2. Application

2.1 Application Categories

Contactor, contactor relays, and thermal overload relay are regulated by IEC 947-1, 947-4-1 and 947-5-1, the duty of contactor related operational voltage, current application range and thermal overload relay's duty is regulated by international standards, the duty of a contactor is characterized by rated operational voltage and current application range.

1. Contactor application categories by IEC 947-4-1

AC	AC-1	Load, resistance furnace with non-inducing or minute inducing characteristic
	AC-2	Drive and stop of wound-rotor type motor
	AC-3	Stop during the driving, starting squirrel-cage type motor
	AC-4	Squirrel-cage type motor: starting, plugging, inching
	AC-5a	Control device switching such as discharging
	AC-5b	Incandescent lamp switching
	AC-6a	Transformer switching
	AC-6b	Condenser bank switching
	AC-7a	Low inducing load about home appliances and similar applications
	AC-7b	Household operational motor load
	AC-8a	Manual reset type overload closed type freezing compressor motor
	AC-8b	Automatic reset type overload closed type freezing compressor motor
DC	DC-1	Load, resistance furnace of non-inducing, minute inducing characteristic
	DC-3	Starting of shunt motor, plugging, inching, dynamic suspension
	DC-5	Starting of series motor, plugging, inching, dynamic suspension
	DC-6	Incandescent lamp switching

2. Contactor relays application categories by IEC 947-5-1

AC	AC-12	Control of suspension load and resistance load with optical coupler in insulation
	AC-13	Control of suspension load which has transformer insulation
	AC-14	Control of minute electric load(≤72VA)
	AC-15	Control of electromagnetic load (>72VA)
DC	DC-12	Control of suspension load and resistance load which has optical coupler in insulation
	DC-13	Control of DC electromagnet
	DC-14	Control of DC electromagnet which has economical resistance

2.2 Durability(durability) Indication Method by Standard

Category Number Type

AC-3 · 1 · 1-0

● Depending on switching frequency and number
possible switching number per hour is indicated

Types		#0	#1	#2	#3	#4	#5	#6
Switching freq. (times/hour)		1800	1200	600	300	150	30	6
Operational ratio (%)	AC contactor	15	25	40	60	60	60	60
	DC contactor	25	40	40	40	60	60	60

Note 1) Operational ratio(%) is applied to AC-1, AC-2, AC-3, DC-1, and DC-6. But the operational ratio of AC-4, DC-3 and DC-5 is taken with manufacturers guaranteed value.

Note 2) Switching frequency indicates individual switching per hour.

● Depending on durability type
mechanical durability and electrical durability are indicated.

Number	Mechanical durability	Electrical durability
#0	More than10 million times	More than 1 million times
#1	More than 5 million times	More than 500,000 times
#2	More than 2.5 million times	More than 250,000 times
#3	More than 1 million times	More than 100,000 times
#4	More than 250,000 times	More than 50,000 times
#5	More than 50,000 times	More than 10,000 times
#6	More than 5,000 times	More than 1000 times

Note 1) Durability indicates the number that switching operation is one time.

Note 2) Combination indication per type is indicated by each type when electrical durability, mechanical durability types are different, and it may be omitted with one of them when the types are matched

● Depending on the class of closed circuit and breaking current :

Depending on the class of closed circuit and breaking current :
current value times for which close circuit or breaking is possible about rated operational current indication value are indicated. Circuit conditions (closed circuit and voltage, current, power factor) are determined to evaluate electrical durability, circuit condtion(closed circuit and voltage, current, power factor)

Types	Category	Test conditions						Representative application example
		Making (KSC, IEC)			Breaking (KSC, IEC)			
		I / Ie	U / Ue	cosØ	Ic / Ie	Ur / Ue	cosØ	
AC magnetic contactor	AC-1	1	1	0.95	1	1	0.95	Resistance load switching of non-inducing or minute inducing char.
	AC-2	2.5	1	0.65	2.5	1	0.65	Starting, stopping wound-rotor type motor
	AC-3 I ≤ 17A	6	1	0.65	1	0.17	0.65	Starting and stopping Squirrel-cage type motor Note1)
	AC-3 17A < I	6	1	0.35	1	0.17	0.35	
	AC-4 I ≤ 17A	6	1	0.65	6	1	0.65	Starting squirrel-cage type motor, anti-phase suspension, inching
	AC-4 17A < I	6	1	0.35	6	1	0.35	
DC magnetic contactor	DC-1	1	1	1	1	1	1	Resistance load switching of non-inducing or minute inducing characteristic
	DC-3	2.5	1	2	2.5	1	2	Starting shunt motor, anti-phase suspension, inching, DC motor dynamic suspension
	DC-5	2.5	1	7.5	2.5	1	7.5	Starting shunt motor, anti-phase suspension, inching, DC motor dynamic suspension

Note 1) AC-3 depending on operational load type may be used in temporary inching or anti-phase suspension in case of limit time, number such as operating machines. It is the number which does not exceed five times per minute, which is confined to be less than 10 times in 10 minutes.

2. Application

2.3 Understanding of Application Categories for AC Circuit Contactor

■ **Category AC-1**

It is applied to every type of AC load which has a power factor more than 0.95(cos j x 0.95), there are non-inducing loads, minute inducing loads, and resistance furnace.

• Application example: heater, incandescent lamp, and general wire distribution

■ **Category AC-2**

It is applied to driving, plugging, inching of wound-rotor type inducing motor, about 2.5 times of motor rated current is generated as starting current, it can break the starting current at the voltage which is the same as the main power voltage or less when breaking.

■ **Category AC-3**

It is applied to starting and suspension of squirrel-cage type inducing motor, and plugging and inching are not considered separately from category AC-4. The current when closed circuit is 5~8 times of motor rated current, it is normally used with standard squirrel-cage type motor with 20% of main power during breaking.

• application example : every standard squirrel-cage type motor
(lift, escalator, conveyor belt, bucket elevator, compressor, pump, mixer, air conditioner etc)

■ **Category AC-4 and AC-2**

It is applied to plugging and inching of squirrel-cage type motors and wound rotor type inducing motors. Contactor is closed with 5~8 times more than rated motor current. And it is operated at the same current with higher, slower speed when breaking. The voltage can be the same as teh main voltage.

• Application example : Printing machine, wire distribution drawing machine, crane and hoist, metal

■ **Test Conditions**

AC Category		Normal operation						Occasional operation					
		Making			Breaking			Making			Breaking		
		I	U	cosØ	I	U	cosØ	I	U	cosØ	I	U	cosØ
AC-1		Ie	1.05Ue	0.8	Ie	1.05Ue	0.8	1.5Ie	1.05Ue	0.8	1.5Ie	1.05Ue	0.8
AC-2		2Ie	1.05Ue	0.65	2Ie	1.05Ue	0.65	4Ie	1.05Ue	0.65	4Ie	1.05Ue	0.65
AC-3	Ie≤100A	2Ie	1.05Ue	0.45	2Ie	1.05Ue	0.45	10Ie	1.05Ue	0.45	8Ie	1.05Ue	0.45
	Ie>100A	2Ie	1.05Ue	0.35	2Ie	1.05Ue	0.35	10Ie	1.05Ue	0.35	8Ie	1.05Ue	0.35
AC-4	Ie≤100A	6Ie	1.05Ue	0.45	6Ie	1.05Ue	0.45	12Ie	1.05Ue	0.35	10Ie	1.05Ue	0.35
	Ie>100A	6Ie	1.05Ue	0.35	6Ie	1.05Ue	0.35	12Ie	1.05Ue	0.35	10Ie	1.05Ue	0.35

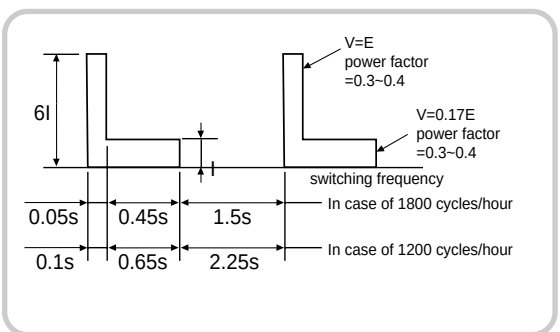


Fig. 32. Category AC3 of electrical switching durability test duty
I : rated operational current E : rated operational Voltage

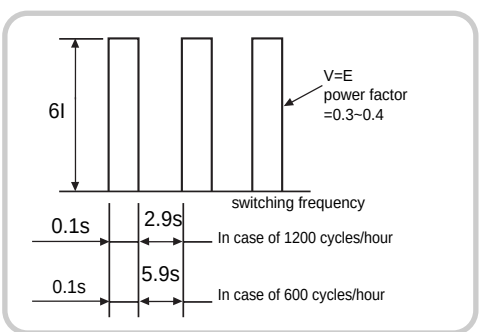


Fig. 33. Category AC4 of electrical switching durability test duty

2.4 Understanding of Application Categories for DC Circuit Contactor (IEC/EN60947-4-1)

■ **Category DC-1**

Is applied to DC load of every type, when time constant (L/R) is the same as 1ms or less.

■ **Category DC-3**

Is applied to starting shunt motor, plugging(anti-phase suspension) and inching (time constant ≤ 2ms). Contactor has a condition of 2.5 times of motor rated current flowing as starting current when closed circuit, and the circuit is broken with 2.5 times starting current at the voltage is the same or less than the main power voltage when breaking. Counter electromotive force decreases and voltage increases as electrical motor operates slowly, so it is difficult to break.

■ **Category DC-5**

It is applied to starting, plugging(anti-phase suspension) and inching of series motor(time constant ≤ 7.5ms). Contactor has a condition of 2.5 times of motor rated current flowing as starting current when closed circuit, and the circuit current is broken at the higher voltage and lower motor speed. Voltage can be the same as main power voltage.

■ **Test conditions (making and breaking condition)**

DC Category	Normal operation						Occasional operation					
	Making			Breaking			Making			Breaking		
	I	U	L/R (ms)	I	U	L/R (ms)	I	U	L/R (ms)	I	U	L/R (ms)
DC-1	Ie	1.05Ue	1	Ie	1.05Ue	1	1.5Ie	1.05Ue	1	1.5Ie	1.05Ue	1
DC-3	2.5Ie	1.05Ue	2	2.5Ie	1.05Ue	2	4Ie	1.05Ue	2.5	4Ie	1.05Ue	2.5
DC-5	2.5Ie	1.05Ue	7.5	2.5Ie	1.05Ue	7.5	4Ie	1.05Ue	15	4Ie	1.05Ue	15

2.5 Understanding of Application Categories for Contacts Auxiliary and Control Relays(IEC/EN60947-4-1)

■ **Category DC-14**

Applied to electromagnetic loads switching by the power when organic electromotive force of breaking electromagnet is less than 72VA, the application range is applied to control coil switching of contactor and relay.

■ **Category DC-15**

Applied to electromagnetic loads switching by the power when organic electromotive force of electromagnetic breaker is less than 72VA, the application range is applied to control coil switching of contactor and relay.

■ **Category DC-13**

Applied to electromagnetic load switching (P≤50W) like six times of power P that time(T=0.95) which reaches 95% of normal operation current worn by load. Application range is applied to operation coil switching of magnetic contactor which doesn't have consumption power reducing type resistance.

■ **Test Conditions (Making breaking conditions)**

AC Category	Normal operation						Occasional operation					
	Making			Breaking			Making			Breaking		
	I	U	cos Ø	I	U	cos Ø	I	U	cos Ø	I	U	cos Ø
AC-14	6Ie	Ue	0.3	Ie	Ue	0.3	6Ie	1.1Ue	0.7	6Ie	1.1Ue	0.7
AC-15	10Ie	Ue	0.3	Ie	Ue	0.3	10Ie	1.1Ue	0.3	10Ie	1.1Ue	0.3
DC-13	Ie	Ue	6P Note1)	Ie	Ue	6P Note1)	1.1Ie	1.1Ue	6P Note1)	Ie	1.1Ue	6P Note1)

Note1) The value 6P(W) is based on real axis, P = 50W, in other words it indicates the most magnetic load up to maximum limit of 6P = 300ms = L/R. The upper load of this consists of smaller loads in parallel. Therefore 300ms is the maximum limit regardless of rated current value.

