on the product is UL and cUL.

3.2 DC operated magnetic contactor

File No. E58968

Mark	Model name	Applicability
(*1)	SD-N11 (CX)	◎
	SD-N12 (CX)	◎
	SD-N21 (CX)	◎
	SD-N35 (CX)	◎
	SD-N50	○
	SD-N65	○
	SD-N80	○
	SD-N95	○
	SD-N125	○
	SD-N150	○
	SD-N220	○
	SD-N300	○
	SD-N400	○

○ : Standard model is applicable.
◎ : Standard model is applicable Listing for products. Also applicable Recognition for parts.

Notes: 1. Marked on the product is and .

2. N125 to N400 coupled thermal overload relay (model name MSOD-N□(KP)) are not applicable.

3.3 Mechanically latched contactor (AC operated and DC operated)

File No. E58968

Mark	Model name	Applicability
(*1)	SL (D) – N21 (CX) UR	☆
	SL (D) – N35 (CX) UR	☆
	SL (D) – N50 (CX) UR	☆
	SL (D) – N65 (CX) UR	☆
	SL (D) – N80 (CX) UR	☆
	SL (D) – N95 (CX) UR	☆
	SL (D) – N125 (CX) UR	☆
	SL (D) – N150 CX) UR	☆
	SL (D) – N220 (CX) UR	☆
	SL (D) – N330 (CX) UR	☆
	SL (D) – N400 (CX) UR	☆

☆ : Special model is applicable.

Note: 1: Marked on the product is and .

3.4 Contactor relay (AC operated and DC operated)

File No. E58969

Mark	Model name	Applicability
c UL us (*1)	SR (D) – N4 (CX) 4NO, 3NO+1NC, 2NO+2NC	○
	SR (D) – N5 (CX) 5NO, 4NO+1NC, 3NO+2NC, 2NO+3NC	○
	SR (D) – N8 (CX) 8NO, 7NO+1NC, 6NO+2NC, 5NO+3NC	○

○ : Standard model is applicable Listing for products. Also applicable Recognition for parts.

Note: 1. Marked on the product is UL and c UL.

3.5 Additional auxiliary contact block

File No. E58969 (AX2 to AX11), E58968 (AX80/AX150)

Mark	Model name		Applicability
c UL us (*1)	UN-AX2	2NO, 1NO+1NC, 2NC	◎
	UN-AX4	4NO, 3NO+1NC, 2NO+2NC	◎
	UN-AX11	1NO+1NC	◎
RU	UN-AX80	1NO+1NC	○
	UN-AX150	1NO+1NC	○

○ : Standard model is applicable.
◎ : Standard model is applicable Listing for products. Also applicable Recognition for parts.

Note: 1. Marked on the product is UL and c UL.

3.6 Mechanical interlock

File No. E58969 (ML11/ML21), E58968 (ML80 to ML220)

Mark	Model name	Applicability
RU	UN-ML11 (CX)	○
	UN-ML21	○
	UN-ML80	○
	UN-ML150	○
	UN-ML220	○

○ : Standard model is applicable.

3.7 Surge absorber

File No. E58969

Mark	Model name	Applicability
c UL US (*1)	UN-SA21	○
	UN-SA23	○
	UN-SA25	○
c UL US	UN-SA721	○
	UN-SA725	○

○ : Standard model is applicable.

Note: 1. Marked on the product is UL and c UL.

4. Compliance of MS-N Series Magnetic Motor Starters with Low Voltage Directives

4.1 Outline of low voltage directives

Since January 1997, the low voltage directives have been enforced, which is one of the European directives.

Low voltage directives	:	73/23/EEC (original issue) 93/68/EEC (revised issue)
Applicable types	:	Equipment operated on 50 to 1000 VAC / 75 to 1500 VDC.

The above types exported as single products to European countries are subject to the low voltage directives. Thus, they need to be CE marking.

4.2 Compliance of magnetic motor starters with low voltage directives

(1) Magnetic motor starter used as a component

The motor starters need to be CE marking when they are exported direct to the EU countries. They do not need to be CE marking if machine tools, control equipment and other similar products are installed. When machine tools, control equipment and other similar products are CE marking, it is recommended that the magnetic motor starters with the third party qualification (TÜV) as described in (3) be used.

(2) Magnetic motor starters to be exported direct

When the magnetic motor starters are exported direct to the EU countries, they are subject to the low voltage directives. The applicable low voltage is "module A" that is to be self-declared basically. The applicable product standards are as follows:

EN60947-1 : Standard for control devices in general
EN60947-4-1: Standard for magnetic motor starters
EN60947-5-1: Standard for contactor relays

As shown in Table 1, the standard models of the MS-N series magnetic motor starters are applicable the low voltage directives.