Note 2) • U(I) = Applied voltage(current) • U = Voltage recovery • L/R = Test circuit time constant
- U(I) = Rated operational voltage(current)
- I = inserted and braking current express symmetric element value such as mean square of DC or AC
- T= The required time to reach 95% of current for maintaining equilibrium condition. Expressed in ms(milliseconds)

2. Application

2.6 Average Full Load Currents of 3-Phase Squirrel-cage Motors

■ **3 phase 4 pole motors (50/60Hz)**

Power		200/208V	220V (1)	230V	380V	400V	415V	433/440V (1)	460V	500/525V (1)	575V	660V	690V	750V	1000V
kW	HP	A	A	A	A	A	A	A	A	A	A	A	A	A	A
0.37	0.5	2	1.8	2	1.03	0.98	-	0.99	1	1	0.8	0.6	-	-	0.4
0.55	0.75	3	2.75	2.8	1.6	1.5	-	1.36	1.4	1.2	1.1	0.9	-	-	0.6
0.75	1	3.8	3.5	3.6	2	1.9	2	1.68	1.8	1.5	1.4	1.1	-	-	0.75
1.1	1.5	5	4.4	5.2	2.6	2.5	2.5	2.37	2.6	2	2.1	1.5	-	-	1
1.5	2	6.8	6.1	6.8	3.5	3.4	3.5	3.06	3.4	2.6	2.7	2	-	-	1.3
2.2	3	9.6	8.7	9.6	5	4.8	5	4.42	4.8	3.8	3.9	2.8	-	-	1.9
3	-	12.6	11.5	-	6.6	6.3	6.5	5.77	-	5	-	3.8	3.5	-	2.5
-	5	-	-	15.2	-	-	-	-	7.6	-	6.1	-	-	-	3
4	-	16.2	14.5	-	8.5	8.1	8.4	7.9	-	6.5	-	4.9	4.9	-	3.3
5.5	7.5	22	20	22	11.5	11	11	10.4	11	9	9	6.6	6.7	-	4.5
7.5	10	28.8	27	28	15.5	14.8	14	13.7	14	12	11	6.9	9	-	6
9	-	36	32	-	18.5	18.1	17	16.9	-	13.9	-	10.6	10.5	-	7
11	15	42	39	42	22	21	21	20.1	21	18.4	17	14	12.1	11	9
15	20	57	52	54	30	28.5	28	26.5	27	23	22	17.3	16.5	15	12
18.5	25	70	64	68	37	35	35	32.8	34	28.5	27	21.9	20.2	18.5	14.5
22	30	84	75	80	44	42	40	39	40	33	32	25.4	24.2	22	17
30	40	114	103	104	60	57	55	51.5	52	45	41	54.6	33	30	23
37	50	138	126	130	72	69	66	64	65	55	52	42	40	36	28
45	60	162	150	154	85	81	80	76	77	65	62	49	46.8	42	33
55	75	200	182	192	105	100	100	90	96	80	77	61	58	52	40
75	100	270	240	248	138	131	135	125	124	105	99	82	75.7	69	53
90	125	330	295	312	170	162	165	146	156	129	125	98	94	85	65
110	150	400	356	360	205	195	200	178	180	156	144	118	113	103	78
132	-	480	425	-	245	233	240	215	-	187	-	140	135	123	90
-	200	520	472	480	273	222	260	236	240	207	192	152	-	136	100
160	-	560	520	-	300	285	280	256	-	220	-	170	165	150	115
-	250	-	-	600	-	-	-	-	300	-	240	200	-	-	138
200	-	680	626	-	370	352	340	321	-	281	-	215	203	185	150
220	300	770	700	720	408	388	385	353	360	310	288	235	224	204	160
250	350	850	800	840	460	437	425	401	420	360	336	274	253	230	200
280	-	-	-	-	528	-	-	-	-	-	-	-	-	-	220
315	-	1070	990	-	584	555	535	505	-	445	-	337	321	292	239
-	450	-	-	1080	-	-	-	-	540	-	432	-	-	-	250
355	-	-	1150	-	635	605	580	549	-	500	-	370	350	318	262
-	500	-	-	1200	-	-	-	-	600	-	480	-	-	-	273
400	-	-	1250	-	710	675	650	611	-	540	-	410	390	356	288
450	600	-	-	1440	-	-	-	-	720	-	576	-	-	-	320
500	-	-	1570	-	900	855	820	780	-	680	-	515	494	450	350
560	-	-	1760	-	1000	950	920	870	-	760	-	575	549	500	380
630	-	-	1980	-	1100	1045	1020	965	-	850	-	645	605	550	425
710	-	-	-	-	1260	1200	1140	1075	-	960	-	725	694	630	480

(1) The values adhere to NEC(National Electrical Code). These values are given as one direction. They can vary depending on motor and manufacturer.

2.7 Making and Breaking Conditions

■ D.C. power circuit switching

Arc restraint is more difficult in DC than AC. Moreover, it is more difficult as circuit time constant is higher. This is the reason that many poles should be connected in series to increase breaking condition.

■ A.C. current circuit switching

Possibility of increasing performance by connected poles in parallel

■ Effect of terminal length

According to operation voltage, coil consumption and control lay-out, the problem by railway resistance and capacitance can happen during magnetic contactor insertion and breaking order.

Making and breaking condition according to application categories

category		Durability conditions						Occasional operation					
		Making			Breaking			Making			Breaking		
		I/I	U/U	cos Ø or L/R(ms)	I/I	U/U	cos Ø or L/R(ms)	I/I	U/U	cos Ø or L/R(ms)	I/I	U/U	cos Ø or L/R(ms)
Magnetic contactors for A.C. circuit switching													
AC-1		1	1	0.95	1	1	0.95	1.5	1.05	0.8	1.5	1.05	0.8
AC-2		2.5	1	0.65	2.5	1	0.65	4	1.05	0.65	4	1.05	0.65
AC-3	I ≤ 17A	6	1	0.65	1	0.17	0.65	10	1.05	0.45	8	1.05	0.45
	17< I ≤ 100A	6	1	0.35	1	0.17	0.35	10	1.05	0.45	8	1.05	0.45
	I > 100A	6	1	0.35	1	0.17	0.35	10	1.05	0.35	8	1.05	0.35
AC-4	I ≤ 17A	6	1	0.65	6	1	0.65	12	1.05	0.45	10	1.05	0.45
	17< I ≤ 100A	6	1	0.35	6	1	0.35	12	1.05	0.45	10	1.05	0.45
	I > 100A	6	1	0.35	6	1	0.35	12	1.05	0.35	10	1.05	0.35
Magnetic contactors for D.C. circuit switching													
DC-1		1	1	1	1	1	1	1.5	1.05	1	1.5	1.05	1
DC-3		2.5	1	2	2.5	1	2	4	1.05	2.5	4	1.05	2.5
DC-5		2.5	1	7.5	2.5	1	7.5	4	1.05	15	4	1.05	15
Comtactor relays for A.C. circuit switching													
AC-14 (≤ 72VA)		-	-	-	-	-	-	9	1.1	0.7	6	1.1	0.7
AC-15 (> 72VA)		10	1	0.7	1	1	0.4	10	1.1	0.3	10	1.1	0.3

2. Application

2.7 Making and Breaking Conditions

Contactor relays for D.C. circuit switching for application Categories

Category	Standard operation						Occasional operation					
	Making			Breaking			Making			Breaking		
	I/I	U/U	T	I/I	U/U	T	I/I	U/U	T	I/I	U/U	T
DC-13	1	1	6P Note 1)	1	1	6P Note 1)	1.1	1.1	6P Note 1)	1.1	1.1	6P Note 1)
DC-14	-	-	-	-	-	-	10	1.1	15ms	10	1.1	15ms

Note 1) "6 x P " is the expected test result for expressing the most DC magnetic load upto the maximum limit of P = 50 W(6 x P = 300ms). It is allowed that load which has more than 50W combination energy is composed with the less load of parallel. As a result, 300ms value conforms the maximum limit regardless of combination power value.

Note 2) U(I): application voltage(current)

Ur: reset voltage

L/R: test circuit time constant

Uo(Io): rated operation voltage(current)

Ic: insertion and breaking current expressed DC and AC such as r.m.s value of symmetric part.

T0.95: required time for reaching 95% of current with certain stopping condition. It is expressed with limiti seconds.

2.8 Application Data for Category AC-1

Maximum operational current and power(open-mounted divice)

Operational current and power \ Type		18AF				22AF				40AF		65AF	
		6a	9a	12a	18a	9b	12b	18b	22b	32a	40a	50a	65a
Maximum operating rate in operating cycles / hour		600											
Cable	**mm²**	4	4	10		4	10			10	16	25	35
maximum operational current Ie ≤40℃	**A**	25	25	25	32	25	25	32	40	50	60	70	100
maximum operational power ≤55℃	**220/240V**	10	10	10	13	10	10	13	17	21	25	29	42
	380/440V	19	19	19	24	19	19	24	30	38	46	53	76
	500/550V	24	24	24	30	24	24	30	38	48	57	67	95
	690V	30	30	48	48	30	48	48	60	72	84	90	120

Operational current and power \ Type		100AF			150AF		225AF		400AF			800AF		
		75a	85a	100a	130a	150a	185a	225a	265a	330a	400a	500a	630a	800a
Maximum operating rate in operating cycles / hour		600			–									
Cable	**mm²**	35	50		70	95		150	240		370	480	–	–
maximum operational current Ie ≤40℃	**A**	110	135	140	160	210	230	275	300	350	450	580	660	900
maximum operational power ≤55℃	**220/240V**	46	56	58	61	80	88	105	114	133	171	221	251	343
	380/440V	84	103	107	105	138	151	181	197	230	296	382	434	592
	500/550V	105	129	133	139	182	199	238	260	303	390	502	572	779
	690V	131	161	167	191	251	275	329	359	418	538	693	789	1076

■ Operational current when connected in parallel

It can be applied with multiplying the values from the upper table and K value, when using contactor with more than 2 pole connection in parallel.

- 2pole in parallel K = 1.6
- 3pole in parallel K = 2.25
- 4pole in parallel K = 2.8

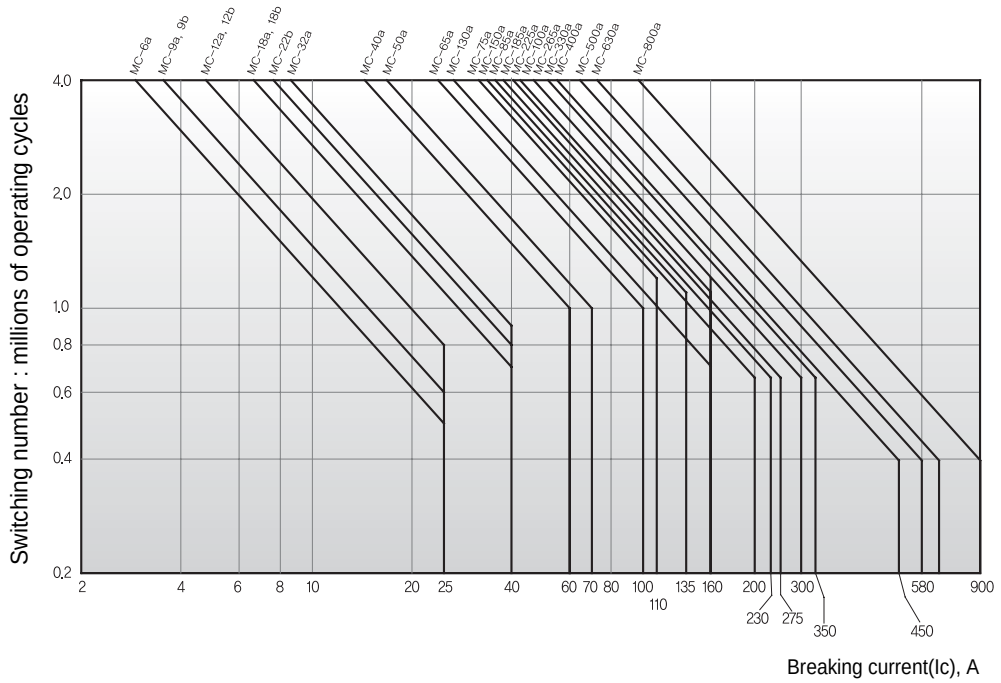
■ Selection guide for electrical durability

- Operational voltage : less than AC 440V
- Power factor : more than 0.95
- It follows when it is applied to resistance load such as heating resistance.

Category	Making and breaking capacity		Electric switching durability	
	Making	Breaking	Making	Breaking
AC-1	1.5Ie, 1.1Ee *Cos* Ø 0.95	1.5Ie, 1.1Ee *Cos* Ø 0.95	Ie, Ee *Cos* Ø 0.95	Ie, Ee *Cos* Ø 0.95

Note) Ie: rated operational current, Ee: rated voltage, Cos Ø: Power factor

The entire load current of motor is applied at the horizontal axis, because current value(Ic) of horizontal axis is same as rated current value(Ie) of load in AC1 load.



Selected example) MC-65a should be selected when Ue=220V, Ie 50A and operational surrounding temperature is less than 40℃, required life span is 2 million times.

2. Application

2.9 Application Data for Categories AC-3

H

1. Maximum operational current and power (IEC, $\theta \leq 55^{\circ}C$)

Operational current and power \ Type			18AF				22AF				40AF		65AF	
			6a	9a	12a	18a	9b	12b	18b	22b	32a	40a	50a	65a
Max operational current	≤ 440V	A	7	9	12	18	9	12	18	22	32	40	50	65
Rated operational power (standard motor power rated)	220/240V	kW	2.2	2.5	3.5	4.5	2.5	3.5	4.5	5.5	7.5	11	15	18.5
	380/440V	kW	3	4	5.5	7.5	4	5.5	7.5	11	15	18.5	22	30
	500/550V	kW	3	4	7.5	7.5	4	7.5	7.5	15	18.5	22	30	33
	690V	kW	3	4	7.5	7.5	4	7.5	7.5	15	18.5	22	30	33

Operational current and power \ Type			100AF			150AF		225AF		400AF			800AF		
			75a	85a	100a	130a	150a	185a	225a	265a	330a	400a	500a	630a	800a
Max operational current	≤ 440V	A	75	85	95	120	150	185	225	265	330	400	500	630	800
Rated operational power (standard motor power rated)	220/240V	kW	22	25	30	37	45	55	75	80	90	125	147	190	220
	380/440V	kW	37	45	55	60	75	90	132	147	160	200	265	330	400
	500/550V	kW	37	45	55	60	75	110	132	147	160	225	265	330	400
	690V	kW	37	45	55	55	75	110	140	160	200	250	300	400	500

2. Maximum operational current and power (UL, CSA, $\theta \leq 55^{\circ}C$)

Operational current and power \ Type			18AF				22AF				40AF		65AF		100AF		
			6a	9a	12a	18a	9b	12b	18b	22b	32a	40a	50a	65a	75a	85a	100a
Continuos Current(A)			25	25	25	32	25	25	32	40	50	60	70	100	110	135	160
Rated operational power (standard motor power rated) 50/60Hz	1HP	100~120V	0.5	0.5	0.75	1	0.5	0.75	1	2	2	3	3	5	5	7.5	10
		220~240V	1.5	1.5	2	3	1.5	2	3	3	5	7.5	10	15	15	15	20
	3HP	200~208V	2	2	3	5	2	3	5	7.5	7.5	15	20	25	25	30	30
		220~240V	3	3	5	7.5	3	5	7.5	10	10	20	25	30	30	40	40
		440~480V	5	5	7.5	10	5	7.5	10	15	20	30	40	50	50	60	75
		550~600V	7.5	7.5	10	15	7.5	10	15	20	25	30	50	60	60	75	75