(3) Third party qualification (TÜV) certified type

When machine tools, control equipment and other similar products are CE marking recommended to use the third party qualification (TÜV) certified type. The MS-N series magnetic motor starters have obtained the TÜV certificate as shown in Tables 2.1 to 2.4. However, since the models listed in Tables 2.1 to 2.4 are with no TÜV mark on the product, order model name followed by suffix "DZ" if TÜV mark on the product is required.

4.3 Miscellaneous

(1) Compliance of magnetic motor starters with EMC directives

Since the MS-N series magnetic motor starters do not integrate electronics circuits, they are not subject to the EMC directives. (Since the electromagnets of S-N50 to S-N800 are simple rectifier circuits, they are not subject to the EMC directives.)

(2) Compliance of magnetic motor starters with mechanical directives:

The MS-N series magnetic motor starters are components intended for use in machine tools, control equipment and other similar products, they are not subject to the mechanical directives. When machine tools, control equipment and other similar products are CE marking, magnetic motor starters installed them are recommended to use the third party qualification (TÜV) certified type. The MS-N series magnetic motor starters have obtained the TÜV certificate as shown in Tables 2.1 to 2.4. However, since the models listed in Tables 2.1 to 2.4 are with no TÜV mark on the product, order model name followed by suffix “DZ” if TÜV mark on the product is required.

Table 1 List of CE marked type and location of CE marking

Type	Model name	Location of marking
Magnetic contactor (AC operated)	S-(2×) N10 (CX) (SA), S-(2×) N11 (CX) (SA), S-N12 (CX) (SA), S-(2×) N18 (CX) (SA), S-(2×) N20 (CX) (SA), S-(2×) N12 (CX) (SA), S-(2×) N25 (CX) (SA), S-(2×) N35 (CX) (SA), S-(2×) N28 (CX) (SA), S-(2×) N38 (CX) (SA), S-(2×) N48 (CX) (SA), S-(2×) N50, S-(2×) N65, S-(2×) N80, S-(2×) N95, S-(2×) N125, S-(2×) N150, S-(2×) N180, S-(2×) N220, S-(2×) N300, S-(2×) N400, S-(2×) N600, S-(2×) N800,	Marking on the product name plate (∗2).
Magnetic motor starter (AC operated)	MSO-(2×) N10 (CX) KP (SA), MSO-(2×) N11 (CX) KP (SA), MSO N12 (CX) KP (SA), MSO-(2×) N18 (CX) KP (SA), MSO-(2×) N20 (CX) KP (SA), MSO-(2×) N21 (CX) KP (SA), MSO-(2×) N25 (CX) KP (SA), MSO-(2×) N35 (CX) KP (SA), MSO-(2×) N50KP, MSO-(2×) N65KP, MSO-(2×) N80KP, MSO-(2×) N95KP, MSO-(2×) N125KP, MSO-(2×) N150KP, MSO-(2×) N180KP, MSO-(2×) N220KP, MSO-(2×) N300KP, MSO-(2×) N400KP,	
Thermal overload relay	TH-N12 (CX) KP, TH-N18 (CX) KP, TH-N20 (CX) KP, TH-N20TA (CX) KP, TH-N60KP, TH-N60TAKP, TH-N120KP, TH-N120TAKP, TH-N220RHKP, TH-N220HZKP, TH-N400RHKP, TH-N400HZKP, TH-N600KP	
Contactor relay (AC operated)	SR-N4 (CX) (SA), SR-N5 (CX) (SA), SR-N8 (CX) (SA)	
Additional auxiliary contact block	UN-AX2 (CX), UN-AX4 (CX), UN-AX11 (CX), UN-AX80, UN-AX150	
Magnetic contactor (DC operated)	SD-(2×) N11 (CX) (SA), SD-N12 (CX) (SA), SD-(2×) N21 (CX) (SA), SD-(2×) N35 (CX) (SA), SD-(2×) N50, SD-(2×) N65, SD-(2×) N80, SD-(2×) N95, SD-(2×) N125, SD-(2×) N150, SD-(2×) N220, SD-(2×) N300, SD-(2×) N400, SD-(2×) N600, SD-(2×) N800	
Magnetic motor starter (DC operated)	MSOD-(2×) N11 (CX) KP (SA), MSOD-N12 (CX) KP (SA), MSOD-(2×) N21 (CX) KP (SA), MSOD-(2×) N35 (CX) KP (SA), MSOD-(2×) N50KP, MSOD-(2×) N65KP, MSOD-(2×) N80KP, MSOD-(2×) N95KP, MSOD-(2×) N125KP, MSOD-(2×) N150KP, MSOD-(2×) N220KP, MSOD-(2×) N300KP, MSOD-(2×) N400KP	
Contactor relay (DC operated)	SRD-N4 (CX) (SA), SRD-N5 (CX) (SA), SRD-N8 (CX) (SA)	

Notes: 1. The standard models can be applied. The outline dimensions, contact arrangement, ratings and type designation for order are the same as those of the standard models.