Operational current and power \ Type			150AF		225AF		400AF			800AF		
			130a	150a	185a	225a	265a	330a	400a	500a	630a	800a
Continuos Current(A)			160	210	230	275	300	350	450	580	660	900
Rated operational power (standard motor power rated) 50/60Hz	1HP	100~120V	10	15	15	15	–	–	–	–	–	–
		220~240V	20	25	30	40	–	–	–	–	–	–
	3HP	200~208V	40	40	60	60	75	100	125	150	200	200
		220~240V	40	50	60	75	100	125	150	200	250	300
		440~480V	75	100	125	150	200	250	300	400	500	600
		550~600V	75	75	125	150	200	250	300	400	500	600

3. Max. operating rate in operating cycles / hour

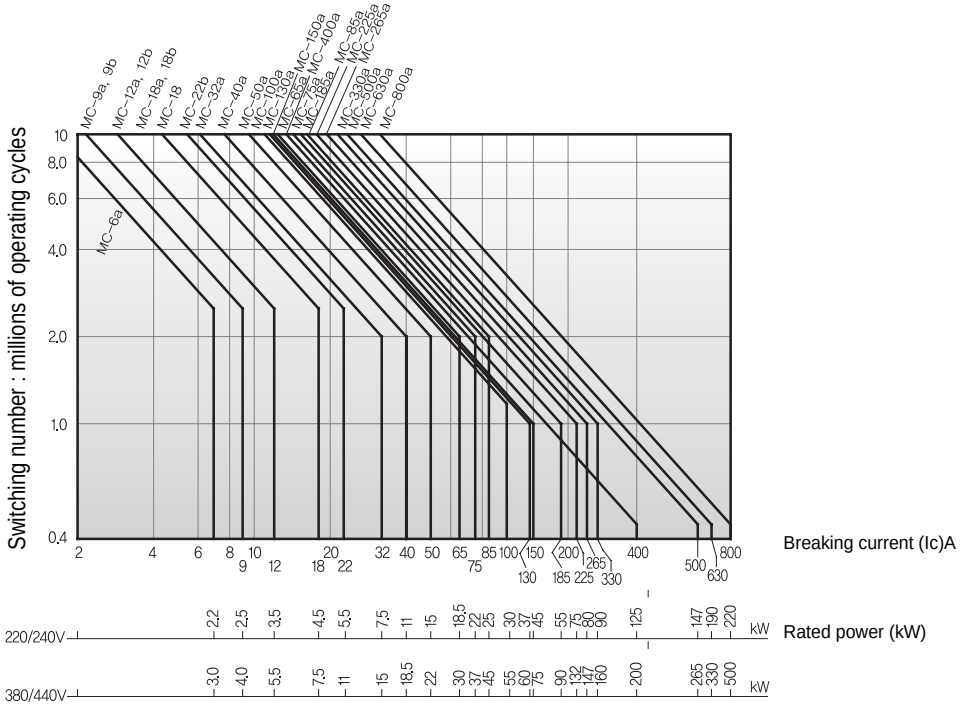
Type name \ Operating cycles	18AF				22AF				40AF		65AF	
	6a	9a	12a	18a	9b	12b	18b	22b	32a	40a	50a	65a
1/h	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1200	1200

Type name \ Operating cycles	100AF			150AF		225AF		400AF			800AF		
	75a	85a	100a	130a	150a	185a	225a	265a	330a	400a	500a	630a	800a
1/h	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200

H

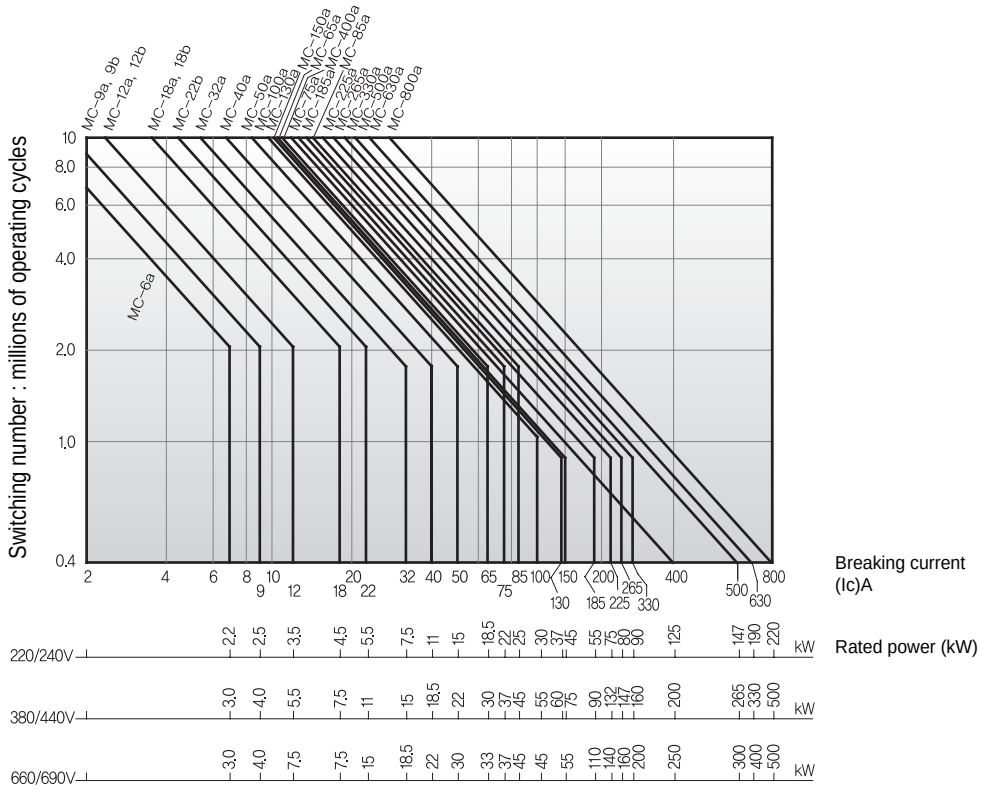
■ Selection guide for electrical durability (category AC-3)

Operational voltage : less than 440V



Selection example) When motor capacity P=5.5kW, Ue=400V, Ie=11A, Ic is egual to Ie. so when required life span of 11A is 3 million times, MC-12a should be selected.

Operational voltage : **less than** AC660/690V



2. Application

2.10 Application Data for Categories AC-2 or AC-4

1. Maximum breaking current

- AC-2 : Wound-rotor type(slipring) motor- starting breaking current
- AC-4 : Squirrel-cage motor- starting breaking current

AC-4 maximum breaking current \ Type name	18AF				22AF				40AF		65AF	
	6a	9a	12a	18a	9b	12b	18b	22b	32a	40a	50a	65a
Ue ≤ 440V	36	54	72	108	54	72	108	132	192	240	300	390
440V < Ue ≤ 690V	26	40	50	70	40	50	70	80	105	150	170	210

AC-4 maximum breaking current \ Type name	100AF			150AF		225AF		400AF			800AF		
	75a	85a	100a	130a	150a	185a	225a	265a	330a	400a	500a	630a	800a
Ue ≤ 440V	450	510	570	780	900	1110	1350	1590	1980	2400	3000	3600	4800
440V < Ue ≤ 690V	210	250	250	540	640	708	810	1020	1410	1830	2130	2760	2910

Note) Ie maximum breaking current= 6 X I motor(A)

2. Maximum operational current according to operation cycle and load factor

operational current Note1) $\theta \leq 55℃$ Note2)

Operating cycle and load factor	Maximum operational current	18AF				22AF				40AF		65AF	
		6a	9a	12a	18a	9b	12b	18b	22b	32a	40a	50a	65a
150 & 15% ~ 300 & 10%	A	20	30	40	45	30	40	45	50	80	110	140	150
150 & 20% ~ 600 & 10%	A	18	27	36	40	27	36	40	45	70	96	120	135
150 & 30% ~ 1200 & 10%	A	16	24	30	35	24	30	35	40	60	80	100	120
150 & 55% ~ 2400 & 10%	A	13	19	24	30	19	24	30	35	50	62	80	100
150 & 85% ~ 3600 & 10%	A	10	16	21	25	16	21	25	30	45	53	70	75

Operating cycle and load factor	Maximum operational current	100AF			150AF		225AF		400AF			800AF		
		75a	85a	100a	130a	150a	185a	225a	265a	330a	400a	500a	630a	800a
150 & 15% ~ 300 & 10%	A	180	200	200	300	310	380	420	560	670	780	1100	1300	1600
150 & 20% ~ 600 & 10%	A	165	170	170	260	280	350	400	500	600	700	950	1190	1400
150 & 30% ~ 1200 & 10%	A	145	145	145	230	240	300	330	400	500	600	750	900	1100
150 & 55% ~ 2400 & 10%	A	130	120	120	140	150	240	270	320	390	450	600	680	820
150 & 85% ~ 3600 & 10%	A	110	100	100	130	145	170	190	230	290	350	500	630	710

Note 1) DC doesn't exceed maximum value of machine operation cycle.

Note 2) Operation rated value such as 80% of the real value is selected in cases where temperature is higher than 55℃.

3. Plugging

There are various current type from maximum plugging breaking current to rated motor current. The input current is suitable for rated input/ breaking capacity of magnetic contactor. Magnetic contactor can be restrained when breaking happens normally at locked rotor current or near it.

4. AC-4 power rated capacity

Operational voltage	Rated capacity	18AF				22AF				40AF		65AF	
		6a	9a	12a	18a	9b	12b	18b	22b	32a	40a	50a	65a
200/240V	kW	1.5	1.5	2.2	3.7	1.5	2.2	3.7	3.7	4.5	5	5.5	7.5
380/400V	kW	2.2	2.2	4	4	2.2	4	4	5.5	7.5	9	11	11
415V	kW	2.2	2.2	4	4	2.2	4	4	5.5	7.5	9	11	11
440V	kW	2.2	2.2	4	4	2.2	4	4	5.5	7.5	9	11	15

Operational voltage	Rated capacity	100AF			150AF		225AF		400AF			800AF		
		75a	85a	100a	130a	150a	185a	225a	265a	330a	400a	500a	630a	800a
200/240V	kW	7.5	7.5	9	22	30	37	45	50	55	75	90	110	160
380/400V	kW	11	15	15	45	55	75	90	102	110	150	176	200	300
415V	kW	11	15	15	45	55	75	90	102	110	150	176	200	300
440V	kW	15	15	15	45	55	75	90	102	110	150	176	200	300

2. Application

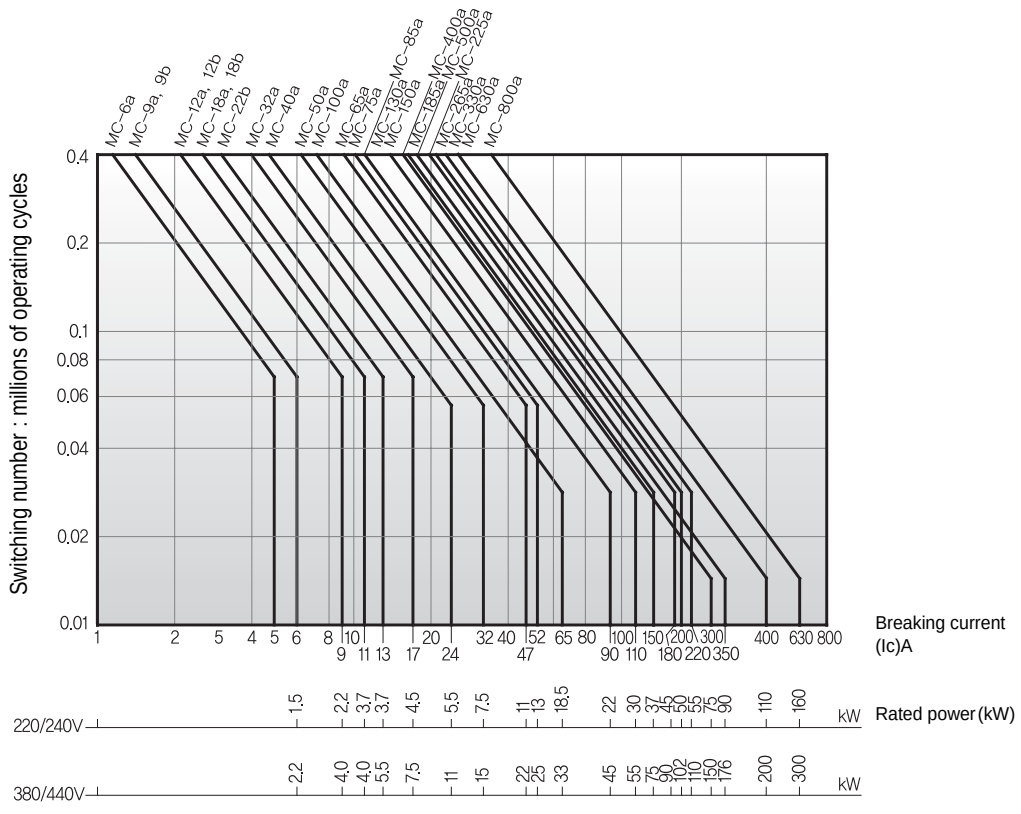
2.10 Application Data for Categories AC-2 or AC-4

H

■ Selection guide for electrical durability

Driving 3 phase squirrel-cage type motor(AC4) or Wound-rotor type motor(AC2) (Including breaking with restrained motor condition)
Breaking current in category AC4, Ic is 6 times of motor rated current, Ie.
Ic=6XIe

Operational voltage : less than 440V (category AC-4)



<Example> Ic=6XIe=66A, when Motor capacity P=5.5Kw, Ue=400V, Ie=11A.
MC-22a should be selected when required life span is 200,000 times.

2.11 Application Data for Categories DC-1 or DC-5

Magnetic contactor can be applied to higher current level compared to motor load, because inrush current is small, power factor is large in case of resistance load switching of electric furnace heater, heater. Metasol series magnetic contactor is manufactured according to the standard[KS C IEC 60947-4-1], and it has the performance as following table.
There is an enough margin in closed circuit and breaking capacity, but there is a limit in temperature increase, when magnetic contactor is applied to resistance load, therefore, the rated value is upto rated flow current. Flow current can be increased by using parallel connection of contact in single phase circuit. In this case, rated flow current I can be theoretically calculated by following equation. User should evaluate on their own, when real operational condition is different from the following condition.

$$I = 2\sqrt{N - 1} \times Io$$

Io: 1 pole's rated current N: Number of poles in parallel

1. Resistance loads(category DC-1) : time constant L/R= 1ms

Rated operational voltage Ue	Number of poles connected in series	Rated operational current (A)											
		18AF				22AF				40AF		65AF	
		6a	9a	12a	18a	9b	12b	18b	22b	32a	40a	50a	65a
24V	1	15	15	15	30	15	15	30	30	30	40	50	50
	2	18	18	18	32	18	18	32	32	32	55	70	70
	3	20	20	20	32	20	20	32	32	32	55	70	70
48 / 75V	1	12	12	12	25	12	12	25	25	25	25	25	25
	2	17	17	17	30	17	17	30	30	30	55	70	70
	3	20	20	20	32	20	20	32	32	32	55	70	70
110V	1	6	6	8	8	6	8	8	8	8	8	8	8
	2	12	12	12	25	12	12	25	25	25	40	50	60
	3	15	15	15	27	15	15	27	27	27	45	60	65
220V	1	4	4	5	5	4	5	5	5	5	5	5	5
	2	8	8	8	15	8	8	15	15	15	35	40	40
	3	10	10	10	22	10	10	22	22	22	40	50	50

Rated operational voltage Ue	Number of poles connected in series	Rated operational current (A)												
		100AF			150AF		225AF		400AF			800AF		
		75a	85a	100a	130a	150a	185a	225a	265a	330a	400a	500a	630a	800a
24V	1	70	70	70	200	200	240	260	300	360	430	580	850	1300
	2	100	100	100	200	200	240	260	300	360	430	580	850	1300
	3	100	100	100	200	200	240	260	300	360	430	580	850	1300
48 / 75V	1	25	25	25	200	200	240	260	300	360	430	580	850	1300
	2	100	100	100	200	200	240	260	300	360	430	580	850	1300
	3	100	100	100	200	200	240	260	300	360	430	580	850	1300
110V	1	8	8	8	180	180	210	230	270	320	380	520	760	1180
	2	80	80	80	180	180	210	230	270	320	380	520	760	1180
	3	85	85	85	200	200	210	230	300	360	430	580	850	1300
220V	1	5	5	5	160	160	–	–	–	–	–	–	–	–
	2	45	45	45	160	160	190	200	250	260	350	450	700	1000
	3	55	55	55	200	200	240	200	300	360	430	580	850	1300

2. Application

2.11 Application Data for Categories DC-1 or DC-5

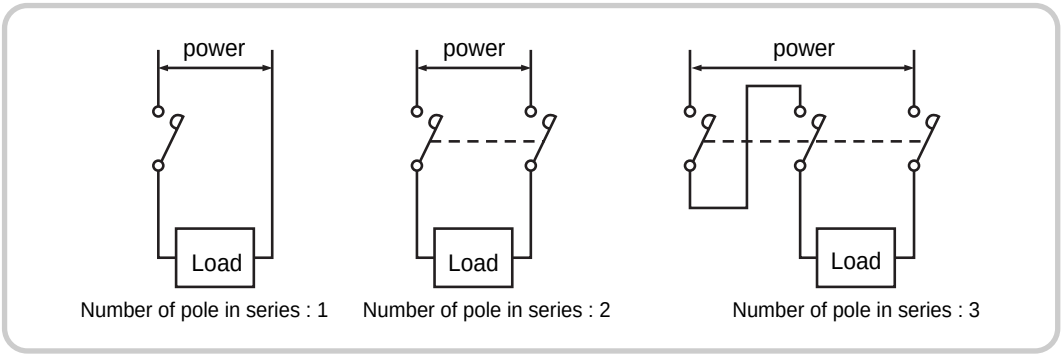


Fig. 34. Type of series connection pole

2. DC electric motor loads(category DC-2~DC-5) : time constant L/R= 15ms

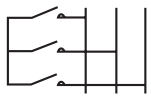
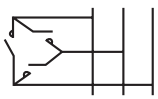
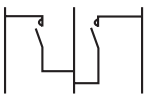
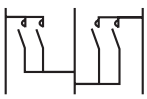
Rated operational voltage Ue	Number of poles connected in series	Rated operational current (A)											
		18AF				22AF				40AF		65AF	
		6a	9a	12a	18a	9b	12b	18b	22b	32a	40a	50a	65a
24V	1	12	12	12	12	12	12	12	12	20	20	35	35
	2	15	15	15	15	15	15	15	15	25	25	45	45
	3	18	18	18	18	18	18	18	18	30	30	55	55
48 / 75V	1	10	10	10	10	10	10	10	10	15	15	15	15
	2	12	12	12	12	12	12	12	12	20	20	40	40
	3	15	15	15	15	15	15	15	15	30	30	50	50
110V	1	2	2	2	2.0	2	2	2.0	2.0	2.5	2.5	2.5	2.5
	2	8	8	8	8	8	8	8	8	15	15	25	25
	3	12	12	12	12	12	12	12	12	20	20	35	35
220V	1	0.75	0.75	0.75	1	0.75	0.75	1	1	1	1	1	1
	2	1.5	1.5	1.5	2	1.5	1.5	2	2	3	3	5	5
	3	6	6	6	6	6	6	6	6	10	10	25	25

Rated operational voltage Ue	Number of poles connected in series	Rated operational current (A)												
		100AF			150AF		225AF		400AF			800AF		
		75a	85a	100a	130a	150a	185a	225a	265a	330a	400a	500a	630a	800a
24V	1	40	40	40	200	200	240	260	300	360	430	580	850	1300
	2	60	60	60	200	200	240	260	300	360	430	580	850	1300
	3	80	80	80	200	200	240	260	300	360	430	580	850	1300
48 / 75V	1	15	15	15	200	200	240	260	300	360	430	580	850	1300
	2	50	50	50	200	200	240	260	300	360	430	580	850	1300
	3	70	70	70	200	200	240	260	300	360	430	580	850	1300
110V	1	2.5	2.5	2.5	100.0	100.0	–	–	–	–	–	–	–	–
	2	40	40	40	140	140	160	180	250	300	350	500	700	1000
	3	60	60	60	200	200	240	240	250	310	350	550	850	1000
220V	1	1	1	1	100	100	–	–	–	–	–	–	–	–
	2	7	7	7	120	120	140	160	220	280	310	480	680	900
	3	35	35	35	140	140	160	160	250	300	350	500	700	1000

2.12 Circuit of Slip-ring Motors

A magnetic contactor used for short-circuiting rotor resistors can be used with their normal operation voltage. Condition of rotor magnetic contactor is different depending on connection mode of main pole. Current value with circuit input, current and voltage value with breaking circuit (generally besides low load factor) flow easily to the magnetic contactor.

■ Rotor connection

Type of connection		Multiple factor	Maximum 3 phase rotor voltage Ue	3 phase rotor voltage with counter - current breaking
Connection circuit	Connection method			
 Star Connection	Star	1	1500V	750V
 Delta Connection	Delta	1.4	1250V	625V
 V Connection	In V	1	1250V	625V
 W Connection	In W	1.6	1250V	750V

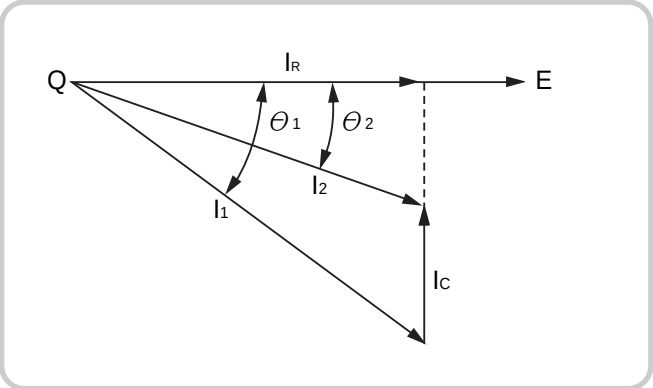
Type / Operation time / Connection		Operational current (A)														
		18AF				22AF				40AF		65AF		100AF		
		6a	9a	12a	18a	9b	12b	18b	22b	32a	40a	50a	65a	75a	85a	100a
Intermediate contactor (operating cycles≤30/h)	6s	36	60	60	90	60	60	90	90	130	210	250	300	330	360	380
	12s	30	50	50	60	50	50	60	60	125	160	200	250	275	300	320
	20s	21	35	35	45	35	35	45	45	90	100	110	120	135	150	170
Rotor short-circuiting contactor and intermediate contactor (operating cycles >30/h)		15	25	25	32	25	25	32	32	50	60	80	80	100	125	140

Type / Operation time / Connection		Operational current (A)									
		150AF		225AF		400AF			800AF		
		130a	150a	185b	225b	265b	330a	400a	500a	630a	800a
Intermediate contactor (operating cycles≤30/h)	6s	390	450	550	670	800	900	1100	1500	2000	2500
	12s	250	280	400	480	550	600	730	1000	1500	2000
	20s	190	220	300	360	400	450	550	750	1200	1500
Rotor short-circuiting contactor and intermediate contactor (operating cycles >30/h)		170	200	270	330	350	420	500	700	1000	1600

2. Application

2.13 Capacitor Load Application

High peak should be considered when harmonic wave current is generated during continuous duty. For this application, IEC publication 947-4-1 regulates the application category AC-6b. Allowed operation current or power about magnetic contactor is determined by our electrical test. IEC publication 947-4-1 provides calculation formula with determining operation current (Table VII b). Applying magnetic contactor to condenser load is mainly for condenser switching of phase advance. Using phase advancing condenser generates damages to voltage, current wave, noise increase of motor, transformer is caused by this damage, therefore, voltage and current damages by the 5th harmonic wave are restrained with generally inserting 6% series reactor of condenser reactance. This reactor has an effect of not only improving wave form, but restraining rush current when input, therefore it is recommended to use with every condenser circuit. It is necessary to check the phenomena in case of condenser switching by magnetic contactor. Condenser capacity required to improve load power factor from $\cos\Theta 1$ to $\cos\Theta 2$ is calculated as following.



E: Voltage
I_1: Current before phase advance
I_2: Current after phase advance
I_C: Current for phase advance
I_R: Effective load current
$\cos\Theta_1$: Power factor before phase advance
$\cos\Theta_2$: Power factor after phase advance
Q: Required capacitor power

Fig. 35. Capacitor capacity and variation chart of power factor

$$Q = EI_C = EI_R(\tan\Theta_1 - \tan\Theta_2) = EI_R\left(\sqrt{\frac{1}{\cos^2\Theta_1} - 1} - \sqrt{\frac{1}{\cos^2\Theta_2} - 1}\right)$$

Application example) Required capacitor power Q(kvar) to improve load factor $\cos\Theta 1$ = 0.7, capacity EIr= 100Kw to $\cos\Theta 2$ =0.95, is as follows.

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

The following table shows the calculated equation of required capacitor capacity (168P).

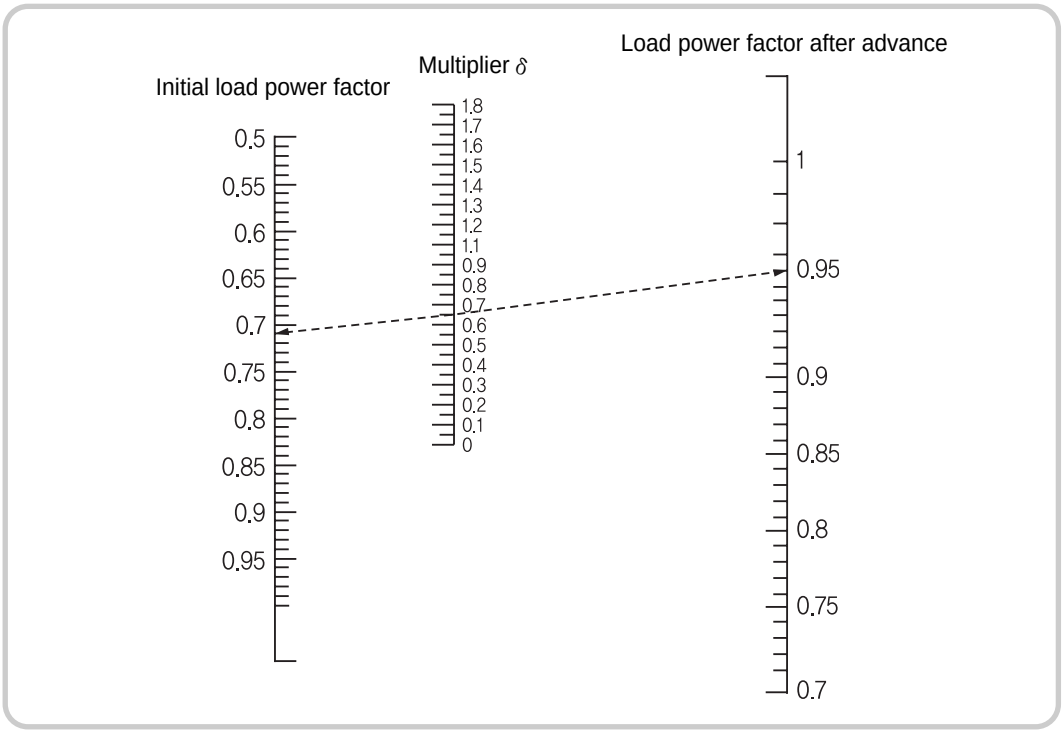


Fig. 36. Capacitor power calculating power

Application example) To advance load power factor from 0.7, power 100kW to power factor 0.95, then setting solution multiplier δ=0.69 is required as following figure, Required capacitor capacity

$$Q = 100 \times 0.69 = 69\text{kvar}$$

■ Input of capacitor

Rush current is determined by circuit impedance when there is no series reactor in the capacitor, generally with a few times to tens of times of original rush current, it becomes extreme to the magnetic contactor.