2. UN-AX80 and UN-AX150 are CE marking on individual packages as they are not provided with name plates.

List of TÜV Certified Type

TÜV Rheinland

Table 2.1 Magnetic contactor

Model name	Applicable standard	IEC standard	Registration No.
S-N10 (CX) (SA) S-N11 (CX) (SA) S-N12 (CX) (SA)	EN60947-4-1	IEC60947-4-1	R9551340
S-N20 (CX) (SA) S-N21 (CX) (SA)	EN60947-4-1	IEC60947-4-1	R9551336
S-N25 (CX) (SA) S-N35 (CX) (SA)	EN60947-4-1	IEC60947-4-1	R9651190
S-N18 (CX) (SA) S-N28 (CX) (SA) S-N38 (CX) (SA) S-N48 (CX) (SA)	EN60947-4-1	IEC60947-4-1	R9650694
S-N50/S-N65	EN60947-4-1	IEC60947-4-1	R9851170
S-N80/S-N95	EN60947-4-1	IEC60947-4-1	R9851138
S-N125	EN60947-4-1	IEC60947-4-1	R9851169
S-N150	EN60947-4-1	IEC60947-4-1	R9851167
S-N180/S-N220	EN60947-4-1	IEC60947-4-1	R9851164
S-N300/S-N400	EN60947-4-1	IEC60947-4-1	R9851171
SD-N11 (CX) (SA) SD-N12 (CX) (SA)	EN60947-4-1	IEC60947-4-1	R9551340
SD-N21 (CX) (SA)	EN60947-4-1	IEC60947-4-1	R9551336
SD-N35 (CX) (SA)	EN60947-4-1	IEC60947-4-1	R9651190
SD-N50/SD-N65	EN60947-4-1	IEC60947-4-1	R9851170
SD-N80/SD-N95	EN60947-4-1	IEC60947-4-1	R9851138
SD-N125	EN60947-4-1	IEC60947-4-1	R9851169
SD-N150	EN60947-4-1	IEC60947-4-1	R9851167
SD-N220	EN60947-4-1	IEC60947-4-1	R9851164
SD-N300/SD-N400	EN60947-4-1	IEC60947-4-1	R9851171

Notes: **1.** Standard models are applicable under following conditions.

Main circuits (main contacts) : AC-3 rated current at 440VAC max. and rated continuous current.
Auxiliary contacts : AC-15 rated current at 550VAC max. and rated continuous current
Operation coil : Coil designation
N10 - N35, N18 - N48 : AC12V - AC380V
N50 - N150 : AC24V - AC400V
N180 - N400 : AC48V - AC400V
DC operated : DC12V - DC220V

2. Standard models are with no TÜV mark on the product. Order model name followed by suffix “DX” if TÜV mark on the product is required.

3. Finger protection type (model name followed by “CX”) is certified according to DIN VDE 0106 part 100.

4. Models with built-in surge absorber (model name followed by “SA”) are also certified.

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Table 2.2 Thermal overload relay

Model name	Applicable standard	IEC standard	Registration No.
TH-N12 (CX) KP	EN60947-4-1	IEC60947-4-1	J9551338
TH-N18 (CX) KP	EN60947-4-1	IEC60947-4-1	J9551338
TH-N20 (TA) (CX) KP	EN60947-4-1	IEC60947-4-1	J9551341
TH-N60 (TA) KP	EN60947-4-1	IEC60947-4-1	J9851140
TH-N120 (TA) KP	EN60947-4-1	IEC60947-4-1	J9851168
TH-N220RHKP/HZKP	EN60947-4-1	IEC60947-4-1	J9851166
TH-N400RHKP/HZKP	EN60947-4-1	IEC60947-4-1	J9851172