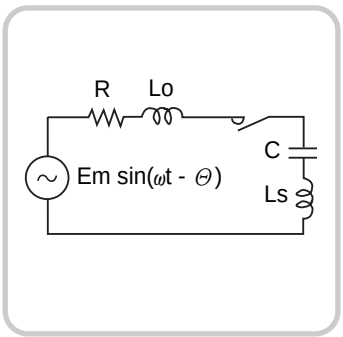


Fig. 37. Capacitor closing equivallent

$$I_{max} = \left(\frac{1}{\omega\sqrt{Lo + Ls}} + 1\right) I_m$$

$$I_m = \frac{E_m}{\sqrt{R^2 + \omega^2 (Lo+Ls)^2 + \frac{1}{\omega^2 C}}} \fallingdotseq \frac{E_m}{\sqrt{\omega^2 Ls^2 + \frac{1}{\omega^2 C^2}}}$$

I_{max} : Rush current R : Circuit resistance Ls : series reactor

I_m : Normal current Lo : Circuit impedance C : Condenser

Maximum value of rush current becomes 5 times of normal current, when Lo<Ls, ω^2 Lsc = 0.06 with series reactor.

2. Application

2.13 Capacitor Load Application

■ **Capacitor breaking**

Voltage between contacts of magnetic contactor is low, so it becomes extinct easily, because of residual electric charge of condenser when breaking. Re-striking is generated in case that insulation recovery isn't connected between contacts from abruptly emerging recovery voltage. According to figure 38, electric charge remains with wave height value of voltage at condenser terminal during breaking, recovery voltage which happens between contacts is given with difference of condenser residual voltage and power voltage, voltage between contacts of breaking moment is small, it passes through 0.5 cycle and indicates approximately 2 times of power voltage right after breaking. Re-striking will occur, if the insulation recovery characteristic between contacts is lower than this.

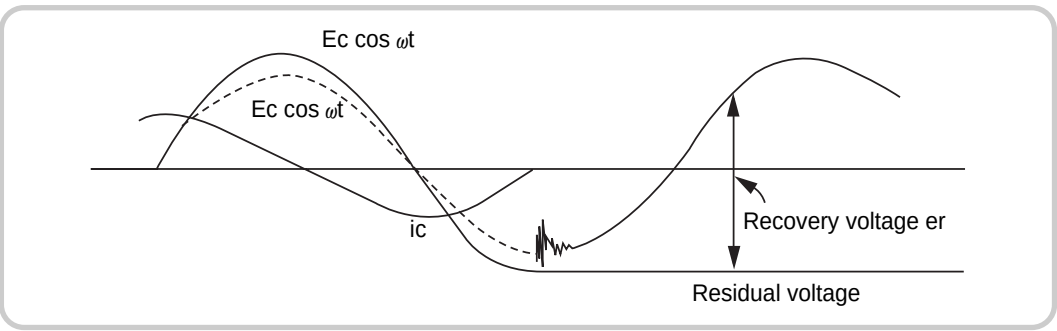


Fig. 38. Recovery voltage wave form between poles of switch

In case of re-striking, the over-voltage of the condenser increases up to approximately three times that of normal voltage, and the re-striking current reaches more than several ten times that of the normal current. It then has a bad influence on the system. If there is a series reactor (6%) and re-striking maximum current is restrained, it becomes less than 9 times of normal current. With application for phase advance condenser because of this, it's necessary to make sure that maximum value of rush current is less than the AC3 class closed circuiting current capacity of magnetic contactor by inserting series reactor. Rush current increases when inserted series reactor is reduced, therefore it's necessary to apply the magnetic contactor with a large rated current. The magnetic contactor is applied, when series reactor is small with the standard of 6% series reactor. Figu 38 shows relation of magnetic rated current increase rate.

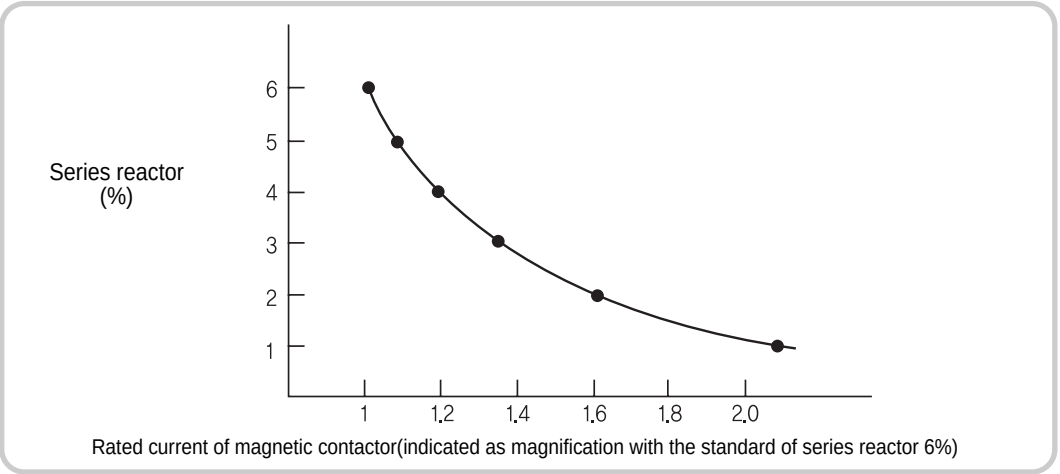


Fig. 39. Characteristic curve of series reactor and contactor rated current

Application example : Category AC3 rated current 100A frame is selected, when series reactor 6%, and 125A frame is selected upper frame of 100x1.2= 120A, when series reactor is reduced 4%.

■ Switching capacitor banks switching

The following things should be considered, when using a magnetic contactor with a switching condenser to improve the power factor.

1) Enduring inrush current determines impedance of circuit during circuit closing.
2) Rated flow current is more than 1.3 x 1.1 times condenser' s rated current (according to KSC4801 low voltage phase advance condenser)
3) No re-striking, exploding when breaking

■ Selection

When Metasol type magnetic contactor is applied to condenser load, operational capacity table of magnetic contactor is as following. It is necessary to carefully select the gauge of wire, because the wire won' t be able to be connected to contactor' s terminal if its too large.

■ Maximum operational power of contactors

Maximum operating rate : 120 operating cycles / hour
Electrical durability : 100,000 operating cycles
Use with connecting damping resistor when required.

Operational power, 50/60Hz						Maximum peak current (A)	contactor size
0≤40˚C			0≤55˚C Note)				
220V 240V	400V 440V	600V 690V	220V 240V	400V 440V	600V 690V		
Kvar	Kvar	Kvar	Kvar	Kvar	Kvar		
2.2	3	3	2.2	3	3	300	MC-6a
2.5	4	4	2.5	4	4	500	MC-9a(b)
3.5	5.5	7.5	3.5	5.5	7.5	560	MC-12a(b)
4.5	7.5	7.5	4.5	7.5	7.5	850	MC-18a(b)
5.5	11	15	5.5	11	15	1600	MC-22b
7.5	15	18.5	7.5	15	18.5	1800	MC-32a
11	18.5	22	11	18.5	22	2000	MC-40a
15	22	30	15	22	30	2100	MC-50a
18.5	30	33	18.5	30	33	3000	MC-65a
22	37	37	22	37	37	3050	MC-75a
25	45	45	25	45	45	3050	MC-85a
25	45	50	25	45	50	3050	MC-100a

Note) Upper limit of temperature category conforming to IEC 60070

2. Application

2.13 Capacitor Load Application

■ Capacitor switching unit

Because there is a very large (about 20 times the rating) rush current during condenser bank switching, the normal magnetic contactor will not last for its durability so apply a condenser unit by selecting proper operational magnetic contactor.

- Characteristic of condenser unit(pre-loading resistor attaching type unit)
  1) It consists of damping resistor which limits input current up to maximum 60In(60 times of rated current) and wire closed circuit.
  2) No heating loss by series resistance
  3) Removing switching surge
  4) Improving life span of capacitor system

This product is suitable for switching single-step or multi-step condenser bank.

- Related standard : IEC 60947-4-1, UL, CSA
- Product composition: magnetic contactor and condenser unit (Pre-loading resistance) are combined.
- Contact point composition : main contact 3 pole (3a), no standard sub-contact point
- Control power (coil) : AC50, 60 Hz or DC
- Installation : for both 35mm DIN rail and screw

■ Application capacitor power table

Type	Application condenser power (kvar)			Rated current (A)	Combined condenser unit
	220~240V	400~440V	600~690V		
MC-6a(D)	5	9	14	12	AC-9
MC-9a,b(D)	5	10	14	14	AC-9
MC-12a,b(D)	7	13	18	18	AC-9
MC-18a,b(D)	9	17	24	24	AC-9
MC-22b(D)	9	17	26	22	AC-9
MC-32a(D)	15	25	36	36	AC-9
MC-40a(D)	20	33	48	48	AC-9
MC-50a(D)	20	40	58	58	AC-50
MC-65a(D)	25	46	66	66	AC-50
MC-75a(D)	30	54	78	78	AC-50
MC-85a(D)	35	60	92	92	AC-50
MC-100a(D)	37	62	94	94	AC-50

Note) kVar rating from table can be applied to connecting wire Y of condenser.
Condenser should be discharged before recharging it after circuit closing the switch.

- maximum residual voltage of terminal < 50V gG type fuse which is 1.5~1.8 times of rating should be used for protecting short circuit.

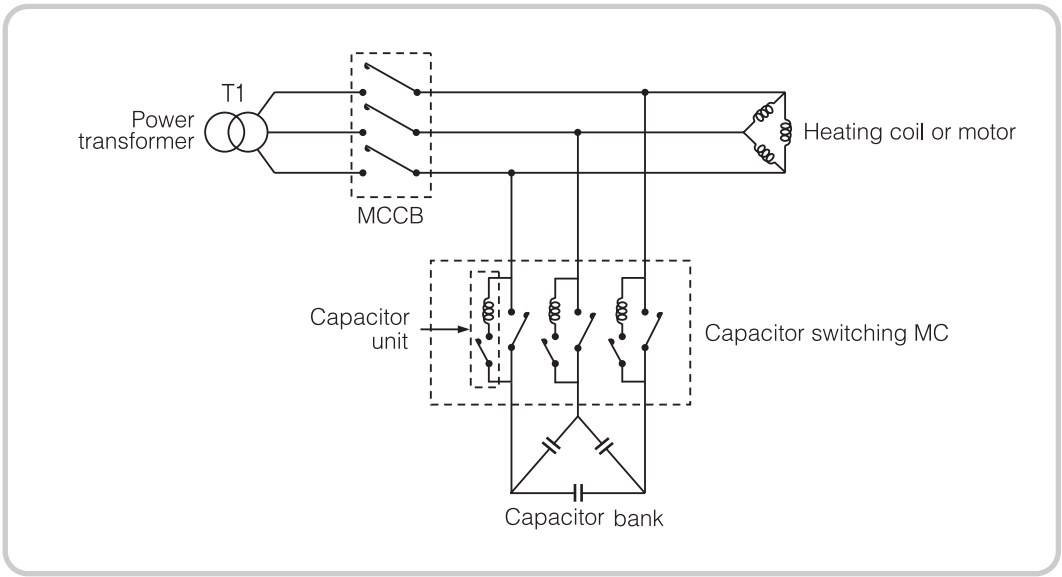


Fig. 40. Capacitor load application circuit

2.14 Lighting Circuit Selection Guid

Current peaks which happen during activation of lighting circuits and power factors depend on type, connection mode and compensation. For this application, IEC 947-4-1 regulates two standard utilization ranges.

- AC-5a for switching discharging lamps.
- AC-5b for switching incandescence lamps

Higher current than normal current(after lighting) flows when driving, in case of lighting loads of fluorescent lamps, mercury lamps, incandescent lamps.

- Fluorescent lamp: Approximately 10 times
- Mercury lamp: Approximately 2 times
- Incandescent lamp: Approximately 10 times

For making current closed in circuit when starting, and enduring until lighting time and with a certain amount of electrical durability, selection of contactor is determined as follows.
[total normal current of lighting load $\leq$ AC3 class rated operational current of magnetic contactor] It is regulated with AC5a(switching control device such as discharging) AC5b(switching incandescent lamp) class for lighting load, but it can be replaced with rated performance of the AC3 class. Moreover, operation condition of lighting circuit has following characteristics.

- Continuous duty : Switching device can be input for several days or months.
- Index of dispersion for 1 : Every lighting device in same group becomes switch on or off simultaneously.
- Operation current for lighting is lower than given value about AC-1 duty, because of relatively higher temperature around the device by case, fuse, control panel location without ventilation.

2. Application

2.14 Lighting Circuit Selection Guid

1. Protection

Continuous current connected to lighting circuit is constant. Actually,
- Lighting circuit number of existing circuit doesn't really change.
- This circuit type generates long-term overload.

Therefore, this circuit only requires short circuit protection, it can be provided with following.
- gG type fuse
- a miniature or modular circuit-breakers

But, it is possible and sometimes economical to protect circuit with an aM Type related with thermal overload relay (smaller cable size).

2. Distribution system

Single phase 220/ 240V
Previous tables (page 175 to 184) are based on single phase 220/240V circuits, therefore they can be directly applied in this case.