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Table 2.3 Contactor relay

Model name	Applicable standard	IEC standard	Registration No.
SR-N4 (CX) (SA) SR-N5 (CX) (SA) SR-N8 (CX) (SA)	EN60947-5-1	IEC60947-5-1	R9551339
SRD-N4 (CX) (SA) SRD-N5 (CX) (SA) SRD-N8 (CX) (SA)	EN60947-5-1	IEC60947-5-1	R9551339

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Table 2.4 Additional auxiliary contact block

Model name	Applicable standard	IEC standard	Registration No.
UN-AX2 (CX) UN-AX4 (CX) UN-AX11 (CX)	EN60947-5-1	IEC60947-5-1	J9551337
UN-AX80 UN-AX150	EN60947-5-1	IEC60947-5-1	R9851225

Notes: **1.** Standard models are applicable under following conditions.

Auxiliary contacts : AC-15 rated current at 550VAC max. and rated continuous current
Operation coil : Coil designation
N10 - N35, N18 - N48 : AC12V - AC380V
DC operated : DC12V - DC220V

2. Standard models are with no TÜV mark on the product. For contactor relay, order model name followed by suffix “DX” if TÜV mark on the product is required.

3. Finger protection type (model name followed by “CX”) is certified according to DIN VDE 0106 part 100.

4. Models with built-in surge absorber (model name followed by “SA”) are also certified.

5. MS-N Series Magnetic Motor Starters Approved to Marine Standards

5.1 Nippon Kaiji Kyokai (NK)

Magnetic contactor and mechanically latched contactor (AC operated and DC operated)

Model name		Certification No.	Note
AC operated	DC operated		
S-N10 (CX)	–	94T415	AC-3 rated current at 440VAC max. and rated continuous current. Standard models can be applied.
S-N11 (CX)	SD-N11 (CX)	94T416	
S-N12 (CX)	SD-N12 (CX)	94T417	
S-N18 (CX) (SA)	–	95T404	
S-N20 (CX)	–	94T418	
S-N21 (CX)	SD-N21 (CX)	94T419	
S-N25 (CX) (SA)	–	95T402	
S-N35 (CX) (SA)	SD-N35 (CX) (SA)	AC:95T403 DC:96T401	
S-N38 (CX) (SA)	–	96T402	
S-N48 (CX) (SA)	–	96T403	
S-N50	SD-N50	98T403	
S-N65	SD-N65	98T404	
S-N80	SD-N80	98T405	
S-N95	SD-N95	98T406	
S-N125	SD-N125	98T407	
S-N150	SD-N150	98T408	
S-N180	–	98T409	
S-N220	SD-N220	98T410	
S-N300	SD-N300	98T411	
S-N400	SD-N400	98T412	
S-N600	SD-N600	85T406	
S-N800	SD-N800	85T407	

Model name		Certification No.	Note
AC operated	DC operated		
SL-N21 (CX) NK	SLD-N21 (CX) NK	95T401	AC-3 rated current at 440VAC max. and rated continuous current.
SL-N35 (CX) NK	SLD-N35 (CX) NK	96T401	
SL-N50NK	SLD-N50NK	98T413	
SL-N65NK	SLD-N65NK	98T414	
SL-N80NK	SLD-N80NK	98T415	
SL-N95NK	SLD-N95NK	98T416	
SL-N125NK	SLD-N125NK	98T417	
SL-N150NK	SLD-N150NK	98T418	
SL-N220NK	SLD-N220NK	98T419	
SL-N300NK	SLD-N300NK	98T420	
SL-N400NK	SLD-N400NK	98T421	
SL-N600NK	SLD-N600NK	85T408	
SL-N800NK	SLD-N800NK	85T409	

Note: 1. Operation coil
AC operated : 440VAC max.
DC operated : 220VDC max.

5.2 Korean Register of Shipping (KR)

Magnetic contactor (AC operated)

Model name	Certificate No.	Note	Model name	Certificate No.	Note
S-N10 (CX)	KOB02571-EL020	AC-3 rated current at 440VAC max. and rated continuous current. Standard models can be applied.	S-N80	KOB02571-EL028	AC-3 rated current at 440VAC max. and rated continuous current. Standard models can be applied.
S-N11 (CX)	KOB02571-EL021		S-N95		
S-N12 (CX)	KOB02571-EL022		S-N125		
S-N18 (CX) (SA)	KOB02571-EL027		S-N150		
S-N20 (CX)	KOB02571-EL023		S-N180		
S-N21 (CX)	KOB02571-EL024		S-N220		
S-N25 (CX) (SA)	KOB02571-EL025		S-N300		
S-N35 (CX) (SA)	KOB02571-EL026		S-N400		
S-N50	KOB02571-EL028				
S-N65					