3. Three phase circuit 380/415V with neutral conductor

Total lamp number(N) is divided into 3 equivalent groups when simultaneous switching. Each one is connected between one phase and neutral conductor. Magnetic contactor can be selected from 220/240V single phase table about lamp number same as N / 3

4. Three phase circuit 220/240V

Total lamp number(N) is divided into 3 equivalent groups when simultaneous switching. Each one is connected between two phases, (L1-L2), (L2-L3), (L3-L1). Magnetic contactor can be selected from 220/240V single phase table about lamp number same as N

5. Contactor selection table

Table page 175 to 184 about various lamp types provide maximum number of device capacity P(watt) possible for switching to each size of magnetic contactor simultaneously. They are based on following.

1) 220/240V single phase circuit
2) Surrounding temperature 55°C with considering operation condition
3) Electrical life span more than 10 years(operating for 200 days per year)

They consider followings.

1) Entire current(including ballast)
2) Transient phenomena, when input
3) Clanking ampere and Circulation of every harmonic wave that period can be expressed.

6. Lamp with compensation capacity C(μF) connected in AC

Transient current flows when switch-on AC connecting capacitor, to guarantee of this transient current is compatible with closing characteristic, value of capacitor should not exceed the following.

This value is independent with switched lamp number with contactor.
1) Iu multiplies 1.2 about surrounding temperature 40° C

Type name of contactors	18AF				22AF				40AF			65AF	
	6a	9a	12a	18a	9b	12b	18b	22b	25a	32a	40a	50a	65a
Max val. of compensating condenser C(μF)	14	18	18	25	18	18	25	96	60	96	120	120	240

Type name of contactors	100AF			150AF		225AF		400AF			800AF		
	75a	85a	100a	130a	150a	185a	225a	265a	330a	400a	500a	630a	800a
Max val. of compensating condenser C(μF)	240	240	240	300	360	800	1200	1700	2500	4000	6000	9000	9000

■ Incandescent lamp

The filament of an incandescent lamp has an especially small resistance at room temperature, a current of 3~16 times the rated current flows theoretically at the moment when voltage is applied, but transient current is restrained up to 7~10 times by circuit impedance or magnetic heating in practical conditions. A characteristic example is as follows at the moment from when voltage is applied to when the current is stable. The magnetic contactor applied to an incandescent lamp needs to be inserted while considering this transient current, the rated current of incandescent lamp should be selected within an AC3 class rated operational current.

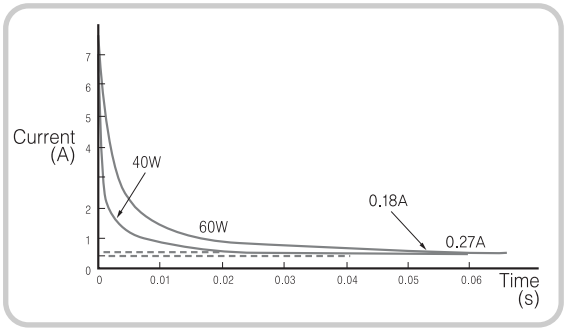


Fig. 41. Voltage applied instant's current characteristic of 220V, 40W, 60W standard lamps

- IB: rated current value of each lamp at rated operation voltage
- C : device capacitance about each lamp, which is suitable for the value provided by usual lamp manufacturer. This value is given about surrounding temperature 55˚C (lu multiplies 1.2 about 40˚C)

1. Incandescent lamp, halogen lamp

unit : EA

P(W)	60	75	100	150	200	300	500	750	1000	Type name of contactor
IB(A)	0.27	0.34	0.45	0.68	0.91	1.36	2.27	3.41	4.55	
Maximum number of lamp according to P(W)	33	27	20	13	10	7	4	3	2	MC-6a
	37	29	22	15	11	7	4	3	2	MC-9a, 9b
	43	35	26	17	13	9	5	3	3	MC-12a, 12b
	60	48	36	24	18	12	7	5	4	MC-18a, 18b
	62	49	37	25	19	12	7	5	4	MC-22b
	87	69	52	35	26	17	10	7	5	MC-32a
	117	93	70	47	35	23	14	9	7	MC-40a
	167	133	100	67	50	33	20	13	10	MC-50a
	217	173	130	87	65	43	26	17	13	MC-65a
	250	200	150	100	75	50	30	20	15	MC-75a
	283	227	170	113	85	57	34	23	17	MC-85a
	317	253	190	127	95	63	38	25	19	MC-100a
	417	333	250	167	125	83	50	33	25	MC-130a
	467	373	280	187	140	93	56	37	28	MC-150a
	700	560	420	280	210	140	84	56	42	MC-185a
	767	613	460	307	230	153	92	61	46	MC-225a
	883	707	530	353	265	177	106	71	53	MC-265a
	1000	800	600	400	300	200	120	80	60	MC-330a
	1267	1013	760	507	380	253	152	101	76	MC-400a
	1717	1373	1030	687	515	343	206	137	103	MC-500a
	2333	1867	1400	933	700	467	280	187	140	MC-630a
	3033	2427	1820	1213	910	607	364	243	182	MC-800a

2. Application

2.14 Lighting Circuit Selection Guid

■ **Incandescent lamp**

2. Mixed lighting

unit : EA

P(W)	100	160	250	500	1000	Type name of contactor
IB(A)	0.45	0.73	1.14	2.27	4.55	
Maximum number of lamp according to P(W)	20	13	8	4	2	MC-6a
	22	14	9	4	2	MC-9a, 9b
	26	16	10	5	3	MC-12a, 12b
	36	23	14	7	4	MC-18a, 18b
	37	23	15	7	4	MC-22b
	52	33	21	10	5	MC-32a
	70	44	28	14	7	MC-40a
	100	63	40	20	10	MC-50a
	130	81	52	26	13	MC-65a
	150	94	60	30	15	MC-75a
	170	106	68	34	17	MC-85a
	190	119	76	38	19	MC-100a
	250	156	100	50	25	MC-130a
	280	175	112	56	28	MC-150a
	420	263	168	84	42	MC-185a
	460	288	184	92	46	MC-225a
	530	331	212	106	53	MC-265a
	600	375	240	120	60	MC-330a
	760	475	304	152	76	MC-400a
	1030	644	412	206	103	MC-500a
	1400	875	560	280	140	MC-630a
	1820	1138	728	364	182	MC-800a

■ Fluorescent lamp with starter

The fluorescent lamp is used with a combination of a fluorescent lamp and ballast, and categorized according to starti starter or rapid starter. Starter type is a ballast which lights using manual switch operation or an automatic starter (groidely used in households. In contrast, rapid starter type lights distinctly differ from starter type, being a type without contact, widely used in buildings, plants, hospitals, schools. The clanking ampere of fluorescent lamps is different d whether there is a ballast circuit and condenser for controlling power factor or not, but it is recommended to selec contactor with less than AC3 class rated operational current, because it flows approximately 10 times of lamp current.

- IB: rated current value of each lamp at rated operation voltage
- C : Device capacitance about each lamp, which is suitable for the value provided by usual lamp manufacturer. This about surrounding temperature 55˚C. (lu multiplies 1.2 about 40˚C)

1. Single fitting

unit : EA

Type	Not compensated					With AC compensation (parallel connection)					Type name of contactor
P(W)	20	40	65	80	110	20	40	65	80	110	
IB(A)	0.39	0.45	0.70	0.80	1.20	0.17	0.26	0.42	0.52	0.72	
C(μF)	–	–	–	–	–	5	5	7	7	16	
Maximum number of lamp according to P(W)	24	21	13	12	8	56	36	22	18	–	MC-6a
	41	35	22	20	13	94	61	38	30	22	MC-9a, 9b
	41	35	22	20	13	94	61	38	30	22	MC-12a, 12b
	53	46	30	26	17	123	80	50	40	29	MC-18a, 18b
	53	46	30	26	17	123	80	50	40	29	MC-22b
	89	77	50	43	29	205	134	83	67	48	MC-32a
	112	97	62	55	36	258	169	104	84	61	MC-40a
	143	124	80	70	46	329	215	133	107	77	MC-50a
	143	124	80	70	46	329	215	133	107	77	MC-65a
	205	177	114	100	66	470	367	190	153	111	MC-75a
	205	177	114	100	66	470	367	190	153	111	MC-85a
	205	177	114	100	66	470	367	190	153	111	MC-100a
	328	283	182	160	106	752	491	304	245	178	MC-130a
	410	354	228	200	132	940	614	380	306	222	MC-150a
	492	426	274	240	160	1128	738	456	368	266	MC-185a
	532	462	296	260	172	1224	800	490	400	288	MC-225a
	614	532	342	300	200	1412	922	570	462	332	MC-265a
	696	604	388	340	226	1600	1046	648	522	378	MC-330a
	882	764	490	430	286	2024	1322	818	662	478	MC-400a
	1190	1030	652	580	386	2728	1724	1104	892	644	MC-500a
	1612	1398	698	786	524	3700	2418	1498	1210	874	MC-630a
	2096	1817	907	1022	681	4810	3143	1947	1573	1136	MC-800a

2. Application

2.14 Lighting Circuit Selection Guid

■ **Fluorescent lamp with starter**

2. Twin fitting

unit : EA

Type	Not compensated					With AC compensation (parallel connection)					Type name of contactor
P(W)	2x20	2x40	2x65	2x80	2x110	2x20	2x40	2x65	2x80	2x110	
IB(A)	2x0.22	2x0.41	2x0.67	2x0.82	2x1.1	2x0.13	2x0.24	2x0.39	2x0.48	2x0.65	
Maximum number of lamp according to P(W)	2x21	2x11	2x7	2x5	2x4	2x36	2x20	2x12	2x10	2x7	MC-6a
	2x36	2x18	2x10	2x8	2x6	2x60	2x32	2x20	2x16	2x12	MC-9a, 9b
	2x36	2x18	2x10	2x8	2x6	2x60	2x32	2x20	2x16	2x12	MC-12a, 12b
	2x46	2x24	2x14	2x12	2x8	2x80	2x42	2x26	2x20	2x16	MC-18a, 18b
	2x46	2x24	2x14	2x12	2x8	2x80	2x42	2x26	2x20	2x16	MC-22b
	2x78	2x42	2x26	2x20	2x14	2x134	2x72	2x44	2x36	2x26	MC-32a
	2x100	2x52	2x32	2x26	2x15	2x168	2x90	2x56	2x44	2x32	MC-40a
	2x126	2x68	2x40	2x34	2x24	2x214	2x116	2x70	2x58	2x42	MC-50a
	2x126	2x68	2x40	2x34	2x24	2x214	2x116	2x70	2x58	2x42	MC-65a
	2x180	2x96	2x58	2x48	2x36	2x306	2x166	2x102	2x82	2x60	MC-75a
	2x180	2x96	2x58	2x48	2x36	2x306	2x166	2x102	2x82	2x60	MC-85a
	2x180	2x96	2x58	2x48	2x36	2x306	2x166	2x102	2x82	2x60	MC-100a
	2x380	2x194	2x118	2x96	2x72	2x614	2x332	2x204	2x166	2x122	MC-130a
	–	–	–	–	–	–	–	–	–	–	MC-150a
	2x436	2x234	2x142	2x116	2x86	2x738	2x400	2x246	2x200	2x146	MC-185a
	2x472	2x254	2x154	2x126	2x94	2x800	2x432	2x266	2x216	2x160	MC-225a
	2x544	2x292	2x178	2x146	2x108	2x922	2x500	2x308	2x250	2x184	MC-265a
	2x618	2x332	2x202	2x166	2x124	2x1046	2x566	2x348	2x282	2x208	MC-330a
	2x782	2x420	2x256	2x210	2x156	2x1322	2x716	2x440	2x358	2x264	MC-400a
	2x1054	2x566	2x346	2x282	2x210	2x1784	2x966	2x594	2x482	2x356	MC-500a
	2x1430	2x766	2x468	2x384	2x286	2x2418	2x1370	2x806	2x654	2x484	MC-630a
	2x1859	2x995	2x608	2x499	2x371	2x3143	2x1781	2x1047	2x850	2x629	MC-800a

■ Fluorescent lamp without starter

- IB: Rated current value of each lamp at rated operation voltage
- IC: Device capacitance about each lamp, which is suitable for the value provided by usual lamp manufacturer. This value is given about surrounding temperature 55° C. (lu multiplies 1.2 about 40° C)

1. Single fitting

unit : EA

Type	Notcompensated					With AC compensation (parallel connection)					Type name of contactor
P(W)	20	40	65	80	110	20	40	65	80	110	
IB(A)	0.39	0.45	0.70	0.80	1.20	0.17	0.26	0.42	0.52	0.72	
C (μF)	–	–	–	–	–	5	5	7	7	16	
Maximum number of lamp according to P(W)	22	17	12	10	6	50	33	20	16	–	MC-6a
	37	29	20	16	11	84	55	34	28	20	MC-9a, 9b
	37	29	20	16	11	84	55	34	28	20	MC-12a, 12b
	48	38	26	22	15	110	72	45	36	26	MC-18a, 18b
	48	38	26	22	15	110	72	45	36	26	MC-22b
	97	63	43	36	25	184	101	76	61	44	MC-32a
	112	97	62	55	36	258	169	104	84	61	MC-40a
	130	101	70	58	40	294	193	121	98	70	MC-50a
	130	101	70	58	40	294	193	121	98	70	MC-65a
	186	145	100	84	57	421	275	173	140	101	MC-75a
	186	145	100	84	57	421	275	173	140	101	MC-85a
	186	145	100	84	57	421	275	173	140	101	MC-100a
	372	290	200	168	114	842	550	340	280	202	MC-130a
	410	320	221	186	120	929	609	383	309	223	MC-150a
	446	348	240	202	130	1010	662	416	336	242	MC-185a
	484	378	260	218	148	1094	716	452	364	262	MC-225a
	558	438	300	252	170	1252	828	522	420	304	MC-265a
	632	494	340	286	194	1462	936	590	476	344	MC-330a
	800	524	430	362	246	1810	1186	748	604	434	MC-400a
	1078	844	580	488	330	2442	1600	1008	814	586	MC-500a
	1462	1144	786	662	448	3310	2168	1366	1104	796	MC-630a
	1901	1487	1022	861	582	4303	2818	1776	1435	1035	MC-800a