5.3 Lloyd's Register of Shipping (LR)
Bureau Veritas (BV)

(1) Magnetic contactor (AC operated and DC operated)

Model name AC operated	LR Certificate No.	BV Certificate No.	Note	Model name AC operated	LR Certificate No.	BV Certificate No.	Note
S-N10 (CX)	95/10008	263/6139	AC-3 rated current at 550VAC max. and rated continuous current. Standard models can be applied.	SD-N11 (CX)	96/10035	263/6987	AC-3 rated current at 550VAC max. and rated continuous current. Standard models can be applied.
S-N11 (CX)				SD-N12 (CX)			
S-N12 (CX)				SD-N21 (CX)			
S-N20 (CX)				SD-N35 (CX)	96/10034	263/6988	
S-N21 (CX)				SD-N50	96/10016	263I/0790	
S-N25 (CX)	96/10034	263/6988		SD-N65			
S-N35 (CX)				SD-N80			
S-N18 (CX)				SD-N95			
S-N28 (CX)				SD-N125			
S-N50	98/10016	2634I/07905		SD-N150			
S-N65				SD-N220			
S-N80				SD-N300			
S-N95				SD-N400			
S-N125				SD-N600			
S-N150				SD-N800			
S-N180							
S-N220							
S-N300							
S-N400							
S-N600							
S-N800							

(2) Contactor relay (AC operated and DC operated)

Model name		Contact arrangement	LR certificate No.		BV certificate No.		Note
AC operated	DC operated		AC operated	DC operated	AC operated	DC operated	
SR-N4 (CX)	SRD-N4 (CX)	4NO, 3NO+1NC, 2NO+2NC	95/10010	96/10035	2634/6139	2634/6987	AC-15 rated current at 550VAC max. and rated continuous current. Standard models can be applied.
SR-N5 (CX)	SRD-N5 (CX)	5NO, 4NO+1NC, 3NO+2NC, 2NO+3NC					
SR-N8 (CX)	SRD-N8 (CX)	8NO, 7NO+1NC, 6NO+2NC 5NO+3NC, 4NO+4NC					

(3) Thermal overload relays

Model name	Heater designation	LR certificate No.	BV certificate No.	Note
TH-N12 (CX) (TP/KP)	0.24A, 0.35A, 0.5A, 0.7A, 0.9A, 1.3A, 1.7A, 2.1A, 2.5A, 3.6A, 5A, 6.6A, 9A, 11A	95/10009	2634/6139	550V max. Standard models can be applied.
TH-N18 (CX) (KP)	1.3A, 1.7A, 2.1A, 2.5A, 3.6A, 5A, 6.6A, 9A, 11A, 15A	96/10033	2634/6988	
TH-N20 (CX) (KP)	0.24A, 0.35A, 0.5A, 0.7A, 0.9A, 1.3A, 1.7A, 2.1A, 2.5A, 3.6A, 5A, 6.6A, 9A, 11A, 15A, 19A	95/10009	2634/6139	
TH-N20TA (CX) (KP)	22A, 29A, 35A	96/10033	2634/6988	
TH-N60 (KP)	15A, 22A, 29A, 35A, 42A, 54A	98/10017	2634I/07905	
TH-N60TA (KP)	67A, 82A			
TH-N120 (KP)	42A, 54A, 67A, 82A			
TH-N120TA (KP)	105A, 125A			
TH-N220RH (KP)/HZ (KP)	82A, 105A, 125A, 150A, 180A			
TH-N400RH (KP)/HZ (KP)	105A, 125A, 150A, 180A, 250A, 330A			
TH-N600 (KP)	250A, 330A, 500A, 660A			

(4) Additional auxiliary contact block

Model name	Contact arrangement	LR certificate No.	BV certificate No.	Note
UN-AX2 (CX)	2NO, 1NO+1NC, 2NC	95/10010	2634/6139	AC-15 rated current at 550VAC max. and rated continuous current. Standard models can be applied.
UN-AX4 (CX)	4NO,3NO+1NC, 2NO+2NC			
UN-AX11 (CX)	1NO+1NC	98/10016	2634I/07905	
UN-AX80	1NO+1NC			
UN-AX150	1NO+1NC			
UN-AX600	2NO+2NC			

MITSUBISHI ELECTRIC CORPORATION
HEAD OFFICE: MITSUBISHI DENKI BLDG., 2-2-3, MARUNOUCHI, CHIYODA-KU, TOKYO 100-8310, JAPAN

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