2. Application

2.14 Lighting Circuit Selection Guid

■ **Fluorescent lamp without starter**

2. Twin fitting

unit : EA

Type	Notcompensated					With AC compensation (series connection)					Type name of contactor
P(W)	2x20	2x40	2x65	2x80	2x110	2x20	2x40	2x65	2x80	2x110	
IB(A)	2x0.22	2x0.41	2x0.67	2x0.82	2x1.1	2x0.13	2x9.24	2x0.39	2x0.48	2x65	
Maximum number of lamp according to P(W)	2x19	2x10	2x6	2x5	2x36	2x34	2x18	2x11	2x9	2x6	MC-6a
	2x32	2x16	2x10	2x8	2x6	2x56	2x30	2x18	2x14	2x10	MC-9a, 9b
	2x32	2x16	2x10	2x8	2x6	2x56	2x30	2x18	2x14	2x10	MC-12a, 12b
	2x42	2x22	2x12	2x10	2x8	2x74	2x40	2x24	2x18	2x14	MC-18a, 18b
	2x42	2x22	2x12	2x10	2x8	2x74	2x40	2x24	2x18	2x14	MC-22b
	2x70	2x36	2x22	2x18	2x12	2x124	2x66	2x40	2x32	2x24	MC-32a
	2x88	2x46	2x28	2x22	2x16	2x156	2x84	2x50	2x40	2x30	MC-40a
	2x112	2x58	2x36	2x30	2x20	2x200	2x106	2x64	2x52	2x38	MC-50a
	2x112	2x58	2x36	2x30	2x20	2x200	2x106	2x64	2x52	2x38	MC-65a
	2x160	2x84	2x52	2x42	2x30	2x234	2x152	2x92	2x74	2x54	MC-75a
	2x160	2x84	2x52	2x42	2x30	2x234	2x152	2x92	2x74	2x54	MC-85a
	2x160	2x84	2x52	2x42	2x30	2x234	2x152	2x92	2x74	2x54	MC-100a
	2x320	2x170	2x104	2x86	2x60	2x570	2x306	2x186	2x150	2x110	MC-130a
	2x353	2x187	2x115	2x93	2x68	2x631	2x338	2x204	2x165	2x121	MC-150a
	2x384	2x204	2x126	2x102	2x74	2x686	2x368	2x222	2x180	2x132	MC-185a
	2x416	2x220	2x136	2x112	2x80	2x742	2x400	2x242	2x196	2x144	MC-225a
	2x480	2x254	2x156	2x128	2x92	2x856	2x462	2x278	2x226	2x166	MC-265a
	2x544	2x288	2x178	2x146	2x104	2x970	2x522	2x316	2x256	2x188	MC-330a
	2x688	2x366	2x226	2x184	2x132	2x1228	2x662	2x400	2x324	2x238	MC-400a
	2x928	2x494	2x304	2x248	2x178	2x1656	2x892	2x540	2x438	2x322	MC-500a
	2x1258	2x668	2x414	2x338	2x242	2x2246	2x1210	2x730	2x592	2x436	MC-630a
	2x1698	2x901	2x558	2x456	2x326	2x3032	2x1633	2x985	2x799	2x588	MC-800a

■ Sodium vapor lamp

- IB: Rated current value of each lamp at rated operation voltage
- C : Device capacitance of each lamp, which is suitable for the value provided by the lamp manufacturer. This value is given for surrounding temperature 55 ˚C. (Iu multiplies 1.2 about 40 ˚C)

1. Low pressure sodium vapor lamps

unit : EA

Type	Not compensated							With AC compensation (parallel connection)							Type name of contactor
P(W)	35	55	90	135	150	180	200	35	55	90	135	150	180	200	
IB(A)	1.2	1.6	2.4	3.1	3.2	3.3	3.4	0.3	0.4	0.6	0.9	1.0	1.2	1.3	
C(μF)	–	–	–	–	–	–	–	17	17	25	36	36	36	36	
Maximum number of lamp according to P(W)	6	5	3	2	2	2	2	–	–	–	–	–	–	–	MC-6a
	10	7	5	3	3	3	3	40	30	–	–	–	–	–	MC-9a, 9b
	10	7	5	3	3	3	3	40	30	–	–	–	–	–	MC-12a, 12b
	12	9	6	4	4	4	4	50	37	25	–	–	–	–	MC-18a, 18b
	12	9	6	4	4	4	4	50	37	25	–	–	–	–	MC-22b
	21	16	10	8	8	7	7	86	65	43	28	26	21	20	MC-32a
	27	20	13	10	10	10	9	110	82	55	36	33	27	25	MC-40a
	35	26	17	13	13	12	12	140	105	70	46	42	35	32	MC-50a
	35	26	17	13	13	12	12	140	105	70	46	42	35	32	MC-65a
	50	37	25	19	18	18	17	200	150	100	66	60	50	46	MC-75a
	50	37	25	19	18	18	17	200	150	100	66	60	50	46	MC-85a
	50	37	25	19	18	18	17	200	150	100	66	60	50	46	MC-100a
	100	75	50	38	36	36	34	400	300	200	132	120	100	92	MC-130a
	129	129	129	129	129	129	129	129	129	129	129	129	129	129	MC-150a
	140	104	70	54	52	50	48	560	420	280	186	168	140	128	MC-185a
	152	114	76	58	56	54	54	606	4545	302	202	182	152	140	MC-225a
	174	130	88	68	66	64	62	700	24	350	232	210	174	162	MC-265a
	198	148	98	76	74	72	70	792	594	396	264	238	198	182	MC-330a
	250	188	124	96	94	90	88	1002	752	502	334	300	250	208	MC-400a
	338	254	168	130	126	122	118	1352	1014	676	450	406	338	312	MC-500a
	496	372	248	192	186	180	174	1982	1488	992	660	694	496	458	MC-630a
	724	543	362	280	272	263	254	2894	2172	1448	964	1013	724	669	MC-800a

2. Application

2.14 Lighting Circuit Selection Guid

■ **Sodium vapor lamp**

2. High pressure sodium vapor lamps

unit : EA

Type	Notcompensated					With AC compensation(parallel connection)					Type name of contactor
P(W)	3.5	5.5	9.	135	150	35	55	90	135	150	
IB(A)	1.2	1.6	2.4	3.1	3.2	0.3	0.4	0.6	0.9	1.0	
C(㎌)	–	–	–	–	–	17	17	25	36	36	
Maximum number of lamp according to P(W)	4	2	1	–	–	–	–	–	–	–	MC-6a
	6	3	2	1	–	–	–	–	–	–	MC-9a, 9b
	6	3	2	1	–	–	–	–	–	–	MC-12a, 12b
	7	4	3	1	1	17	–	–	–	–	MC-18a, 18b
	7	4	3	1	1	17	–	–	–	–	MC-22b
	13	8	5	2	2	30	18	11	6	–	MC-32a
	17	10	6	3	2	39	23	15	8	6	MC-40a
	22	13	8	4	3	50	30	19	10	7	MC-50a
	22	13	8	4	3	50	30	19	10	7	MC-65a
	31	18	12	6	4	71	42	27	15	10	MC-75a
	31	18	12	6	4	71	42	27	15	10	MC-85a
	31	18	12	6	4	71	42	27	15	10	MC-100a
	62	36	24	12	8	142	84	54	30	20	MC-130a
	81	48	31	17	13	184	110	70	39	28	MC-150a
	88	52	34	18	14	200	120	76	42	30	MC-185a
	96	56	36	20	16	216	130	82	46	32	MC-225a
	110	66	42	24	18	250	150	94	54	38	MC-265a
	124	74	48	26	20	282	170	108	60	42	MC-330a
	158	94	60	34	24	358	214	136	76	54	MC-400a
	214	126	80	46	32	482	290	184	104	74	MC-500a
	312	186	118	68	48	708	424	270	152	108	MC-630a
	452	270	171	99	70	1027	615	392	220	157	MC-800a

■ Mercury lamp

- IB: Rated current value of each lamp at rated operation voltage
- C : Device capacitance of each lamp, which is suitable for the value provided by the lamp manufacturer. This value is given for surrounding temperature 55˚C. (Iu multiplies 1.2 about 40˚C)

1. High pressure mercury vapour lamp

unit : EA

Type	Not compensated							With AC compensation (parallel connection)							Type name of contactor
P(W)	50	80	125	250	400	700	1,000	35	55	90	135	150	180	200	
IB(A)	0.54	0.81	1.20	2.30	4.10	6.80	9.90	0.30	0.45	0.67	1.30	2.30	3.80	5.50	
C (μF)	–	–	–	–	–	–	–	10	10	10	18	25	40	60	
Maximum number of lamp according to P(W)	14	9	6	3	1	–	–	–	–	–	–	–	–	–	MC-6a
	22	14	9	5	2	1	1	40	26	17	9	–	–	–	MC-9a, 9b
	22	14	9	5	2	1	1	40	26	17	9	–	–	–	MC-12a, 12b
	27	18	12	6	3	2	1	50	33	22	11	6	–	–	MC-18a, 18b
	27	18	12	6	3	2	1	50	33	22	11	6	–	–	MC-22b
	48	32	21	11	6	3	2	86	57	38	20	11	6	4	MC-32a
	61	40	27	14	8	4	3	110	73	49	25	14	8	6	MC-40a
	77	51	34	17	10	6	4	140	93	62	32	18	11	7	MC-50a
	77	51	34	17	10	6	4	140	93	62	32	18	11	7	MC-65a
	111	74	49	26	14	8	6	200	133	89	46	26	15	10	MC-75a
	111	74	49	26	14	8	6	200	133	89	46	26	15	10	MC-85a
	111	74	49	26	14	8	6	200	133	89	46	26	15	10	MC-100a
	222	146	100	52	28	16	12	400	266	178	92	52	30	20	MC-130a
	285	190	129	66	37	22	16	515	342	230	118	66	40	28	MC-150a
	310	206	140	72	40	24	17	560	372	250	128	72	44	30	MC-185a
	336	224	152	78	44	26	18	606	404	272	140	78	48	32	MC-225a
	388	258	174	90	50	30	20	700	466	312	162	90	54	38	MC-265a
	440	294	198	102	58	34	24	792	528	354	182	102	62	42	MC-330a
	556	372	250	130	72	44	30	1002	668	448	232	130	78	54	MC-400a
	752	500	338	176	96	60	40	1352	902	606	312	176	106	74	MC-500a
	1102	734	496	258	144	88	60	1982	1322	888	458	258	156	108	MC-630a
	1609	1072	724	377	210	128	88	2894	1930	1296	669	377	228	158	MC-800a

2. Application

2.14 Lighting Circuit Selection Guid

H

■ **Mercury lamp**

2. Metal Iodine vapour lamp

unit : EA

Type	Not compensated				With AC compensation(parallel connection)				Type name of contactor
P(W)	35	55	90	150	35	55	90	150	
IB(A)	1.2	1.6	2.4	3.2	0.3	0.4	0.6	1.0	
C(μF)	–	–	–	–	17	17	25	36	
Maximum number of lamp according to P(W)	3	2	–	–	–	–	–	–	MC-6a
	4	3	1	–	–	–	–	–	MC-9a, 9b
	4	3	1	–	–	–	–	–	MC-12a, 12b
	6	4	1	–	–	–	–	–	MC-18a, 18b
	6	4	1	–	–	–	–	–	MC-22b
	10	7	2	1	18	13	4	–	MC-32a
	13	9	3	1	23	16	6	–	MC-40a
	16	11	4	2	30	21	7	–	MC-50a
	16	11	4	2	30	21	7	–	MC-65a
	24	16	6	3	42	30	11	5	MC-75a
	24	16	6	3	42	30	11	5	MC-85a
	24	16	6	3	42	30	11	5	MC-100a
	48	32	12	6	84	60	22	10	MC-130a
	61	42	17	7	110	77	29	13	MC-150a
	66	46	18	8	120	84	32	14	MC-185a
	72	50	20	10	130	90	34	16	MC-225a
	84	58	22	12	150	104	40	18	MC-265a
	94	66	24	14	170	118	44	20	MC-330a
	120	84	32	16	214	150	56	26	MC-400a
	162	112	42	20	290	202	76	36	MC-500a
	238	164	62	30	424	298	112	52	MC-630a
	347	239	91	44	619	435	164	76	MC-800a

2.15 Heating Circuit

A thermal circuit is a power switching circuit providing more than one resistance element by magnetic contactor. The same general regulations are applied to an electric motor circuit, but a heating circuit requires only the provision of short-circuit protection, because it normally excludes condition of overload current.

■ Characteristics of heating elements

The following examples are based on resistance heating element used for industrial furnace and heating building (infrared ray or resistance radiation type, magnetic contactor heater and making loop thermal circuit etc.) Shift of resistance value causes current peak at switch-on which doesn't exceed 2 to 3 times of operating current between hot and cold condition. This initial peak doesn't happen again during normal operation of automatic temperature control in switching. Rated capacity and current of heater are given about normal operating temperature.

■ Protection

Stabilized current by the heating circuit is constant, when voltage is stabilized. Specifically,

- Load number at existing circuit is not altered well.
- This type of circuit can not generate overload.

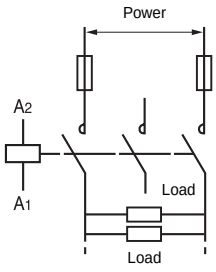
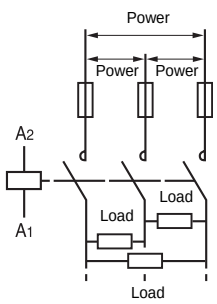
Therefore, it is necessary to select among followings for providing short-circuit protection.

- G type fuse or
- Modular circuit breakers

However, it is always possible to protect circuit with aM type fuse related to thermal overload relay, sometimes it is more economical.(smaller cable size)

■ Switching, control, protection

Heating element group of given power or heating element is probably single phase or 3 phases, it can be provided at 220/127V or 400/230V power distribution system. Excluding single phase 127V system (which is no longer commonly used), it is possible to arrange following 3 circuits.

1 phase 2 pole switching	3 phase switching
	
Controlled circuit by 2 poles of contactor	Controlled circuit by 3 poles of contactor

2. Application

2.15 Heating Circuit

■ **Component selection according to switching power**

The following table has a standard with surrounding temperature 55℃. But, it is guaranteed to switch overloads extending to 1.05 of rated voltage, when it's applied with single phase.

1. Single phase 2 pole switching

Maximum power(kW)				Contactor	Application example
220/240V	380/415V	660/690V	1000V		
3	5.5	9.5	–	MC-6a	Single phase circuit providing total heating load of 12.5kW about 220V, 60Hz. Selection : 3 pole contactor MC-65a
4	7	12	–	MC-9a, 9b,12a,12b	
5	9.0	15.5	–	MC-18a, 18b, 22b	
9	15.0	25.5	–	MC-32a	
11	19	33	40	MC-40a	
14	24.0	41.5	57.0	MC-50a, 65a	
20	35	61	69	MC-75a, 85a, 100a	
44	76	118	157	MC-130a, 150a	
48	83	130	170	MC-185a	
52	90	145	185	MC-225a	
80	104	160	210	MC-265a	
75	130	200	250	MC-330a	
86	145	230	300	MC-400a	
116	200	310	400	MC-500a	
155	268	415	536	MC-630a	
225	389	602	777	MC-800a	

2. 3 phase switching

Maximum power(kW)				Contactor	Application example
220/240V	380/415V	660/690V	1000V		
4.5	8	13.5	–	MC-6a	Single phase circuit providing total heating load of 18kW about 220V, 60Hz. Selection : 3 pole contactor MC- 40a
6	11	21	–	MC-9a, 9b,12a,12b	
8	15.5	27.0	–	MC-18a, 18b, 22b	
15	26.0	44.0	–	MC-32a	
19	32	57	65	MC-40a	
24	41.0	72.0	94.0	MC-50a, 65a	
34	59	105	113	MC-75a, 85a, 100a	
76	131	206	275	MC-130a, 150a	
82	143	220	295	MC-185a	
90	155	250	320	MC-225a	
103	179	275	370	MC-265a	
130	225	345	432	MC-330a	
149	256	395	525	MC-400a	
200	346	530	710	MC-500a	
268	464	710	951	MC-630a	
389	672	1030	1380	MC-800a	

2.16 Switching the primaries of 3 phase LV/ LV transformers

An extremely large amount of transient rush current flows when connecting transformer to circuit. Twice as much magnetic flux of a normal state needs to flow in order to generate the induced voltage required according to the closing phase of exciting current, rush current to transformer becomes approximately 20~30 times of transformer' s rated current for general saturation state with large amount of exciting current in this case.
Peak by magnetization should be considered when flowing current; IEC 947-4-1 regulates application range AC-6a for this application. AC-3 or AC-4 category test is applied for allowable operating current and capacity about magnetic contactor, and it is determined by calculating given formula from IEC 947-4-1(Table VII b).

■ Operating condition

Maximum ambient temperature : 55°C
initial current surge is generated normally which momentarily reaches peak value during switch-on of transformer, it decreases rapidly as stabilized state value.

■ Selection of contactors

Peak magnetising current of transformer must be lower than given value from the table below. following table shows operating capacity about maximum switching frequency of 60 operating cycles per hour.

Type name of contactors		18AF				22AF				40AF		65AF	
		6a	9a	12a	18a	9b	12b	18b	22b	32a	40a	50a	65a
Closing maximum operational power [kVA]	220/240V	2	3	4	5	3	4	5	6.1	8.5	16	16	18
	380/400V	3.3	5	6.7	8.4	5	6.7	8.4	10.2	15	27	27	31
	415/440V	3.7	5.5	7.3	9.2	5.5	7.3	9.2	11.2	17	32	32	36
	500V	4.2	6.2	8.3	10.4	6.2	8.3	10.4	12.8	20	36	36	40
	600/690V	5.7	8.6	11.5	14.4	8.6	11.5	14.4	17.6	26.5	48	48	53
Maximum permissible closing peak current [A]		160	350	350	420	350	350	420	420	770	1250	1250	1400

Type name of contactors		100AF			150AF		225AF		400AF			800AF		
		75a	85a	100a	130a	150a	185a	225a	265a	330a	400a	500a	630a	800a
Closing maximum operational power [kVA]	220/240V	18.1	19.3	24.1	31.3	31.3	40	45.8	50.7	64.5	74.8	99.8	114.7	179.6
	380/400V	30.1	32.1	40.2	52.2	52.2	66.6	76.4	84.5	112	130.3	166.3	191.2	288.2
	415/440V	33.2	35.4	44.2	57.5	57.5	73.3	84	92.9	123.2	149.4	182.9	210.3	323.1
	500V	37.7	40.2	50.2	65.3	65.3	83.3	95.5	105.6	140	169.7	207.8	249.4	367.2
	600/690V	52	55.5	69.3	90.1	90.1	115	131.8	142.5	173.5	200.8	268.9	329.9	411.1
Maximum permissible closing peak current [A]		1400	1550	1650	1800	2000	2900	3300	3800	5000	6300	7700	9000	12000

Note 1) Please select a magnetic contactor with the current less than 10 times of rated operational current , when rush current of transformer exceeds 20 times of it. On the contrary, when the rush current is less than 20 times smaller, you can use a contactor with a slightly larger amount of capacity than the value from upper table.

Note 2) Electrical durability is 500,000 cycles.

2. Application

2.17 Influence of Conductors Length Used in Contactor Control Unit

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Excess length of control circuit conductor under specific condition may interfere with execution of magnetic contactor's closing and breaking.

- Impossible closing: due to excessive voltage decrease (AC, DC)
- Impossible breaking: due to excessive capacitance (AC)

■ **Permissible disconnection length of control circuit conductor in closing contactor.**

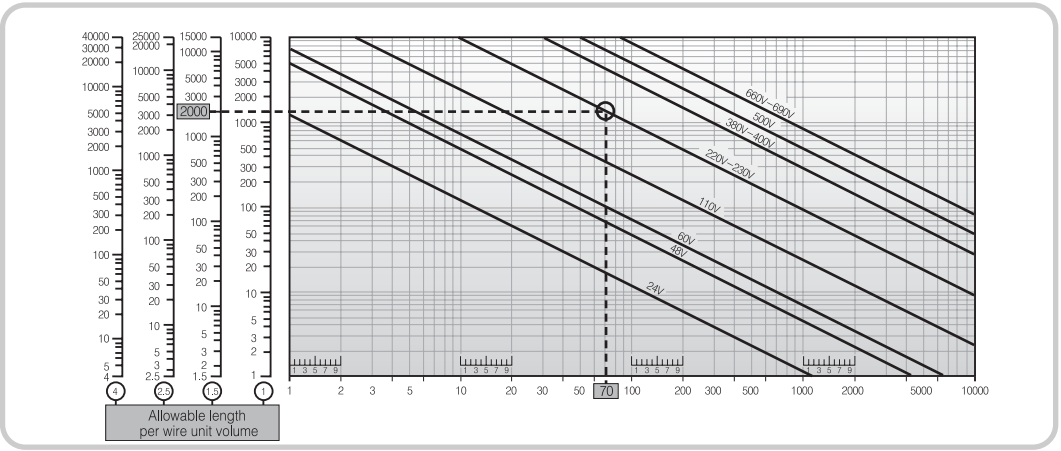
First case: closing (Magnetic contactor with AC or DC control circuit)
Voltage drop is caused by rush current (inrush power) and resistance of control circuit conductor. Table and graph below can be used for determining disconnection length (distance between the control device and magnetic contactor coil) of line related with following.

- Closing coil consumption
- Supply voltage
- Sectional area of connecting line

This graph is about maximum line voltage decrease of 5%. Coil closing consumption power

Type	AC coil control circuit		DC coil control circuit	
	Applied contactor	Closing consumption powe (50/60Hz)	Applied contactor	Closing consumption powe (50/60Hz)
18AF	6a, 9a, 12a, 18a	80 VA	6a, 9a, 12a, 18a	3 W
22AF	9b, 12b, 18b, 22b	80 VA	9b, 12b, 18b, 22b	3 W
40AF	32a, 40a	80 VA	32a, 40a	2.2 W
65AF	50a, 65a	120 VA	50a, 65a	2.2 W
100AF	75a, 85a, 100a	220 VA	75a, 85a, 100a	5.1 W

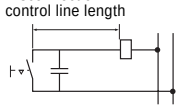
It changes depending on service voltage, control circuit conductor's sectional area, and closing consumption power.



<Example : MC-9a magnetic contactor>
Coil voltage : 230V 50Hz, magnetic contactor coil closing power consumption : 70VA,
Control circuit conductors sectional area : Cu 1.5mm^2
Maximum permissible length : 2000m

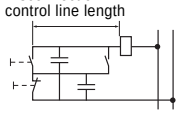
■ Permissible disconnection length of control circuit conductor in a breaking contactor

Disconnection control line length



Wiring diagram A
Retained push button and 2- core cable
(ex: capacity0.2㎌/km)

Disconnection control line length



Wiring diagram B
Instant push button, holding contact and 3-core cable
(ex: capacity 2 X0.2 = 0.4㎌/km)

Second case: breaking (conductor with AC control circuit)
AC operating magnetic contactor under specific condition doesn't break, when control circuit is inactivated. This is due to magnetic contactor's coil control lay-out type and extremely long control circuit line.(refers to diagram A, B)

This can be caused by following elements.

- High control voltage • Low coil holding
- low stand-off voltage of magnetic contactor (according to IEC 947-4-1: 0.75xUc at 0.2)

Following preparation should be required, when demanding longer line.

- Select higher rated magnetic contactor
- Select lower control voltage
- Connect "p" impedance in parallel with magnetic contactor' s coil.

- value of parallel resistance : $Rp = \frac{10^2}{C}$ (C = ㎌)

Following table and graph can be used for determining single length of line(distance between control device and magnetic contactor coil)

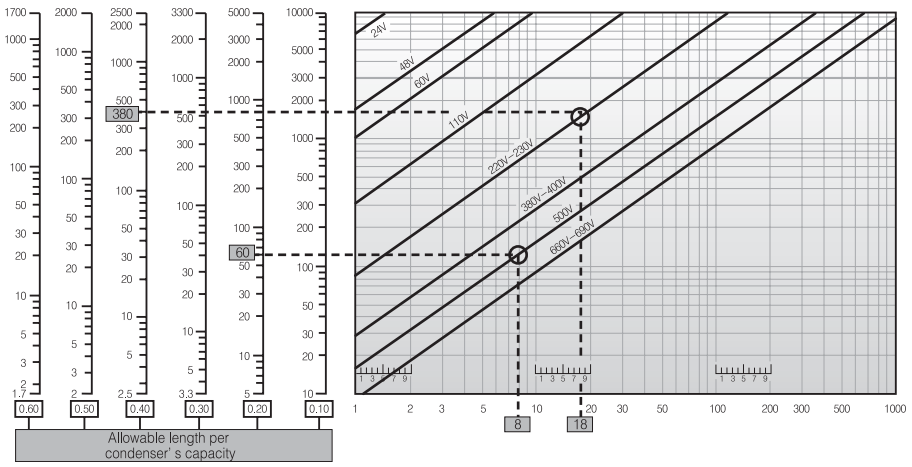
- Coil holding consumption VA • Service voltage
- Capacity(㎌/km) (according to control lay-out)
- Power distribution diagram A, B shows examples of 2 services and coil control distribution.

Coil holding consumption power(average value)

Type	Applied contactor	Coil holding consumption power(50/60Hz)
18AF	6a, 9a, 12a, 18a	11 VA
22AF	9b, 12b, 18b, 22b	11 VA
40AF	32a, 40a	9 VA
65AF	50a, 65a	11 VA
100AF	75a, 85a, 100a	16 VA

<example>
MC-18a magnetic contactor
Coil voltage Uc=500V, 50Hz, 8VA magnetic contactor coil maintaining consumption, control type: 2-core cable with capacity of 0.2mF /km and diagram A through kept push button
Maximum allowable length: 60m
MC-50a magnetic contactor
Coil voltage Uc=230V, 50Hz, 18VA magnetic contactor coil maintaining consumption, control type: 3-core cable with capacity of 2x0.2mF/km= 0.4 mF/km and holding contact. diagram B through kept instant push button
Maximum allowable length: 380m

It is different depending on capacity of control circuit magnetic contactor, voltage and coil holding consumption power.



2. Application

2.18 Selection of Transformer Power for Operation

Operating transformer power for magnetic contactor is selected by following :

1. Transformer's power = operating magnetic coil normal VA x (1.5~2.5)

2. In case of plural magnetic contactors with tranformers load
   1) In the case of simultaneous closing power transformer
      transformer power = sum of full load normal VA x (1.3~1.7)
   2) In case of simultaneous closing 2/3rd of transformer load(VA)
      transformer power = sum of full load normal VA x (1.2~1.5)
   3) In case of simultaneous closing less than 1/2nd of transformer load(VA)
      transformer power = sum of full load normal VA x (1~1.3)

3. Voltage decrease by connecting cable of operating circuit must be considered in case of selecting a transformer for operation.

4. Standard of transformer power is as following table, when connecting cable is short between operating transformer and magnetic contactor.
   (Less than 1m, more than 1.25mm^2 thick)

Frame	Metasol series MC	
	Operating coil normal VA	Operating transformer capacity(VA)
18AF	9.5	15~25
22AF	9.5	15~25
40AF	9	15~25
65AF	11	20~30
100AF	16	25~40
150AF	24	75~100
225AF	40	100~150
400AF	50	100~150
800AF	90	100~150